75.

# Jahrestagung

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Deutsche Gesellschaft für Neurochirurgie

Neurochirurgie 2024: Exzellenz und Evidenz

**2024**

**9.–12. Juni**

**GÖTTINGEN**

## Abstracts

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c/o Conventus Congressmanagement & Marketing GmbH
Carl-Pulfrich-Str. 1
07745 Jena
Tel. 03641 31 16-460 I Fax 03641 31 16-240
gs@dgnc.de I www.dgnc.de

## Tagungsorganisation und Veranstalter/*Programme typesetting*
Conventus Congressmanagement & Marketing GmbH
Sandra Thoß I Nicole Hirsch
Carl-Pulfrich-Straße 1
07745 Jena
Tel. 03641 31 16-349 I Fax 03641 31 16-243
dgnc-kongress@conventus.de I www.conventus.de

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# Inhaltsverzeichnis/*Content*

# Spinal – Verschiedenes 1 | Spinal – Various 1

## V001

### 5-Jahres Follow-up des patientenbezogenen Outcomes nach nicht-fusionierendermikrochirurgischer Dekompressionsoperation bei symptomatischer lumbalerSpinalkanalstenose sowie begleitender degenerativer Grad I Spondylolisthesis

***5-Year follow-up of patient-reported outcomes following non-fusion microsurgical decompression for symptomatic lumbar spinal stenosis with concomitant degenerative grade I Spondylolisthesis***

F. Bytyqi[1], H. Alshaheen[1], V. Abdullahu[1], A. Csokonay[2], M. Walter-Diessars[1], F. Sergejew[3], J. Walter[4]

[1]Medical Center Saarbruecken, Neurosurgery, Saarbrücken, Deutschland
[2]Klinikum Saarbrücken, Klinik für Neurochirurgie, Saarbrücken, Deutschland
[3]Klinikum Saarbrücken, Department of Neuroradiology, Saarbrücken, Deutschland
[4]Klinikum Saarbrücken, Neurosurgery, Saarbrücken, Deutschland

#### Objective

The choice between fusion and motion-preserving decompression procedures forsymptomatic lumbar spinal stenosis in combination with degenerativespondylolisthesis remains controversial. This retrospective study investigates the effectiveness of standalone microsurgical osteoligamentous decompression without additional fusion in patients with monosegmental lumbar spinal stenosis and degenerative spondylolisthesis (Meyerding I°) over a 5-year follow-up period, assessing clinical outcomes and the incidence of secondary fusion-inducing instabilities.

#### Methods

All patients undergoing monosegmental decompression without fusion for symptomatic lumbar spinal stenosis with Spondylolisthesis (Grade I within the same segment) between January 2018 and December 2020 were included. The primary outcome was assessed based on the Oswestry Disability Index (ODI) score difference at 5 years (2018 cohort), 4 years (2019 cohort), and 3 years (2020 cohort). Additionally, the minimal clinically important difference (MCID) in ODI scores at 5, 4, and 3 years, along with the rate of secondary fusion-inducing instabilities, was analyzed.

#### Results

A total of 144 patients were included. In the 5-year follow-up evaluation (67 patients), the ODI score difference was -30 points, indicating a relative 5-year ODI improvement of 35%. In the 4-year follow-up assessment (46 patients), the ODI score difference was -23.2 points (32% improvement), and in the 3-year follow-up, the ODI score difference was -19.6 points (31% improvement). All three patient cohorts showed clinically significant improvement (MCID ODI score > 12.8 points = >30%). These results correlated with the calculated NASS Satisfaction Index: at the end of the follow-up period, 71% of patients in the 2018 cohort, and 69% and 73% in the 2019 and 2020 cohorts, respectively, were satisfied with the clinical outcome of motion-preserving microsurgical decompression. Secondary fusion due to a fusion- inducing instability occurred in only 14% of all cohort patients over the entire 5-year follow-up.

#### Conclusion

These results suggest that standalone decompression without initial fusion in patients with monosegmental lumbar spinal stenosis and concomitant degenerative Spondylolisthesis Grade I leads to sustained symptom reduction and significant functional improvement after up to 5 years of observation. Additionally, there is a low occurrence of postoperative fusion-inducing instability in the index segment.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## V002

### Intraoperativ CT-navigierte Anlage von zevikalen Pedikelschrauben - Eine prospektive single-center Analyse von 655 zervikalen Pedikelschrauben.

***Intraoperative CT-navigated placement of cervical pedicle screws – A prospective single center cohort analysis of 655 cervical pedicle screws***

U. Bertram[1], J. Böhmer[1], T. P. Schmidt[1], H. R. Clusmann[1], C. A. Müller[1], C. Blume[1]

[1]Universitätsklinikum RWTH Aachen, Neurochirurgie, Aachen, Deutschland

#### Objective

Intraoperative (i)CT-navigated screw placement has led to a paradigm shift in dorsal instrumented fusion surgery of the cervical spine. While internal screw-rod systems used to rely heavily on lateral mass screws (LMS), we have discovered a trend towards the use of pedicle screws (CPS) within one year after the implementation of iCT. This study assess accuracy and associated risks of iCT navigated dorsal CPS placement.

#### Methods

A consecutive series of patients that received dorsal instrumented fusion of the c-spine using iCT navigated screw placement between Sep 17 and Feb 23 was prospectively analyzed. A modified Gertzbein&Robbins classification was used for qualitative assessment. Pedicle or transverse foramen breaches of ≥4mm were deemed misplacements. Surgery-related adverse events and follow-up were documented.

#### Results

The cohort comprises 142 patients with 655 CPS (79.9%). Initial accuracy was 91.6% (acceptably placed screws) and 93% after intraoperative correction of 19 CPS. The accuracy was lower at C3 and C4 levels (88.5 and 79.6%; p <.05). Pedicle breaches were found mainly lateral (55.9%) and medial (36%), rarely sup-/inferior (8%). Transverse foramen was breached in 39.4% of patients resulting in 1 vertebral artery injury (0.7% of all patients; 0.15% of all CPS), followed by cerebellar stroke without fatal course. One screw misplacement resulted in spinal cord injury (0.7% of all patients). No nerve root injury was observed. In total, 6 (4.2%) patients suffered from transient, 4 (2.8%) from permanent neurological deterioration, however only 2 cases were directly related to screw misplacement (1.4%). Eight patients (5.6%) received revision surgery due to infection. Complete follow-up was assessed for 49.7% (n=71) of all patients. Radiological follow-up found 5 cases of osteolytic screw loosening (3.5% of all patients) and 6 cases of broken pedicle screws (4.2%), leading to four cases of revision surgery due to loss of fixation (2.8%).

#### Conclusion

iCT navigated CPS placement results in very good accuracy. There is a tendency towards lateral pedicle and thus transverse foramen breach. Overcorrection might lead to medial pedicle breach, endangering the spinal cord. Our study shows that screw related adverse events are rare, but may result in severe injury. Even screw-misplacement seldom results in neurological deterioration, nor verifiably in poor biomechanical outcome. However, larger follow-up series are needed to address biomechanical outcome in an adequate manner.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## V003

### Risikofaktoren für die Fehlplatzierung von Pedikelschrauben in der minimal-invasiven navigierten Wirbelsäulenchirurgie

***Risc factors for misplacement of pedicle screws in minimally invasive computer assisted navigated spine surgery***

R. Doria-Medina[1], I. Vasilikos[1], A. Stathi[1], A. El-Rahal[1], R. Rölz[1], J. Beck[1], U. Hubbe[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Pedicle screw placement is crucial in spinal reconstructions, and computer-assisted navigation can reduce the misplacement of screws. Nonetheless, the actual PS position has never been compared to the intended trajectory in navigation. We aim to identify and address these errors to improve surgical outcomes. Therefore, we investigated the technical errors of PS placement using CAN in minimally invasive spine surgery (MISS).

#### Methods

175 patients who underwent MISS with CAN between 2015 and 2021 were included. The intended screw position was recorded on the navigation system. The 3D intraoperative scans were merged with the postoperative CT scans using SpineMap® 3D (Stryker©). The difference between the actual PS position and the intended position stored on the navigation system was defined as the technical error, and measured as PS angle deviation (PAD) in degrees and adjacent PS deviation (APD) in mm. Patient factors (age, gender, body mass index (BMI), back tissue depth (BTD), and osteoporosis), surgical factors (cement use, PS relaxation, surgical duration (ST), and estimated blood loss (EBL)) and technical factors (number and size of PSs inserted and type of navigation tracking) were evaluated. Tests were conducted on GraphPad Prism 9.4.0, utilizing Mann-Whitney and Kruskal-Wallis analyses. Linear and logistic regression analysis were employed to determine probable impacts on the primary endpoint.

#### Results

A total of 952 out of 1054 placed PS could be measured (mean PAD of 5.32 degrees (±3.70) and mean APD of 2.97mm (±1.83)). Increased deviation was associated with patient factors such as high BMI and BTD, surgical factors such as longer ST, higher EBL, loose PS, and greater number of PS placed, as well as technical factors such as PS dimensions and use of a spinous process navigation tracker. Regression analysis revealed that body mass index (BMI), back tissue depth (BTD), and screw loosening - with shorter and thicker screws - were significant risk factors for increased deviation rates

#### Conclusion

Our findings demonstrate the patient, surgical and technical risk factors that influence technical errors in PS placement using CAN. This highlights the need for greater attentiveness towards potential mistakes with CAN. In a first step, the use of two or more navigation scans may help to imporove accuracy in cases of multilevel surgery (with higher EBL, ST, number of screws). Furthermore interoperative imaging and the navigation systems should be improved for the use in obese patients.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## V004

### Wirbelsäulennavigation: Der technische Fehler bei der Platzierung von Pedikelschrauben in der minimal-invasiven navigierten Wirbelsäulenchirurgie

*Spinal navigation: The technical error in navigated minimal invasive pedicle screw placement*

U. Hubbe[1], I. Vasilikos[1], A. Stathi[1], A. El-Rahal[1], R. Rölz[1], J. Beck[1], R. Doria-Medina[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Pedicle screw (PS) placement is crucial in spinal reconstructions. Computer-assisted navigation (CAN) helps reducing PS misplacements. However, the real PS position has not been compared to the intended trajectory planned with CAN. We aim to identify and address these errors to improve surgical outcomes. Therefore, we investigated the technical errors of PS placement using CAN in minimally invasive spine surgery (MISS).

#### Methods

175 patients undergoing MISS with CAN between 2015 and 2021 were evaluated. The intended PS position was recorded on the navigation system. Intraoperative 3D scans were fused to postOP CT scans using SpineMap® 3D (Stryker©). The deviation of the real PS position on the postOP CT from the intended position was defined as the technical error and measured as PS angle deviation (PAD) in degrees and adjacent PS deviation (APD) in mm. In addition, pedicle breach (PB) grading of the real position of the PS using the Gertzmann score was performed. The deviation measurements were analyzed using GraphPad Prism 9.4.0. Statistics included Mann-Whitney and Kruskal-Wallis tests, as well as linear and logistic regression models to determine any possible impact on the technical error.

#### Results

952 out of 1054 pedicle screws were eligible for measurement. 420 (44.1%) screws were placed in the lumbar region, 344 (36.1%) in the thoracic region, 119 (12.5%) in the sacral region, and 69 (7.3%) in the cervical region. The mean pedicle angle deviation was 5.32 degrees (±3.70), and the mean pedicle diameter deviation was 2.97 mm (standard deviation= ±1.83). A total of 384 (40.3%) PB were detected, of which 233 (24.5%) were less than 2 mm which is deemed insignificant. 151 (15.9%) PB were greater or equal to 2 millimeters with 53 (5.4%) pedicle screws breaching the pedicle by 4 mm or more. Higher grades of PB were significantly associated with increased values for PAD and APD. Regression analysis demonstrated that both PAD and APD are significant risk factors for PB.

#### Conclusion

Our findings reveal significant deviations of the real position of PS in comparison to the intended trajectory when utilizing spinal navigation. The correlation between greater deviations from the plan and an increase in pedicle breach grading reinforces on the one hand the internal consistency of the current results. On the other hand further investigations to analyze variables that impact the technical and CAN errors on PS placement and thus affect the outcome are warranted.

Abb. 1

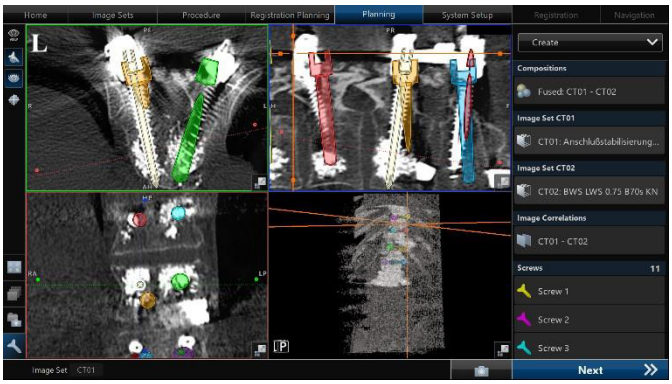
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Image Sets
Procedure
Registration Planning
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System Setup
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Image Set CT01
CT01: Anschlußstabilisierung...
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Image Correlations
CT01 - CT02
Screws
11
Screw 1
Screw 2
Screw 3
Image Set CT01
Next

# Spinal – Verschiedenes 1 | Spinal – Various 1

## V005

### Bewertung der Genauigkeit von AR-Navigation mit einem Optical-See-Through Head-Mounted-Display im Vergleich zur konventionellen Navigation bei Bohraufgaben - eine Machbarkeitsstudie.

***Accuracy evaluation of AR navigation using an optical-see-through head-mounted display compared to conventional navigation for drilling tasks – A feasibility study***

S. Drobinsky[1], Y. Li[2], A. Müller[3], F. Hölzle[2], K. Radermacher[1], B. Puladi[2,4], M. de la Fuente[1]

[1]RWTH Aachen University, Lehrstuhl für Medizintechnik, Aachen, Deutschland
[2]Universitätsklinikum RWTH Aachen, Klinik für Mund-, Kiefer-, und Gesichtschirurgie, Aachen, Deutschland
[3]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[4]Universitätsklinikum RWTH Aachen, Institut für Medizinische Informatik, Aachen, Deutschland

#### Objective

High-risk neurosurgical procedures, such as pedicle screw placement, require advanced technical skill and experience. Compared to conventional navigation systems (CNS) augmented reality navigation systems (ARNS) can reduce mental transformations and mitigate hand-eye coordination problems [1]. This study compares drilling accuracy with ARNS and CNS support.

#### Methods

Six participants with varying levels of medical experience (2 engineers, medical students, surgeons) were instructed to drill along five pre-planned trajectories with different orientations in SikaBlock M330 material (Sika Industry, Swiss). The drill hand piece and material block were tracked using a Polaris Vicra camera (NDI, ON, Canada). In a cross-over study design, participants were either first supported by an ARNS through the optical-see-through head-mounted display (OST-HMD) Hololens 2 (Microsoft, NM, USA) or a CNS with an external 2D monitor. The ARNS presented the target trajectory on a 3D digital twin within the operating field (Fig 1.), whereas the CNS provided three orthogonal 2D views along with an additional compensatory display (Fig.2). Subsequently, deviations were assessed through postoperative computed tomography scans.

#### Results

Translational and rotational deviations from the target trajectory are slightly lower with ARNS (1.45 ± 0.7 mm, 0.78 ± 0.52°) compared to CNS (1.75 ± 1.28 mm, 1.51 ± 2.43°), however findings are not significant (t-test, p=0.27 for translational, p=0.12 for rotational). Commonly, pedicle breaches below 2 mm are acceptable [2]. For drilling depth absolute deviations are slightly lower with CNS (-0.97 ± 1.35 mm) compared to ARNS (-1.18 ± 1.11 mm), however findings are not significant (p=0.52).

#### Conclusion

Further research is needed to determine whether ARNS improves drilling accuracy compared to CNS. In future investigations usability factors like efficiency and user satisfaction must also be considered to explore the potential of ARNS to support safe and successful surgery.

1. Deib, G., Johnson, A., Unberath, M., Yu, K., Andreß, S., Qian, L., Osgood, G., Navab, N., Hui, F. & Gailloud, P. (2018). Image guided percutaneous spine procedures using an optical see-through head mounted display: proof of concept and rationale. Journal of NeuroInterventional Surgery, 10(12)
2. Aoude, A., Fortin, M., Figueiredo, R., Jarzem, P., Ouellet, J. & Weber, M. H. (2015). Methods to Determine pedicle screw placement accuracy in spine Surgery: A Systematic review. European Spine Journal, 24(5), 990–1004

Abb. 1

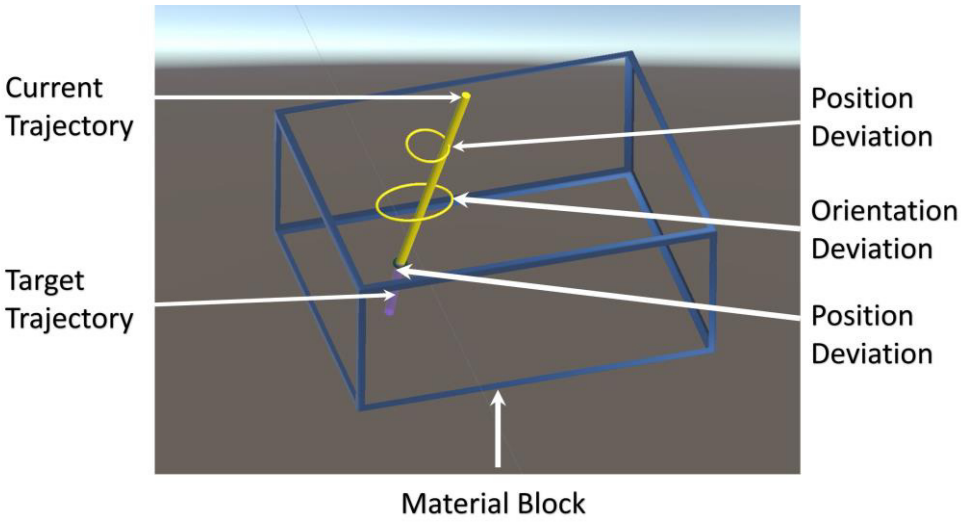



*Figure 1: Augmented Reality navigation system showing the deviation from the target trajectory on a digital twin.*

Abb. 2

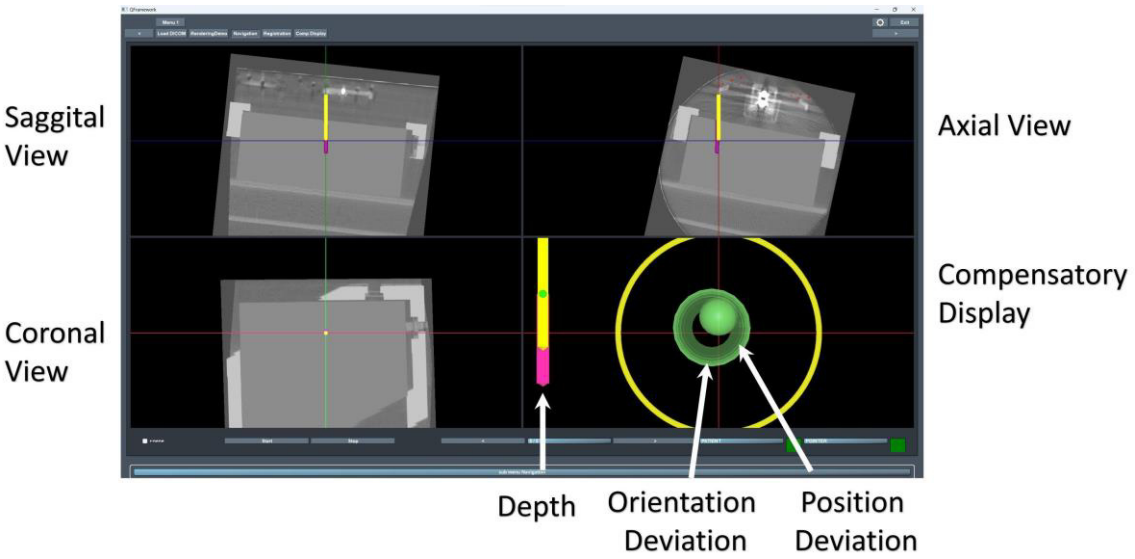



*Figure 2: Conventional navigation system with three orthogonal views and a compensatory display.*

# Spinal – Verschiedenes 1 | Spinal – Various 1

## BO-02

### Verbessert auch die bisegmentale ACDF die Beweglichkeit der HWS wie beim monosegmentalen Eingriff – Eine prospektive monozentrische Studie

M. Hohenhaus[1], M. Bissolo[1], S. Behringer[1], J. Beck[1], J.-H. Klingler[1], U. Hubbe[1], C. Scholz

[1] Universitätsklinikum Freiburg, Freiburg i. Br., Deutschland

**Objective**

Die Beweglichkeit der Halswirbelsäule (HWS) ist ein wichtiger Outcome-Parameter nach zervikalen Operationen. Nach monosegmentaler anteriorer Diskektomie und Fusion (ACDF) liegen zuverlässige Daten vor, dass der Eingriff zu keiner Verschlechterung der objektiven HWS-Mobilität und gar zur Verbesserung der subjektiven Beweglichkeit führt, obwohl das betroffene Segment fixiert wird. Diese Arbeit untersucht, ob sich dieser Effekt bei bisegmentalen Eingriffen bestätigen lässt.

**Methods**

Prospektive Erfassung der objektiven graduellen HWS-Beweglichkeit mittels CROM *(Cervical Range Of Motion)*-Device und subjektiven Bewegungsqualität mittels *Patient-Reported Restriction Score (PRRS)* und *Numeric Rating Scale (NRS)* in jeder Bewegungsrichtung bei degenerativer bisegmentaler ACDF vor sowie 3 und 12 Monate nach OP. Zusätzlich wurde die Zufriedenheit der Patienten mit dem Eingriff mittels *Patient Satisfaction Index (PSI)* ermittelt.

**Results**

Einschluss von 78 Patienten im Alter von 56,9 ± 11,4 Jahren, wobei für 69 Patienten auch Daten nach 12 Monaten vorlagen. 85,9% waren mit dem OP-Ergebnis nach 3 Monaten sowie 92,8% nach 12 Monaten zufrieden. Die objektive Beweglichkeit verschlechterte sich 3 Monate post-OP ($p<0,001$-$0,096$), wobei sich nach 12 Monaten wieder eine Verbesserung auch das präoperative Niveau ergab ($p=0,605$-$1,000$, Abb.1). Die subjektive Beweglichkeit zeigte in allen Bewegungsrichtungen eine Verbesserung, welche durchweg nach 1 Jahr signifikant war ($p\leq0,001$, Abb.2). Die NRS-Werte waren bereits nach 3 Monaten signifikant reduziert ($p<0,001$).

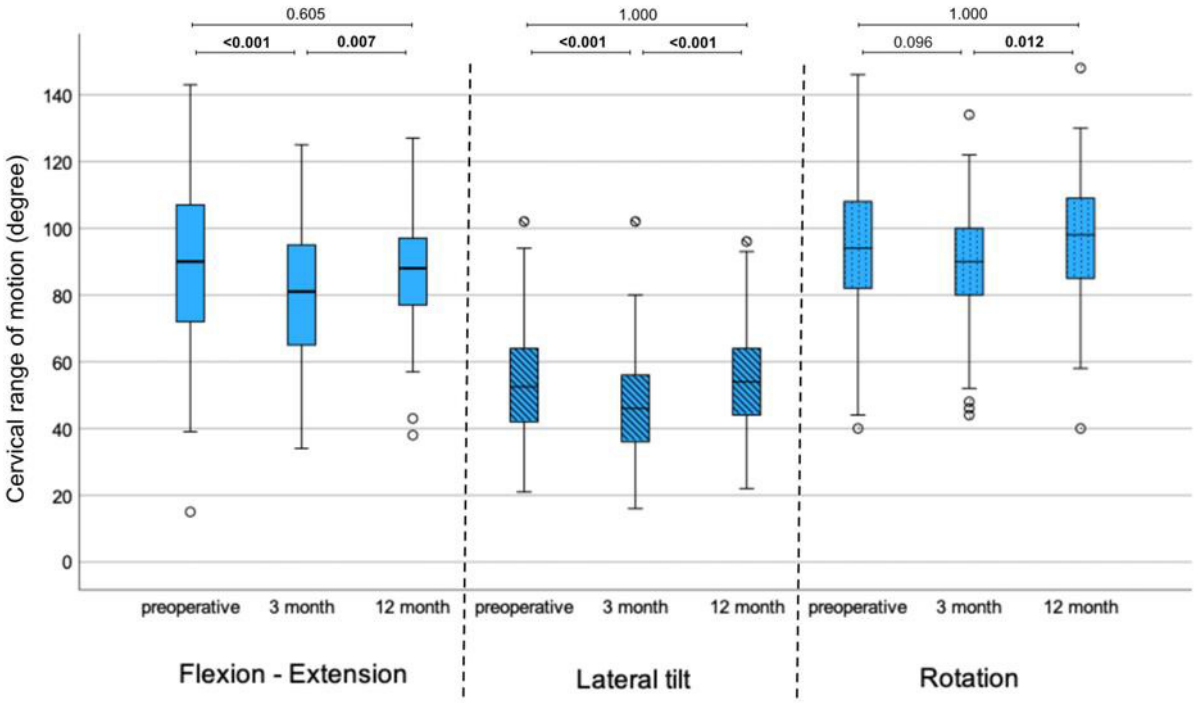
**Conclusion**

Die bisegmentale ACDF geht wie der monosegmentale Eingriff mit keiner Verschlechterung der HWS-Beweglichkeit einher. Die objektive Beweglichkeit scheint vorübergehend reduziert, jedoch nach 1 Jahr wieder auf dem Ausgangsniveau. Die subjektive Beweglichkeit ist nach 12 Monaten ebenso signifikant in allen Bewegungsrichtungen verbessert. Assoziiert zeigt sich auch eine signifikante Schmerzreduktion, am ehesten ursächlich für die gefühlt verbesserte Beweglichkeit.

Abb.1: Boxplots zum objektiven Bewegungsumfang (Grad) in allen Bewegungsrichtungen zu den 3 Messzeitpunkten. Gruppenvergleich mittels ANOVA, $p<0,05$ statistisch signifikant.

Abb.2: Gestapelte Balkendiagramme des *PPRS* als Maß der Einschränkung der subjektiven HWS-Beweglichkeit: 0=keine (grün), 1=leichte (gelb), 2=mittelgradige (orange), 3=starke (rot) Einschränkung. Gruppenvergleich mittels Wilcoxon-Test, $p<0,05$ statistisch signifikant.

Abb. 1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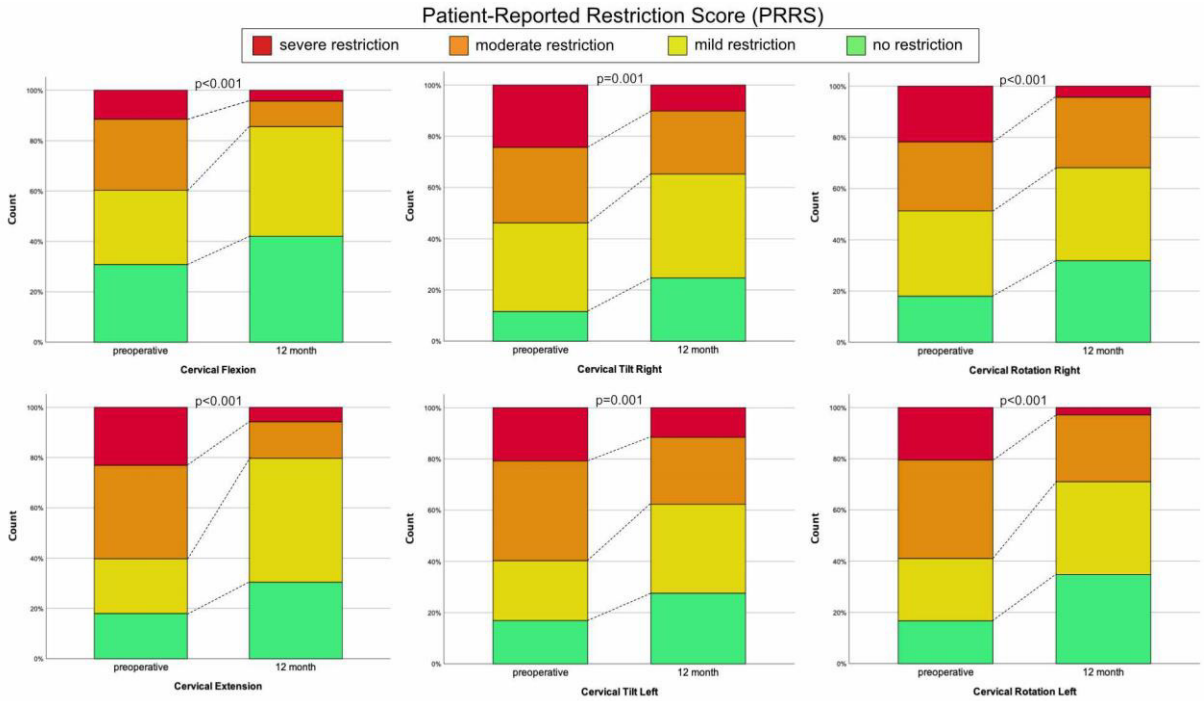
<0.001
0.007
1.000
<0.001
<0.001
1.000
0.096
0.012
Cervical range of motion (degree)
0
20
40
60
80
100
120
140
preoperative
3 month
12 month
preoperative
3 month
12 month
preoperative
3 month
12 month
Flexion - Extension
Lateral tilt
Rotation

Abb. 2.


Patient-Reported Restriction Score (PRRS)
severe restriction
moderate restriction
mild restriction
no restriction
p<0.001
p=0.001
p<0.001
p<0.001
p=0.001
p<0.001
Count
preoperative
12 month
Cervical Flexion
Cervical Tilt Right
Cervical Rotation Right
Cervical Extension
Cervical Tilt Left
Cervical Rotation Left

# Vaskuläre Neurochirurgie – Gefäßmalformationen | Vascular Neurosurgery – Vascular malformations

## V006

### Funktionelle Konnektivität im Sprachnetzwerk bei Patienten mit arteriovenösen Malformationen
*Functional network plasticity in network connectivity in patients with arteriovenous malformation language*

J. Rossmann[1,2], K. Hense[1], D. Deuter[1], C. Ott[1], C. Doenitz[1], S. Karl-Michael[2], N. O. Schmidt[1], K. Rosengarth[1]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Paracelsus Medizinische Privatuniversität (PMU), Klinik für Neurochirurgie, Nürnberg, Deutschland

#### Objective

The influence of arteriovenous malformations (AVMs) on possible neuroplastic processes in the language network and its intrinsic functional connectivity is not yet well understood. There is only rare literature addressing this issue reporting AVM-associated changes in resting state fMRI. This study investigated possible neuroplastic effects of AVMs on functional network connectivity in the cortical language network, and second, assesses, if there are differences in language network connectivity dependent on the AVM"s location (adjacent or distant to the language network)

#### Methods

24 (8 female; median age 38 years) AVM patients and 32 healthy control subjects were included in this study. Connectivity analysis was based on a visual presented word generation task during fMRI, to reliably address the language network. Data preprocessing was conducted using Statistical Parametric Mapping. CONN-Toolbox was used for functional connectivity analysis by applying a seed-to-voxel approach. We focused on 22 seed regions in the default mode, salience, dorsal attention, frontoparietal, and language networks.

#### Results

On seed level, AVM showed increased network connectivity in 20 of 22 tested seed regions compared to healthy control subjects with 108 detected significant connectivity clusters. Most clusters were detected connected to the right prefrontal cortex seed of the salience network. The largest cluster was within the left cingulate gyrus and was connected to the left prefrontal cortex seed of the frontoparietal network. On network level, AVM showed increased network connectivity in all 5 tested networks with 47 detected clusters (13 clusters each in the default mode and salience network, 9 clusters in the dorsal attention network and 6 clusters each in the fronto-parietal and the language network). In comparison to non-language adjacent AVM, the language adjacent AVM showed increased connectivity in three of 22 seeds (middle prefrontal cortex seed of default mode network, right supramarginal gyrus seed of the salience network and left lateral prefrontal cortex seed of the frontoparietal network) and diminished connectivity in the left supramarginal gyrus seed of the salience network seed.

#### Conclusion

AVM have a higher network activation in language fMRI compared to healthy control subjects. Language adjacency only played a marginal role. This data suggests a general alteration in network connectivity in AVM patients.

# Vaskuläre Neurochirurgie – Gefäßmalformationen | Vascular Neurosurgery – Vascular malformations

## V007

### Klinische Wirksamkeit der Revaskularisierungsoperation bei Moyamoya-Angiopathie: Langzeitergebnisse einer europäischen Kohorte

*Clinical efficacy of revascularization surgery for Moyamoya angiopathy: Long-term results of a European cohort*

R. Mertens[1,2], K. Lucia[3], F. Mrosk[1], I. Efe[1], P. Leissa[1], L. Mödl[4], E. D. Sprünken[4], G. Acker[1], P. Vajkoczy[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, BIH Charité Junior Clinician Scientist Program, Berlin, Deutschland
[3]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[4]Charité – Universitätsmedizin Berlin, Institut für Biometrie und Klinische Epidemiologie, Berlin, Deutschland

#### Objective

Moyamoya angiopathy (MMA) is a rare cerebrovascular disease treated by surgical revascularization. Postoperative long-term courses of European patients are not well described. Therefore, the aim of this study was to present radiological and clinical long-term outcomes of MMA patients who underwent surgical revascularization at our institution.

#### Methods

We retrospectively identified angiographically verified MMA patients who were treated by surgical revascularization and underwent at least one clinical and radiological follow-up examination at our department after a minimum of 3 months after surgery. Patient data were analyzed and uni- and multivariate logistic regression were performed to determine risk predictors for unfavorable clinical outcome.

#### Results

Between 2008 and 2020, 438 patients were treated at our department, of which 148 patients met the inclusion criteria. The mean age was 34.7 ± 17.7 years (range 1-71 years) at first surgery, including 107 women and 41 men, predominantly of Caucasian ethnicity (91.9%). The proportion of pediatric patients (<18) was 21.6%. Ischemic symptoms were the most common symptom at onset (81.1%), followed by hemorrhage (10.1%). Combined revascularization surgery was the treatment of choice (72.3%), followed by direct (24.0%) and indirect (3.7%) revascularization. The rate of immediate postoperative complications <30 days was 4.1%, including 1.4% ischemic events. During a mean follow-up period of 88.6 ± 21.0 months in the long-term cohort of 44 patients with follow-up >60 months after surgery, the rate of radiological and clinical stroke was 4.5% and 2.3% with no occurrence of hemorrhage. The estimated risk for new radiological and clinical stroke was 0.6% and 0.3% per patient-year. The rate of bypass patency was 95.5% and 86.4% of patients presented with a favorable outcome. Only 2.3% of patients had a worse outcome compared to the preoperative state. Uni- and multivariate logistic regression revealed that stroke as an onset symptom was a significant predictor for an unfavorable clinical outcome.

#### Conclusion

This study represents the largest published long-term data from a European Moyamoya cohort after surgical revascularization. The majority of patients benefited from revascularization surgery with good clinical outcome, high bypass patency rates and 0.6% stroke risk per patient-year, indicating a relatively benign long-term course of MMA in European patients after surgery.

# Vaskuläre Neurochirurgie – Gefäßmalformationen | Vascular Neurosurgery – Vascular malformations

## V008

### Blutungsrisiko von zerebralen Kavernomen in Patienten unter Medikation mit Statinen und Thrombozytenaggregationshemmern: Eine Kohortenstudie

***Bleeding risk of cerebral cavernous malformations in patients on statin and antiplatelet medication: A cohort study***

L. Marques[1], C. Jaeggi[2], M. Branca[3], A. Raabe[4], D. Bervini[4], J. Goldberg[4]

[1]Universitätsspital Basel, Neurochirurgie, Basel, Schweiz
[2]Kantonsspital Olten, Innere Medizin, Olten, Schweiz
[3]Universität Bern, CTU Bern, Bern, Schweiz
[4]Inselspital – Universitätsspital Bern, Neurochirurgie, Bern, Schweiz

#### Objective

Statin medication has been identified as a potential therapeutic target for stabilizing cerebral cavernous malformations (CCMs). Although increasing evidence suggests that antiplatelet medication decreases the risk of CCM hemorrhage, data on statin medication in clinical studies are scarce. Therefore, the objective of this study was to assess the risk of symptomatic CCM-related hemorrhage at presentation and during follow-up in patients on statin and antiplatelet medication.

#### Methods

A single-center database containing patients harboring CCMs was retrospectively analyzed over 41 years and interrogated for symptomatic hemorrhage at diagnosis, during follow-up, and statin and antiplatelet medication.

#### Results

In total, 212 of 933 CCMs (22.7%), harbored by 688 patients, presented with hemorrhage at diagnosis. Statin medication was not associated with a decreased risk of hemorrhage at diagnosis (odds ratio [OR] 0.63, CI 0.23-1.69, *P* = .355); antiplatelet medication (OR 0.26, CI 0.08-0.86, *P* = .028) and combined statin and antiplatelet medication (OR 0.19, CI 0.05-0.66; *P* = .009) showed a decreased risk. In the antiplatelet-only group, 2 (4.7%) of 43 CCMs developed follow-up hemorrhage during 137.1 lesion-years compared with 67 (9.5%) of 703 CCMs during 3228.1 lesion-years in the nonmedication group. No follow-up hemorrhages occurred in the statin and the combined statin and antiplatelet medication group. Antiplatelet medication was not associated with follow-up hemorrhage (hazard ratio [HR] 0.7, CI 0.16-3.05; *P* = .634).

#### Conclusion

Antiplatelet medication alone and its combination with statins were associated with a lower risk of hemorrhage at CCM diagnosis. The risk reduction of combined statin and antiplatelet medication was greater than in patients receiving antiplatelet medication alone, indicating a possible synergistic effect. Antiplatelet medication alone was not associated with follow-up hemorrhage.

# Vaskuläre Neurochirurgie – Gefäßmalformationen | Vascular Neurosurgery – Vascular malformations

## V009

### Erkennung von venösen Entwicklungsanomalien bei zerebralen kavernösen Malformationen in hämosiderinempfindlichen Sequenzen: Ist das Kontrastmittel verzichtbar?

***Detection of cerebral cavernous malformation associated developmental venous anomalies in hemosiderin-sensitive sequences: Can we skip the contrast?***

L. Rauschenbach[1], A. N. Santos[1], J. Rodemerk[1], H. H. Gull[1], T. F. Dinger[1], M. Darkwah Oppong[1], A. Engel[1], M. Schüssler[2], Y. Li[2], R. Jabbarli[1], K. H. Wrede[1], U. Sure[1], P. Dammann[1]

[1]Universitätsklinikum Essen, Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland
[2]Universitätsklinikum Essen, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Essen, Deutschland

#### Objective

Hemosiderin-sensitive magnetic resonance imaging (MRI) sequences are frequently used for microbleed detection in cerebral cavernous malformation (CCM) disease. However, the value of susceptibility-weighted imaging (SWI) and gradient-echo T2* weighted imaging (GRE-T2*) sequences in detecting CCM-associated developmental venous anomalies (DVA) is unclear.

#### Methods

We screened our institutional database of CCM patients treated between 2003 and 2023. Inclusion regarded clinical baseline characteristics and MRI dataset including contrast-enhanced (CE) T1, T2, and SWI or GRE-T2* sequences. The existence of CCM-related DVA was proposed according to all images, based on CE T1 imaging. A subset of 200 patients with or without DVA and SWI (n = 50 / n = 50) and with or without DVA and GRE-T2* imaging (n = 50 / n = 50) were randomly selected. Univariate analyses were used to ensure homogeneity between the groups for baseline parameters. The existence of DVA was assessed by two experienced and blinded neuroradiological raters based on SWI or GRE-T2* sequences.

#### Results

There was no difference in the basic characteristics between the patients with SWI sequences and the patients with GRE-T2* sequences ($p > 0.05$). When comparing patients with or without DVA, there was an increased incidence of CCM-related DVA in infratentorial lesions ($p = 0.01$) and deep lesions ($p < 0.01$). The evaluation of the blinded investigators revealed agreement in 76% of the SWI sequences and in 82% of the GRE-T2* images. While SWI sequences were convincing with a high sensitivity of 81.4%, GRE-T2* sequences showed a low sensitivity of 19.1%. The specificity was different, where SWI sequences achieved a value of 60.6% and GRE-T2* sequences a value of 97.5%.

#### Conclusion

The evaluation of SWI and GRE-T2* sequences for the assessment of CCM-related DVA is inferior to the everyday use of the CE T1 sequence. Thus, the use of contrast agents still appears necessary for detailed diagnostics and appropriate surgery planning.

# Vaskuläre Neurochirurgie – Gefäßmalformationen | Vascular Neurosurgery – Vascular malformations

## BO-01

***A long-term comparative analysis of endovascular coiling and clipping for ruptured cerebral aneurysms: An individual patient-level meta-analysis assessing re-rupture rates***

J. Wach[1], M. Vychopen[1], A. Guranda[1], U. Nestler[1], E. Güresir[1]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland

### Objective

Although the initial findings of the randomized International Subarachnoid Aneurysm Trial initially suggested a greater efficacy of coil embolization compared to surgical clipping at one year after treatment for aneurysmal subarachnoid hemorrhage (aSAH), the lack of comprehensive long-term data regarding re-rupture rates has given rise to notable concerns. The present meta-analysis reconstructs individual patient data (IPD) with the intention to delving into this matter more extensively.

### Methods

The present meta-analysis included studies that compared clipping with coiling of ruptured cerebral aneurysm regarding the long-term probability of rerupture. IPD of rerupture rates were extracted from published Kaplan-Meier curves using the R package *IPDfromKM* in R studio (RStudio, Boston, MA, USA). Kaplan-Meier Plots of the pooled data were created using the R package Survminer, and Hazard ratios (HR) were used as effective measures.

### Results

The ISAT and the CARAT study were eligible for inclusion and the pooled patient cohort included 2654 patients. The neurosurgically treated arm included 1546 patients, whereas the endovascularly treated arm included 1108 patients. The median time of reconstructed follow-up time was 9.3 years (IQR=0.5-13.1). The rerupture rate in the total cohort was 1.3%. The rerupture rate in the neurosurgically treated arm was 0.7%, and in the endovascularly treated arm 2.1% of the 1108 patients had a rerupture of the aneurysm, respectively ($p$=0.003). The one-, six, and 10-year rerupture-free-rates in the neurosurgically, and endovascularly treated patients were 99.5% vs. 99.1%, 99.4% vs. 98.1%, and 99.1% vs. 97.6%, respectively. Kaplan-Meier chart of the 2654 patients was constructed and revealed a shortened time to rerupture in endovascularly treated aSAH patients (log-rank test: $p$=0.01). The univariate Cox regression analysis showed a Hazard ratio of 2.40 (95%CI:1.17-4.93, $p$=0.02) for endovascularly treated patients compared with neurosurgically treated patients regarding rerupture.

### Conclusion

Cerebral aneurysm rerupture, whether following endovascular treatment or neurosurgical clipping, is rare and uncommon beyond the initial year. Pooled long-term individual patient data from 2654 patients revealed that rerupture of treated cerebral aneurysms is more common after endovascular treatment and might be considered in the pretherapeutic decision-making process of aSAH patients.

# Tumor – Diagnostik | Tumour – Diagnostics

## V011

### Artifizielle Intelligenz basierte Erkennung molekularer Subtypen des Glioblastoms mittels intraoperativer stimulierter Raman Histologie

***Artificial-intelligence-based detection of molecular substypes of glioblastoma using label free intraoperative stimulated Raman histology***

J. Strähle[1], P. Scheffler[1], N. Neidert[1], D. Erny[2], O. Schnell[3,4], J. Beck[1], D. H. Heiland[1,4]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[2]Universitätsklinikum Freiburg, Institut für Neuropathologie, Freiburg i. Br., Deutschland
[3]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[4]Universitätsklinikum Erlangen, Klinik für Neurochirurgie, Erlangen, Deutschland

#### Objective

Glioblastoma encompasses three epigenetically defined subclasses without significant differences in clinical outcome. Recent investigations demonstrated that predominantly patients with RTK 1 subclass benefited from gross-total resection compared to patients with RTK 2 or MES Intraoperative evaluation of molecular subgroups is a key to pave the way for molecular stratified surgical strategies. Here we developed an artificial intelligence (AI) based prediction of the epigenetic subclasses based on intraoperative, label-free stimulated Raman histology (SRH) images.

#### Methods

Tissue samples from 66 patients with primary (73%) and recurrent (27%) glioblastoma undergoing either resection (n=63) or biopsy (n=3). Intraoperative stimulated Raman scattering imaging at wavenumber 2845 cm–1 and 2940 cm–1 was performed using the NIO-Microscopy System (Invenio Imaging). DNA was extracted and analyzed for genome-wide DNA methylation patterns using the Illumina EPIC (850k) array. Assessment of epigenetic subtypes was performed using the brain tumor classifier (version 12.8) of the DKFZ Heidelberg. Subclass prediction was performed by an attention-based graph-neural network (5 attentions heads) coupled by a ResNet18 encoder for node feature extraction.

#### Results

The 66 glioblastoma samples were classified into MES (42%), RTK 1 (12%), RTK 2 (42%) and PNC (4%). The imaging time for a 1.7 x 1.8 mm SRH image is ~100 s. The 10-fold cross validation demonstrated an overall accuracy of 92 % to predict the epigenetic subclasses. Using graph attention and integrated gradients we identified image pattern and neighborhood relationships associated with the different subclasses.

#### Conclusion

Here we present an AI-based prediction model of epigenetic molecular subtypes of glioblastoma based on intraoperative stimulated Raman imaging. The accuracy of the AI-based prediction of 92 % surpasses recently published classification results based on intraoperative sequencing. SRH imaging and AI-based image classification are fast and easily applicable during routine neurosurgical procedures and are therefore promising methods for intraoperative molecular diagnostics.

# Tumor – Diagnostik | Tumour – Diagnostics

## V012

### Analyse des GC-reichen TERT Promoters und des MGMT Methylierungsstatus in liquid biopsies - ein optimiertes Workflow für die Genomamplifikation von Einzelzellen und zellfreier DNA

***Analysis of GC-rich TERT promoter and MGMT methylation status in liquid biopsies – A modified workflow for whole genome amplification for single cells and cell-free DNA***

T. Mederer[1,2], D. Deuter[1,2], J. Vollmayr[1,2], S. Schachinger[1,2], J. Gludowatz[1,2], A. Pietryga-Krieger[1], N. O. Schmidt[1,2], M. Proescholdt[1,2]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Regensburg, Wilhelm-Sander Einheit Neuro-Onkologie, Regensburg, Deutschland

#### Objective

Liquid biopsies have shown promising results. However, due to low DNA quantity and quality, the methodology needs to be optimized for single cells and cell-free DNA while taking into account the necessities of neuro-oncological molecular pathology, i.e. analysis of GC-rich regions and epigenetic markers. Therefore, we aimed to optimize the Ampli1 Whole Genome Amplification Kit for better amplification of GC-rich regions, combining the method"s advantages of high fidelity, excellent genome coverage and low allelic dropouts with the analysis of GC-rich regions in single cells. Furthermore, we included methylation-sensitive digestion for epigenetic analyses and adapted this method for the use with cell-free DNA.

#### Methods

DMSO and betaine were tested for their improvement in amplification of GC-rich DNA fragments in the Ampli1 WGA protocol. Successful amplification of GC-rich fragments was evaluated by PCR with fragments up to 70% GC and amplicons up to 85% GC. The WGA protocol was modified to allow for addition of the methylation-sensitive Hin6I enzyme in the digestion step. For the adaptation of the protocol to cell-free DNA, an end-repair and dA-tailing step was tested prior to the ligation of a modified adapter to the short cell-free DNA fragments and their subsequent amplification.

#### Results

Conventional Ampli1 WGA failed to amplify DNA fragments above 60% GC content, while additives enabled the amplification of fragments up to 70% GC and the analysis of amplicons up to 80% GC. The inclusion of methylation-sensitive Hin6I digestion prior to adapter ligation and amplification allows for the analysis of ~ 300K CpG dinucleotides and 72K of the CpG dinucleotides in the Illumina EPIC 850K chip. MGMT methylation status was correctly analyzed in 100% of analyzed single GBM cells and PBLCs. Successful adaptation of the method for cell-free DNA by inclusion of DNA end repair and dA tailing resulted in ~ 2 µg of DNA for further analysis with 1 ng of input.

#### Conclusion

While existing methods for WGA of single cells perform well for the majority of assays, molecular analysis of certain neuro-oncological alterations in GC-rich regions (TERT promoter) and epigenetic changes are not feasible. With the adaptation of existing methodology, these analyses are possible on both single cells and cell-free DNA. Inclusion of betaine and methylation-sensitive enzymes enable the evaluation of methylation status of up to 300K CpG dinucleotides and genetic analysis of GC-rich regions by PCR and sequencing.

# Tumor – Diagnostik | Tumour – Diagnostics

## V013

### Diagnostisches Potential der Infrarot-Spektroskopie für Meningeompatienten – Machine Learning zur Prädiktion von WHO Grad und Methylierungsklasse

***Diagnostic potential of infrared spectroscopy for meningioma patients – Machine learning for prediction of WHO grade and methylation class***

F. Lehner[1], S. Richter[1,2], M. Meinhardt[2], T. Juratli[2], A. Temme[2], F. Sahm[3], M. Kirsch[4], I. Y. Eyüpoglu[2], O. Uckermann[1]

[1]TU Dresden, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Dresden, Deutschland
[3]Universitätsklinikum Heidelberg, Heidelberg, Deutschland
[4]Klinikum Chemnitz, Neurochirurgie, Chemnitz, Deutschland

#### Objective

Vibrational spectroscopy probes molecular vibrations within tissue, and allows optical brain tumor diagnosis. Here, we explored infrared (IR) spectroscopy as a translational technology for the identification of aggressive meningioma and evaluated its ability to detect WHO grade 3 anaplastic meningioma. In addition, we investigated whether the technology allows further classification of meningioma based on methylation classes as intermediate (MC int) or malignant (MC mal).

#### Methods

Unstained tissue frozen sections of 21 meningioma WHO 2 (14 MC int and 7 MC mal) and 26 meningioma WHO 3 (10 MC int and 16 MC mal) were examined. IR spectroscopic imaging was performed at three positions (170 x 170 µm, 16x16 = 256 spectra) in reference to HE histology. Data preprocessing involved baseline correction, area normalization, and dimensionality reduction via principal component analysis. A neural network (NN) classifier was trained and the class assignment for each sample of the test set (n=23) was calculated as average value of respective spectra.

#### Results

IR spectroscopic differences were more pronounced between WHO grade 2 and 3 than between MC int and MC mal, although similar spectral ranges were affected. Aggressive meningioma exhibited reduced bands of carbohydrates (C-O vibrations at 1024 $cm^{-1}$) and nucleic acids (symmetric stretching of $PO_2$- at 1080 $cm^{-1}$), along with increased bands of phospholipids (stretching of $PO^{2-}$ at 1240 $cm^{-1}$ and $CH_3$ bending at 1450 $cm^{-1}$). The NN classifier achieved effective classification for WHO grade (AUC 0.91) and MC (AUC 0.83), resulting in the correct classification of 21/23 meningioma of the test set for either WHO grade or MC. Misclassifications occurred in samples where the assessments of malignancy according to WHO grade and MC did not align.

#### Conclusion

IR spectroscopy proved capable of extracting information about the malignancy of meningioma tissue samples, not only according to the WHO grade, but also for a diagnostic system based on molecular tumor characteristics. In future clinical use, the goodness of the classification could be assessed by considering classification probabilities and cross-measurement validation. While this approach may incur the occasional challenge of non-ratable samples, it results in heightened reliability of the clinical information obtained. This might enhance the overall accuracy and clinical utility, reinforcing the potential of IR spectroscopy in advancing precision medicine for meningioma characterization.

# Tumor – Diagnostik | Tumour – Diagnostics

## V014

### Fluorescein-kontrastierte konfokale Laserendomikroskopie versus konventionelle Gefrierschnitte für das intraoperative histopathologische Assessment von intrakraniellen Tumoren

***Fluorescein-stained confocal laser endomicroscopy versus conventional frozen section for intraoperative histopathological assessment of intracranial tumors***

A. Wagner[1], M. C. Brielmaier[1,2], C. Kampf[1], L. Baumgart[1,3], A. K. Aftahy[1], H. S. Meyer[1,3], V. Kehl[4], J. Höhne[5,6], K. M. Schebesch[5,6], N. O. Schmidt[5], S. Zoubaa[7], M. Riemenschneider[7], M. Ratliff[8], F. Enders[8], A. von Deimling[9,10], F. Liesche-Starnecker[11], C. Delbridge[2], J. Schlegel[2], B. Meyer[1], J. Gempt[1,3]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Abteilung für Neuropathologie, München, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Abteilung für Neurochirurgie, Hamburg, Deutschland
[4]Klinikum rechts der Isar, Technische Universität München, Institute for AI and Informatics in Medicine, München, Deutschland
[5]Universitätsklinikum Regensburg, Abteilung für Neurochirurgie, Regensburg, Deutschland
[6]Paracelsus Medizinische Privatuniversität (PMU), Abteilung für Neurochirurgie, Nürnberg, Deutschland
[7]Universitätsklinikum Regensburg, Abteilung für Neuropathologie, Regensburg, Deutschland
[8]Universitätsmedizin Mannheim, Abteilung für Neurochirurgie, Mannheim, Deutschland
[9]Universitätsklinikum Heidelberg, Abteilung für Neuropathologie, Heidelberg, Deutschland
[10]Deutsches Krebsforschungszentrum (DKFZ), CCU Neuropathology, Heidelberg, Deutschland
[11]Universitätsklinikum Augsburg, Abteilung für Neuropathologie, Augsburg, Deutschland

#### Objective

The aim of this clinical trial was to compare Fluorescein-stained intraoperative confocal laser endomicroscopy (CLE) of intracranial lesions and evaluation by a neuropathologist with routine intraoperative frozen section (FS) assessment by Neuropathology.

#### Methods

In this phase II non-inferiority, prospective, multicenter, non-randomized, off-label clinical trial (Eudra-CT: 2019-004512-58), patients above the age of 18 years with any intracranial lesion scheduled for elective resection were included. The diagnostic accuracies of both CLE and FS referenced with the final histopathological diagnosis were statistically compared in a non-inferiority analysis, representing the primary endpoint. Secondary endpoints included the safety of the technique and time expedited for CLE and FS.

#### Results

210 patients were included by 3 participating sites between November 2020 and June 2022. Most common entities were high grade gliomas (37.9%), metastases (24.1%), and meningiomas (22.7%), A total of 6 serious adverse events in 4 (2%) patients were recorded. For the primary endpoint, the diagnostic accuracy for CLE was inferior with .87 versus .91 for FS, resulting in a difference of .04 (95% confidence interval -.10; .02; p=.367). The median time expedited until intraoperative diagnosis was 3 minutes for CLE and 27 minutes for FS, with a mean difference of 27.5 minutes (standard deviation 14.5; p<.001).

#### Conclusion

CLE allowed for a safe and time-effective intraoperative histological diagnosis with a diagnostic accuracy of 87% across all intracranial entities included. The technique achieved histological assessments in real-time with a tenfold reduction of processing time compared to FS, which may invariably impact surgical strategy on the fly.

# Tumor – Diagnostik | Tumour – Diagnostics

## V015

### Vergleichende miRNA-Analyse aus nativen Tumorgewebe, Primärkulturen und Liquid Biopsy von Meningeomen
***Comparative miRNA analysis from native tumor tissue, primary cultures, and liquid biopsy of meningioma***

S. Urbschat[1], M. Henia[1], H. Blatt[1], W. Schulz-Schaeffer[2], R. Ketter[1], J. Oertel[1]

[1]Uniklinikum Homburg/Saar, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Uniklinikum Homburg/Saar, Institut für Neuropathologie, Homburg a. d. Saar, Deutschland

#### Objective

Meningioma are often benign, but this is not always equivalent with the prognosis of a complete cure. MicroRNAs are small non-coding RNAs that represent promising biomarkers in Meningioma to classify treatment modalities.The miRNAs are not only located in cells and thus in the tumor but are also secreted into the blood. It is therefore of major interest to determine possible biomarkers e.g., in the form of miRNAs for meningioma to establish a tumor model system in relation to miRNAs using primary cell cultures. In addition, aberrations of chromosomal segments 22q11, 18q21, and 17p13 were determined, as these are also relevant to meningioma.

#### Methods

By real-time polymerase chain reaction, we investigated the expressions of four microRNA miRNA-21, miRNA-34a, miRNA-200a and miRNA-409 on native tumor tissue, primary cell cultures, and blood plasma of 20meningioma patients as well as in blood samples of 20 healthy individuals. The analysis of chromosomal aberrations of chromosomal segments 1p36, 14q24, and 17q22 was realized through FISH.

#### Results

A strong negative correlation was found between miRNA 34a expression in the blood plasma of meningioma patients and the deletion of 1p36. Furthermore, a strong positive correlation was detected between the 17p13 deletion and miRNA-34a expression in native tumor tissue. The primary cell culture is not suitable as a model system with respect to miRNAs. In contrast, miRNA-34a is a potential candidate to be used as a biomarker for 1p36 deletion due to the correlation between its expression in blood plasma and the loss of 1p36 in native tumor tissue.

#### Conclusion

MiRNA-34a is a promising candidate biomarker in meningioma, correlating with blood expression and loss of 1p36. In addition, MiRNA-34a correlates to its expression in native tumor tissue and to the loss of 17p13, which is linked to the tumor suppressor p53 and has been linked to recurrence.

# Tumor – Diagnostik | Tumour – Diagnostics

## V016

### Liquid biopsies bei Meningeomen - Plasma zellfreie DNA als potentieller Biomarker für die Tumorlast bei Meningeomen

***Liquid biopsies in meningioma – plasma cell-free DNA as a potential biomarker for meningioma tumor burden***

T. Mederer[1,2], D. Deuter[1,2], J. Vollmayr[1,2], S. Schachinger[1,2], J. Gludowatz[1,2], C. Jungbauer[3], A. Pietryga-Krieger[1], N. O. Schmidt[1,2], M. Proescholdt[1,2]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Regensburg, Wilhelm-Sander Einheit Neuro-Onkologie, Regensburg, Deutschland
[3]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland

#### Objective

Meningiomas are the most common primary brain tumors, and mostly of benign character. The current gold standard for the diagnosis and monitoring of meningiomas involves MRI scans and tissue resection or biopsy with histopathological examination of the tumor tissue. Currently, there are no established circulating biomarkers in meningioma patients. Only few studies have analyzed liquid biopsies for meningiomas. Some circulating biomarkers in blood and/or cerebrospinal fluid (CSF) have been identified, such as signatures of non-coding RNAs, microRNAs or serum proteins for tumor grade estimation, however the role of cell-free DNA in meningioma patients and its correlation with tumor characteristic, such as tumor burden, has not yet been sufficiently evaluated.

#### Methods

Plasma samples from patients undergoing meningioma resection were prospectively collected starting in April 2022. After a two-step centrifugation step, cell-free DNA was extracted from 3-4 ml blood plasma using the QIAamp Circulating Nucleic Acid Kit (Qiagen). DNA quantity was measured with the Qubit High Sensitivity DNA Kit (Thermo Fisher Scientific). Relative cell-free DNA quantity was calculated as the ratio of total amount of DNA and total volume of plasma used for DNA extraction. Overall tumor burden was measured by volumetric analysis of patients" tumors using the SmartBrush tool in the Brainlab navigation software on T1 weighted MRI images with contrast enhancement. Patients with a tumor burden of at least 5 cm3 were included in this study.

#### Results

Plasma of n=20 patients were analyzed for quantity of cell-free DNA and its correlation to clinical variables. Relative DNA quantities ranged from 4.8 to 50.8 ng/ml plasma, while tumor burden ranged from 5 to 99 cm3. Correlation of tumor burden and relative plasma cell-free DNA quantity was strong (r=0.6028, p=0.0038, Spearman" rank correlation), while WHO grading or occurrence of seizures did not associate with elevated plasma cell-free DNA quantities (p>0.05).

#### Conclusion

Plasma cell-free DNA quantity in meningioma patients strongly correlates with overall tumor burden, irrespective of WHO grading or occurrence of seizures in patients with a tumor burden of 5 cm3 or greater. Further longitudinal studies with larger collectives and genetic analyses are warranted to evaluate the translational potential of cell-free DNA in meningioma patients.

# Tumor – Vestibularisschwannome 1 | Tumour – Vestibular schwannomas 1

## V017

### Die immunhistochemische Expression von COX2 in Vestibularisschwannomen ist mit der Infiltration durch M2-Makrophagen, einer stärkeren Proliferation und ausgedehnterer Tumorgröße verbunden.

***Immunohistochemical expression of COX2 in vestibular schwannomas is associated with the infiltration by M2 macrophages, increased proliferation and bigger tumor size***

L. Dörner[1], E. M. Suhm[1], V. Ries[1], J. Schittenhelm[2], M. Tatagiba[1], F. Behling[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland

### Objective

There is increasing evidence for the involvement of inflammatory processes in the genesis and growth of vestibular schwannomas. COX2 has been shown to be highly expressed in vestibular schwannomas and its role in tumor progression and as a potential therapy target are frequently discussed. However, the role of COX2 in vestibular schwannoma is still poorly understood.

### Methods

We analyzed the expression of COX2 and markers for macrophage (CD163 and CD68) and lymphocyte infiltration (CD3 and CD8) in 1065 vestibular schwannoma tumor samples. Semiquantitative scoring systems were applied for the assessment of COX2, CD163 and CD68 expression while CD3 and CD8 immunopositivity was quantified via manual counting. Furthermore, clinical data was included in the uni- and multivariate analyses. .

### Results

An increased COX2 expression was associated with more extensive macrophage infiltration in vestibular schwannoma samples (CD68 and CD163 each $p<0.0001$). Additionally, lymphocyte detection was also higher in tumors with higher COX2 immunopositivity (CD3 and CD8 each $p<0.0001$). Furthermore, with each higher score for COX2 expression the infiltration with lymphocytes and macrophages increased significantly ($p<0.0001$).

### Conclusion

The extent of COX2 expression in vestibular schwannomas is clearly correlated with increased infiltration with lymphocytes and macrophages reflecting inflammatory processes.

# Tumor – Vestibularisschwannome 1 | Tumour – Vestibular schwannomas 1

## V018

### Prädiktive Faktoren für die Strahlenresistenz und frühzeitige Erkennung eines Tumorrezidivs nach Gamma-Knife Radiochirurgie bei Vestibularisschwannome: eine retrospektive Kohortenstudie

***Prediction of radioresistance and early identification of tumor relapse after Gamma-Knife radiosurgery in vestibular schwannomas: A retrospective cohort study***

L. Fabbrocini[1], H. Hurth[2], G. Horstmann[3], F. H. Ebner[4]

[1]Alfried-Krupp-Krankenhaus Essen, Neurochirurgie, Essen, Deutschland
[2]Eberhard-Karls Universität Tübingen, Neurochirurgie, Tübingen, Deutschland
[3]Gamma Knife Zentrum, Krefeld, Deutschland
[4]Alfried-Krupp-Krankenhaus Essen, Neurochirurgie, Essen, Deutschland

#### Objective

As microsurgical resection after failed radiosurgery is associated with higher morbidity in patients with vestibular schwannoma (VS), the identification of factors that may influence radioresistance plays a critical role. Additionally, differentiating between treatment-related changes (pseudoprogression) and tumor relapse (TR) can often be challenging. This study aims to identify radioresistance predicting factors and, secondly, to differentiate pseudoprogression from TR at an early stage.

#### Methods

A cohort of 705 patients with unilateral sporadic vestibular schwannoma who underwent stereotactic radiosurgery (SRS) at the same center from 1998 to 2020 was retrospectively analyzed. Clinical data concerning symptoms, tumor volume (Hannover and OHATA Classification), side effects of SRS were recorded. Of these patients, 598 achieved remission while 107 experienced TR and required a second treatment, either microsurgical resection or SRS.

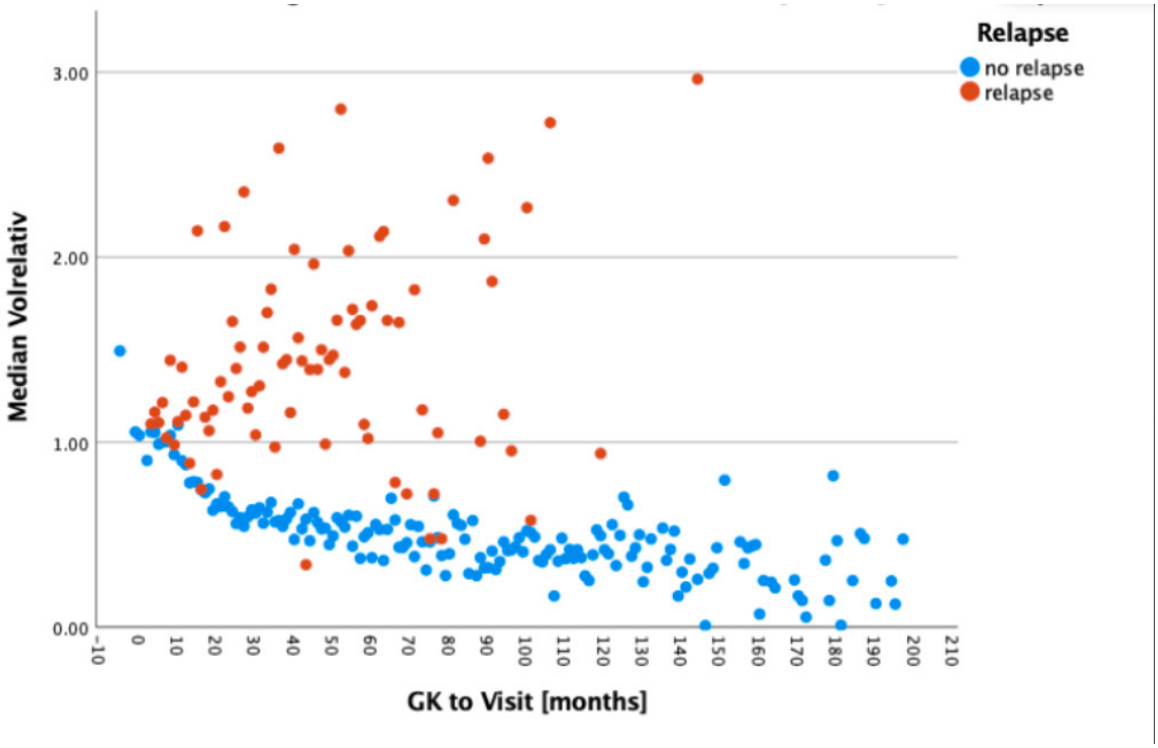
#### Results

In our cohort, TR was significantly higher in women ($p<0.05$). However, clinical symptoms such as facial palsy, hypoacusis, tinnitus, and vertigo, as well as tumor volume and tumor configuration (cystic vs solid), were not predictive factors for radioresistance. Patients who experienced TR had significantly more side effects of SRS (20.6% vs 8.4%, $p<0.001$), particularly regarding facial spasm ($p<0.001$). A higher risk of facial spasm was significantly related to OHATA-Class (A>B>C>D). An earlier recurrence was observed in cystic tumors. The average follow-up period was 4 years for the recurrence group and 7 years and 10 months for the remission group. Regarding the trend of relative and absolute tumor volumes, a significant difference ($p<0.001$) was observed between patients with and without TR. This became noticeable at 12 months and even more evident at 24 months after SRS. In this time frame, patients without TR had a decrease in volume, while patients with TR showed an increase.

#### Conclusion

Clinical symptoms, tumor volume, and tumor configuration are not predictive factors of TR. Only female sex predisposes to an increased risk of TR. Patients with TR experience significantly higher side effects of SRS, particularly facial spasm. TR is strongly suspected at 12 months and even more at 24 months after SRS if there is a further increase in absolute and relative tumor volume, making pseudoprogression unlikely.

Abb. 1


Relapse
no relapse
relapse
Median Volrelativ
3.00
2.00
1.00
0.00
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
GK to Visit [months]

# Tumor – Vestibularisschwannome 1 | Tumour – Vestibular schwannomas 1

## V022

### Postoperativer Pneumozephalus nach Operationen der hinteren Schädelgrube in halbsitzender Position - Vergleich von intrakranieller Luftmenge und klinischem Outcome abhängig vom operativen Zugangsweg mittels voxelbasierter Volumetrie

***Postoperative pneumocephalus after posterior fossa surgeries in the semi-sitting position – Comparison of intracranial air collections and clinical outcome according to the surgical approach by means of voxel-based volumetry***

H. Hurth[1], K. Machetanz[1], F. H. Ebner[1,2], E. Clement[1,3], B. Drexler[3], M. Tatagiba[1], G. Naros[1]

[1]Universitätsklinikum Tübingen, Neurochirurgie, Tübingen, Deutschland
[2]Alfried-Krupp-Krankenhaus Essen, Neurochirurgie, Essen, Deutschland
[3]Universitätsklinikum Tübingen, Anästhesie, Tübingen, Deutschland

#### Objective

To assess the extent and distribution of postoperative pneumocephalus in patients undergoing posterior fossa surgery in the semi-sitting position after midline vs. lateral surgical approaches.

#### Methods

In a retrospective analysis 465 patients who underwent posterior fossa surgery in the semi-sitting position were included. Patients" individual postoperative CCT scans were registered and normalized to the common MNI space. Intraventricular, subdural, and total intracranial air were measured by voxel-based volumetry and compared between patient groups according to the surgical approach. Clinical details such as age, duration of surgery and outcome were evaluated.

#### Results

Indication for surgery was resection of a posterior fossa tumor in 95.9% (n=446) of which 69.0% were vestibular schwannomas and 18.1% meningiomas. A lateral suboccipital (LA) and a midline suboccipital approach (MA) were performed in 92.0% (n=428) and in 8.0% (n=37), respectively. The total intracranial air volume (38ml vs. 29ml, p=0.049) and the intraventricular air volume (9.2ml vs. 0.0ml, p<0.001) were significantly higher in MAs. Clinically relevant tension pneumocephalus (TP) was present in a total of 3.0% of patients (n=14), which was treated by frontal air exchange with saline in 64.3% (n=9) and external ventricular drainage (EVD) in 35.7% (n=5). TP occurred significantly more often in MAs (10.8%) than in LAs (2.3%; p=0.019). Air replacement was performed via EVD in all cases of TP after a MA and via a frontal twist-drill in 90% of TP cases after a LA. In two patients, revision surgery was necessary after air exchange. No permanent disabilities occurred due to air replacement therapy. A weak correlation was found between total intracranial air and age (ρ=0.28, p<0.001) as well as time to extubation (ρ=0.1, p=0.026). A weak negative correlation was found between intraventricular air and BMI (ρ=-0.15, p=0.001). No association was detected between air volumes and duration of surgery, ICU or inpatient stay or postoperative Karnofsky index.

#### Conclusion

MAs harbor a significantly higher risk of clinically relevant TP than LAs. These patients usually showed intraventricular air requiring external ventricular drainage as opposed to more frequent subdural air collections in LAs. Overall outcome was good even in patients requiring air replacement indicating that, if treated subsequently, the semi-sitting position can be safely performed in patients with midline pathologies.

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V023

### Erwartungen an eine Hydrozephalus-Behandlung: Ein Vergleich zwischen Betreuungsperson und Chirurg
*Expectations of hydrocephalus treatment: A comparison between primary caregiver and surgeon*

S. Al Omari[1], M. P. Meier[1], J. Lehmberg[1]

[1]München Klinik Bogenhausen, Neurochirurgie, München, Deutschland

### Objective

The outcome of surgical treatment depends strongly on patients" expectations. Although optimal management of idiopathic normal pressure hydrocephalus (iNPH) by central nervous system shunt placement is evident, symptom response rates are variable. The aim of this study was to investigate the expectations of patients' relatives and treating surgeons regarding the iNPH treatment outcome.

### Methods

Following ethics committee approval in December 2021, patients diagnosed with iNPH and selected for CNS shunt surgery were considered for inclusion in this prospective longitudinal clinical trial. iNPH symptoms were assessed using well-established grading scales (iNPH grading scale; Kiefer score) at baseline and follow-up. Similarly, primary caregivers, neurosurgical residents, and neurosurgeons recorded their expectations regarding the presumed outcome of surgical treatment. Expectations were correlated with outcome data, and statistical analyses were performed using the Pearson correlation test and Wilcoxon signed-rank test. Additionally, factors that might influence the accuracy of expectations, such as age, gender, education level, Charlson comorbidity index, duration of symptoms, and adverse events, were assessed.

### Results

Since January 2022, 25 iNPH patients were screened, with 20 eligible for study participation (55% male, median age 73.1 years). All underwent ventriculoperitoneal shunt placement. Median follow-up at 57.1 days showed significant symptom improvement ($p<0.001$). Using the Pearson correlation test, the expectations of neurosurgeons and residents showed a strong correlation with postoperative outcomes ($r=0.74$; $r=0.64$), whereas the expectations of primary caregivers correlated less strongly ($r=0.61$). A Wilcoxon test revealed a significant difference between expectations of primary caregivers and actual postoperative outcomes ($p=0.001$). In contrast, neurosurgeons' and residents' expectations showed no significant difference compared to postoperative outcomes ($p > 0.05$), indicating an agreement between expectations and treatment outcomes.

### Conclusion

Our results underline that shunt placement improves symptoms in iNPH patients. Surgeons and patients' relatives have different expectations regarding the outcome following shunt surgery. The patients" relatives had much more optimistic expectations than the surgeons. These findings emphasize the importance of realistic expectations and aim to encourage better communication among surgeons and patients and their relatives.

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V024

### Verbesserung der Ergebnisse von Shunt-Operationen und Vorhersage der Shunt-Reaktion bei iNPH mit KI: Versprechen und Herausforderungen prädiktiver Modelle

***Enhancing shunt surgery outcomes and predicting shunt response in iNPH with AI: Promises and challenges of predictive models***

S. G. Thavarajasingam[1,2], R. T. Fernandes[2], M. El-Khatib[2], D. S. C. Ramsay[2], D. Jankovic[1], A. Kramer[1], F. Ringel[1]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich

#### Objective

Idiopathic normal pressure hydrocephalus is a chronic neurological disorder and a known reversible cause of dementia. Shunt surgery remains the standard treatment, but its effectiveness is variable. Recent advancements in artificial intelligence (AI) offer the potential to refine shunt response prediction by analysing vast amounts of data. We aimed to assess the uses, methological rigour and performance of current models.

#### Methods

This systematic review aimed to evaluate the efficacy of artificial intelligence in predicting shunt response (SR) in iNPH. A systematic search of the literature was conducted in MEDLINE, EMBASE and Web of Science to identify studies that employed AI or machine learning (ML) algorithms for shunt response prediction in iNPH. Original articles published from inception until September 2023 were included. Qualitative synthesis followed the Synthesis Without Meta-Analysis (SWiM) reporting guidelines.

#### Results

The initial search identified 3541 studies from which 33 were assessed for eligibility. 8 studies were included, featuring 479 patients. Sample size (with follow-up) ranged from 28 to 132 patients. Each model incorporated different input data, the most common being imaging/radiomics (62.5%), followed by demographic inputs (37.5%). The most used ML algorithm was the Support Vector Machine (87.5%). 2 articles (25%) implemented multiple machine learning algorithms with the aim of assessing their relative effectiveness. All studies employed cross-validation techniques as a validation method. Only half (4/8) of the articles reported AUC, which ranged from 0.80 to 0.94. However, the predefined outcome measures were not consistently reported in every article, highlighting the heterogeneity and the lack of quantitative data to compare each model, in addition to the high risk of bias and unclear applicability of some models.

#### Conclusion

While AI holds significant promise for improving the diagnosis and management of iNPH, it requires standardized data and more extensive validation studies for each model, which in turn requires a homogenous approach of iNPH management. Besides coming to a field-wise consensus, to enhance clinical utility, future research should focus on developing more robust and generalizable AI models. The potential benefits for patients are clear, including improved diagnostic accuracy and personalized treatment strategies.

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V025

### Der Einfluss telemetrischer Shuntsensoren auf die Behandlung komplexer Hydrocephlus-Patienten mit chronischer Überdrainage oder dysmorphen Ventrikelsystem.

***The impact of telemetric sensor implantations in complex hydrocephalus patients with chronic overdrainage or distorted ventricles***

S. Senger[1], F. Awamleh[1], M. Hülser[1], F. Teping[1], S. Linsler[1], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

Children with shunt dependency suffer the risk of overdrainage related complications in their future live. Neurosurgeons have to take care of patients from the pre-anti-syphon area. Those young adults can suffer from chronic overdrainage and slit ventricles. The implantation of telemetric sensor devices have been successfully established for the shunt therapy. We evaluated our results from those sensor in a cohort of young adults with dysmorphic ventricles

#### Methods

A retrospective analysis of the patient cohort with telemetric shunt sensor devices (n=145) in our department was performed. We included patients that received their first shunt as infants from 1973 to 1999. The inclusion criteria were distorted ventricles including slit ventricles and a change to adjustable valves and anti-syphon devices.

#### Results

We could identify 25 patients in total, six were lost to follow-up after less than 12 months. Main symptoms were unstable clinical course (n=14) and cephalgia (n=9). After sensor implantation and according valve adjustments 12 of 19 patients reached a stable course and significant reduced symptoms in the follow-up (mean 49 months). The amounts of MRIs could be reduced after the sensor implantations (35 vs. 91). Also, the frequency of appointments was reduced (312 vs 428).

#### Conclusion

Telemetric shunt sensors are a versatile tool for the long term follow up and treatment of complex cases of hydrocephalus. The measurement can be performed quick and easy in the outpatient clinic and supports the decision making process and reduces the need for imaging controls.

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V026

### Langzeit-Nachverfolgung beim Normaldruckhydrocephalus
*Long-term follow-up in normal pressure hydrocephalus*

L. H. Stieglitz[1], F. Kuser[1], S. Fernandes Sargento Dias[1]

[1]Kinderspital Zürich, Klinik für Neurochirurgie, Zürich, Schweiz

### Objective

Normal pressure hydrocephalus (iNPH) is characterized by a slowly progressive clinical triad of gait disorder, cognitive decline and urinary incontinence combined with ventricular dilation. Studies on short-term outcome after ventriculoperitoneal shunt implantation have shown a clinically significant improvement in 80 to 85% of patients after surgery. However, long-term results have rarely been published.

### Methods

A consecutive series of 165 patients (mean age 74.7 ± 7.4 years) treated by a single surgeon with a ventriculoperitoneal (VP) shunt between 2012 und February 2023 at the neurosurgical department of University Hospital Zurich with mean preoperative DESH score of 6.8 ± 2.7 were included in this retrospective study. They were followed without limit yearly or more frequently in case of need. Preoperative patient selection was based on clinical evaluation, radiological findings, and CSF dynamic supplemental tests. Outcomes were assessed using the Kiefer Scale and the NPH-Recovery Rate (NPH-RR). Secondarily, the number of steps needed for 180° turn as a measure of gait disturbance, the Montreal Cognitive Assessment (MoCA) score as a measure of cognitive decline and continence of patients were recorded preoperatively and at the last follow-up.

### Results

The mean preoperative Kiefer Score was 7.3 ± 3.1, significantly higher than the Kiefer Score 6 months, 1, 2, 3, 4, 5 ($p < 0.001$) and 6 years ($p = 0.006$) after shunting procedure. The lowest Kiefer Score of 2.9 ± 2.7 was reached one year postoperatively with subsequent continuous slight increase to 4.1 ± 2.6 at the 6-year postoperative follow-up. The NPH-RR in the first 3 years after shunting procedure was greater than 5 and therefore representing a good clinical outcome. The number of steps for 180° turn decreased from 4.4 ± 1.9 preoperatively to 2.8 ± 1.6 postoperatively. 28 of 165 patients (17.0 %) underwent MoCA testing both pre- and postoperatively, with 9 patients (32.1 %) showing significant improvement. The proportion of urinary incontinent patients decreased from 70.4 % to 29.6 %.

### Conclusion

Patients with iNPH benefit significantly from shunt therapy up to 6 years postoperatively, with improvements noted among all components of the clinical triad.

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V027

### Ein Vergleich der Wirksamkeit und Sicherheit von Liquor-Shunt- und -Umleitungsverfahren bei idiopathischem Normaldruckhydrozephalus (iNPH): Eine Meta-Analyse

***A comparison of efficacy and safety of CSF shunting and diversion procedures in iNPH: A Meta-Analysis***

S. G. Thavarajasingam[1,2], A. Salih[2], M. El-Khatib[2], D. Jankovic[1], A. Kramer[1], F. Ringel[1]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich

#### Objective

Idiopathic normal pressure hydrocephalus (iNPH) is commonly treated using various cerebrospinal fluid (CSF) diversion procedure including ventriculo-peritoneal, ventriculo-atrial (VA), lumbo-peritoneal (LP) shunting, and endoscopic third ventriculostomy (ETV). Despite the prevalence of these interventions, there is limited comparative data on their efficacy and revision and complication rate over time.

#### Methods

EMBASE, MEDLINE and Scopus were screened for studies investigating CSF shunting of iNPH patients. A meta-analysis and regression analyses were conducted with the primary outcome being shunt response, and secondary outcomes were complication rates and rate of surgical revisions between different shunt types.

#### Results

Out of the 1749 studies screened, 56 were included in this review. 5,624 patients were pooled in this meta-analysis. Overall, more than 70% of patients experienced improvement after surgical treatment ($p<0.05$). LP shunt demonstrated the highest efficacy at 74% ($p<0.01$), followed VP shunt at 72% ($p<0.01$). ETV exhibited the lowest success rate at 67%. Complication rates were however lowest for ETV (19%), but highest for VP (17%) and LP shunt (16%). Revision rates were lowest for VP shunt (12%), and highest for ETC (19%). The efficacy of CSF shunting was found to have significantly increased between 2005 and 2023 ($p<0.05$).

#### Conclusion

This meta-analysis underscores the overall efficacy of CSF diversion procedures in managing iNPH, with a substantial majority of patients reporting symptomatic improvement. The comparative analysis reveals that while no CSF diversion technique significantly outperforms others in terms of outcomes, ETV is associated with a lower success rate. Moreover, the trend of increasing efficacy over the studied period suggests improvements in surgical techniques or patient selection. This study aids in informing clinical decisions in iNPH patients and highlights the benefit of continued refinement of iNPH treatment protocols.

#### Abb. 1

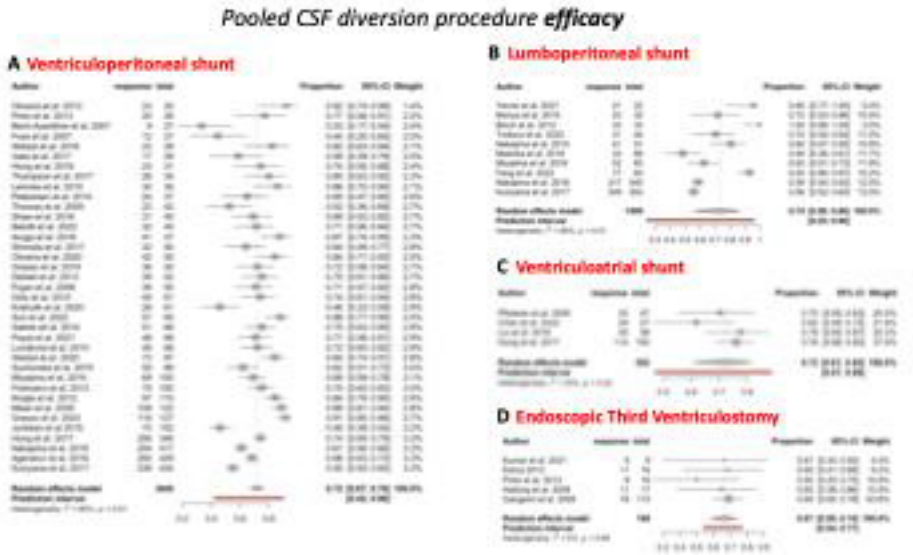
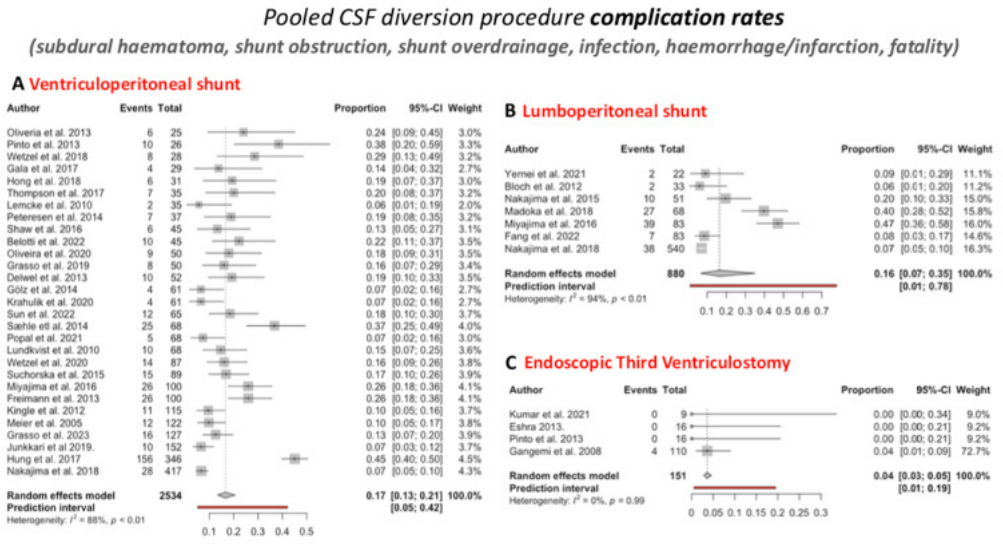

Pooled CSF diversion procedure efficacy
A Ventriculoperitoneal shunt
B Lumboperitoneal shunt
C Ventriculoatrial shunt
D Endoscopic Third Ventriculostomy

Abb. 2


Pooled CSF diversion procedure complication rates
(subdural haematoma, shunt obstruction, shunt overdrainage, infection, haemorrhage/infarction, fatality)
A Ventriculoperitoneal shunt
Author Events Total Proportion 95%-CI Weight
Oliveria et al. 2013 6 25 0.24 [0.09; 0.45] 3.0%
Pinto et al. 2013 10 26 0.38 [0.20; 0.59] 3.3%
Wetzel et al. 2018 8 28 0.29 [0.13; 0.49] 3.2%
Gala et al. 2017 4 29 0.14 [0.04; 0.32] 2.7%
Hong et al. 2018 6 31 0.19 [0.07; 0.37] 3.0%
Thompson et al. 2017 7 35 0.20 [0.08; 0.37] 3.2%
Lemcke et al. 2010 2 35 0.06 [0.01; 0.19] 2.0%
Peteresen et al. 2014 7 37 0.19 [0.08; 0.35] 3.2%
Shaw et al. 2016 6 45 0.13 [0.05; 0.27] 3.1%
Belotti et al. 2022 10 45 0.22 [0.11; 0.37] 3.5%
Oliveira et al. 2020 9 50 0.18 [0.09; 0.31] 3.5%
Grasso et al. 2019 8 50 0.16 [0.07; 0.29] 3.4%
Delwel et al. 2013 10 52 0.19 [0.10; 0.33] 3.5%
Gölz et al. 2014 4 61 0.07 [0.02; 0.16] 2.7%
Krahulik et al. 2020 4 61 0.07 [0.02; 0.16] 2.7%
Sun et al. 2022 12 65 0.18 [0.10; 0.30] 3.7%
Sæhle et al. 2014 25 68 0.37 [0.25; 0.49] 4.0%
Popal et al. 2021 5 68 0.07 [0.02; 0.16] 3.0%
Lundkvist et al. 2010 10 68 0.15 [0.07; 0.25] 3.6%
Wetzel et al. 2020 14 87 0.16 [0.09; 0.26] 3.8%
Suchorska et al. 2015 15 89 0.17 [0.10; 0.26] 3.9%
Miyajima et al. 2016 26 100 0.26 [0.18; 0.36] 4.1%
Freimann et al. 2013 26 100 0.26 [0.18; 0.36] 4.1%
Kingle et al. 2012 11 115 0.10 [0.05; 0.16] 3.7%
Meier et al. 2005 12 122 0.10 [0.05; 0.17] 3.8%
Grasso et al. 2023 16 127 0.13 [0.07; 0.20] 3.9%
Junkkari et al 2019. 10 152 0.07 [0.03; 0.12] 3.7%
Hung et al. 2017 156 346 0.45 [0.40; 0.50] 4.5%
Nakajima et al. 2018 28 417 0.07 [0.05; 0.10] 4.3%
Random effects model 2534 0.17 [0.13; 0.21] 100.0%
Prediction interval [0.05; 0.42]
Heterogeneity: $I^2$ = 88%, $p$ < 0.01
0.1 0.2 0.3 0.4 0.5
B Lumboperitoneal shunt
Author Events Total Proportion 95%-CI Weight
Yernei et al. 2021 2 22 0.09 [0.01; 0.29] 11.1%
Bloch et al. 2012 2 33 0.06 [0.01; 0.20] 11.2%
Nakajima et al. 2015 10 51 0.20 [0.10; 0.33] 15.0%
Madoka et al. 2018 27 68 0.40 [0.28; 0.52] 15.8%
Miyajima et al. 2016 39 83 0.47 [0.36; 0.58] 16.0%
Fang et al. 2022 7 83 0.08 [0.03; 0.17] 14.6%
Nakajima et al. 2018 38 540 0.07 [0.05; 0.10] 16.3%
Random effects model 880 0.16 [0.07; 0.35] 100.0%
Prediction interval [0.01; 0.78]
Heterogeneity: $I^2$ = 94%, $p$ < 0.01
0.1 0.2 0.3 0.4 0.5 0.6 0.7
C Endoscopic Third Ventriculostomy
Author Events Total Proportion 95%-CI Weight
Kumar et al. 2021 0 9 0.00 [0.00; 0.34] 9.0%
Eshra 2013. 0 16 0.00 [0.00; 0.21] 9.2%
Pinto et al. 2013 0 16 0.00 [0.00; 0.21] 9.2%
Gangemi et al. 2008 4 110 0.04 [0.01; 0.09] 72.7%
Random effects model 151 0.04 [0.03; 0.05] 100.0%
Prediction interval [0.01; 0.19]
Heterogeneity: $I^2$ = 0%, $p$ = 0.99
0 0.05 0.1 0.15 0.2 0.25 0.3

# Hydrozephalus – Verschiedenes | Hydrocephalus – Various

## V028

### Klinisches Langzeitoutcome bei idiopathischem Normaldruckhydrocephalus (iNPH) nach Liquor-Shunt: Ist langfristige Besserung häufig oder außergewöhnlich?

***Clinical long-term outcome in idiopathic normal pressure hydrocephalus (iNPH) after CSF shunt surgery: Is long-term improvement common or exceptional?***

S. Smoly[1], J. Shawarba[1], A. Reinprecht[1], K. Rössler[1]

[1]Medizinische Universität Wien, Wien, Österreich

#### Objective

Long-term efficacy of cerebrospinal fluid (CSF) shunt surgery in idiopathic normal pressure hydrocephalus (iNPH) patients is differently reported. The aim of this study was to assess responsiveness, symptom improvement and long-term outcome after shunt surgery.

#### Methods

Altogether, 307 shunted patients with improved Hakim symptoms after preoperative test CSF diversion were retrospectively investigated. Ventriculo-atrial (in 26.1%) or ventriculo-peritoneal (in 73.9%) shunts and anti-siphon devices (in 22.8%) were used. Epidemiological data were retrospectively assessed using hospital records and telephone interviews (59.9 months mean follow up, FU).

#### Results

Patient age at the time of shunt surgery was 70.3 mean ± 9.0 years. 18 patients were lost to FU. Of the remaining 289 cases, 253 (87.5%) showed postoperative symptom improvement, and 36 patients (12.5%) did not respond to shunt surgery. Most frequent symptom prior to surgery was gait disturbance (99.4%) followed by cognitive impairment (80.6%) and urinary incontinence (69.3%). A complete Hakim's Triad was present in 60.2%. Postoperative symptom improvement was observed in 80.6%, 46.9%, and 40.8% for gait disturbance, cognitive impairment, and urinary incontinence respectively. Improvement of all three symptoms was seen in 25.6%. Average duration of symptom improvement was 51.5 months (4.3 yrs, from 0 to 21 yrs), 56% had continuing improvement of symptoms after 10 years of FU. Mean number of valve pressure changes was 2.36 ± 2.08. Older patients had significantly shorter duration of symptom improvement ($p < .001$). Neither comorbidity nor longer symptom duration were statistically significant negative shunt outcome predictors. Overall surgical complication rate was 17.3%, shunt infection rate was 3.3%, and shunt revision rate 14.9%, mostly due to shunt dislocation and/or dysfunction.

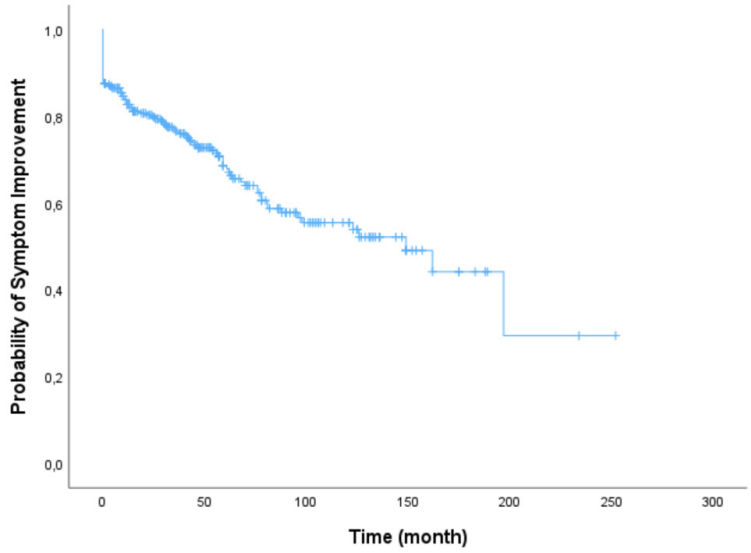
#### Conclusion

Surgical CSF diversion by implanting shunt systems is an effective and long-lasting treatment method for iNPH, especially concerning the improvement of gait, with up to 21 years symptom improvement in our study. However, surgical complications are common and shunt revision surgery rate was found higher than commonly expected.

Abb. 1

| | | |
|---|---|---|
| Male | 181 | 58.6 % |
| Female | 128 | 41.4 % |
| Age (years old) | 70.1 ± 9.6 | |
| VA-Shunt | 80 | 26.1 % |
| VP-Shunt | 227 | 73.9 % |
| Shunt assistant device | 70 | 22.8 % |
| Mean FU in months | 59.9 | |
| No FU | 18 | 5.9 % |
| < 1 yr. FU | 41 | 13.4 % |
| 1 – 2 yrs. FU | 33 | 10.7 % |
| 2 – 4 yrs. FU | 64 | 20.8 % |
| 4 – 6 yrs. FU | 55 | 17.9 % |
| 6 – 8 yrs. FU | 30 | 9.8 % |
| 8 – 10 yrs. FU | 20 | 6.5 % |
| > 10 yrs. FU | 46 | 15.0 % |
| Gait disturbance | 305 | 99.3 % |
| Cognitive impairment | 247 | 80.5 % |
| Urinary incontinence | 213 | 69.4 % |
| Complete Hakim's Triad | 185 | 60.3 % |
| Improvement of gait disturbance | 247 | 80.5 % |
| Improvement of cognitive impairment | 143 | 46.6 % |
| Improvement of urinary incontinence | 125 | 40.7 % |
| Improvement of all three symptoms | 78 | 25.4 % |
| Mean duration of symptom improvement in months | 51.5 | |
| Mean number of valve pressure changes | 2.36 ± 2.08 | |
| Surgical complication rate | | 17.3 % |
| Shunt infection rate | | 3.3 % |
| Shunt revision rate | | 14.9 % |

Abb. 2



# Trauma und Neurointensiv – Verschiedenes 1 | Neurointensive – Various 1

# V029

## Ein neues experimentelles Modell zur Untersuchung von spreading depolarizations bei zerebraler Hypoperfusion im gyrenzephalen Gehirn

***A novel experimental model to study spreading depolarizations under cerebral hypoperfusion in the gyrencephalic brain***

L. Wessels[1], S. Major[1], A. Liotta[2], J. Woitzik[3], P. Drömer[3], J. P. Dreier[1], N. Hecht[4]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurologie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Klinik für Anästhesiologie, Berlin, Deutschland
[3]Carl-von-Ossietzky Universität Oldenburg, Klinik für Neurochirurgie, Oldenburg, Deutschland
[4]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland

### Objective

The effect of cerebral hypoperfusion on the development of Spreading Depolarization (SD) has not yet been determined. Here, we developed a novel swine model of endovascular, intracranial vessel occlusion without acute infarction for simulation of reversible cerebral hypoperfusion.

### Methods

Twelve female landrace swine were anesthetized and mean arterial blood pressure was targeted at 60-80mmHg. Bilateral iliac artery punctures were performed and two 8F angiographic sheaths were inserted. Using 2D angiographic guidance, balloon catheters were positioned within both carotid arteries directly proximal to the main feeding trunk of the porcine rete mirabilis. Next, the animals were repositioned prone and a bilateral craniectomy was performed. The dura was excised and a Laser Speckle Imaging (LSI) device was positioned for continuous recording of cortical perfusion. With angiographic control, a baseline LSI perfusion measurement (60 min) was obtained, followed by LSI during unilateral (60 min) and bilateral (60 min) occlusion and subsequent reperfusion (60 min).

### Results

In 9/12 animals (75%), a total number of 51 SD-associated hemodynamic response patterns were recorded during a recording time of 2.880 hours. The mean SD propagation velocity was 3.2±0.9mm/min across a propagation area of 90±40mm2. The mean SD numbers were 0.42±1.7 SDs/h at baseline, 0.17±0.39 SDs/h during unilateral occlusion, 2.58±3.5 SDs/h during bilateral occlusion and 1.08±2.8 SDs/h during reperfusion (p=0.058, one way ANOVA).

### Conclusion

Endovascular balloon occlusion proximal to the porcine rete mirabilis can reliably trigger SD activity in the gyrencephalic brain, which may help to unravel the pathophysiology of TIA in patients suffering chronic cerebral ischemia.

# Trauma und Neurointensiv – Verschiedenes 1 | Neurointensive – Various 1

## V030

### Prädiktiver Score zur Vorhersage postoperativer Komplikationen nach elektiven Kraniotomien
*Prediction score for postoperative complications after elective craniotomies*

E. Kurz[1], D. Kalasauskas[1], D. Wesp[1], H. Krenzlin[1], A. Schulze[2], M. Bulut[1], T. Kerz[1], F. Ringel[1], N. Keric[1]

[1]Universitätsmedizin Mainz, Neurochirurgie, Mainz, Deutschland
[2]Institut für Medizinische Biometrie, Epidemiologie und Informatik, Mainz, Deutschland

#### Objective

Postoperative complications that need to be monitored after elective craniotomies occur in about 2% of cases. In most neurosurgical departments, an elective craniotomy is routinely followed by a postoperative monitoring in an intensive or intermediate care unit (ICU; IMC). However, there is no systematic allocation to this procedure; patients at risk postoperative complications are not monitored as a priority.The aim of this study was to develop a prediction score for postoperative complications after elective craniotomies and to redefine the monitoring algorithm.

#### Methods

Data acquisition was performed as a retrospective analysis of a single center. Patients who underwent elective craniotomy between 2018 and 2021 were included. Demographic data, diagnosis, location of the pathology (infra-/ supratentorial), American Society of Anaesthesiologists (ASA)-score, Charlson comorbidity index (CCI), duration of surgery, blood loss, complications (hemorrhage, respiratory failure, deterioration of neurological status), and type and duration of monitoring were analyzed. The score was calibrated and validated internally for predictive reliability.

#### Results

860 consecutive patients (376 male, 484 female) with a mean age of 60.6 years (range: 19-93 years) were included. Forty-three patients experienced a postoperative adverse event that was detected by close monitoring and required intensive care monitoring/treatment. The main predictors for postoperative complications were CCI (OR=1.19, CI95%=1.04-1.36), operative time (OR=45.9, CI95%=10.01-229.3), location of pathology (OR=1.68, CI95%=0.9-3.1) and ASA score (OR=1.1, CI95%=1.01-1.2). The score was based on the above characteristics, the score weight was calculated as shown in the attached figure. The discriminatory value for clinical outcomes of the established score achieved an AUC of 0.8 (CI95%=0.76-0.86).

#### Conclusion

This score including CCI, ASA and the location of the pathology provides a practical approach for individual risk assessment of patients undergoing elective craniotomy. Dependent on the reached score a preoperative risk evaluation can grade the risk for postoperative complications. Postoperative monitoring capacities should preferably be assigned to elaborated high-risk cases. Patients with a low risk score could be transferred to the normal ward as fast track after a few hours to make optimum use of valuable capacity.

Abb. 1

| Parameters | Points |
|---|---|
| **Charlson Comorbidity Index** | |
| Per CCI point (max. 24) | 2 (max. 48) |
| **Location** | |
| Infratentorial | 6 |
| Supratentorial | 0 |
| **ASA** | |
| 1 | 1 |
| 2 | 4 |
| 3 | 9 |
| 4 | 16 |
| **Max. score** | **70 points** |

**Risk per points:**

| | | |
|---|---|---|
| 0-36 points: 0-5% | 36-43 points: 5-10% | low risk |
| 44-49 points: 10-20% | 50-55 points: 20-30% | Intermediate low |
| 56-59 points: 30-40% | 60-63 points: 40-50% | Intermediate high |
| 64-66 points: 50-60% | 67-70 points: 60-70% | high risk |

# Trauma und Neurointensiv – Verschiedenes 1 | Neurointensive – Various 1

## V032

### Der Einfluss der Traumaintensität auf die systemische Ausschüttung pro-inflammatorischer Zytokine nach experimentellem Schädel-Hirn-Trauma im Mausmodell

***The influence of trauma severity on the systemic pro-inflammatory cytokine release after experimental traumatic brain injury in mice***

J. Walter[1], A. Balandina[1], N. Kruck[1], O. Alhalabi[1], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

#### Objective

Even though the systemic inflammatory response is an important contributor to poor outcomes after traumatic brain injury (TBI), little is known about the influence of trauma severity on the release of pro-inflammatory cytokines into the bloodstream and the temporal pattern of this systemic inflammation in preclinical models of TBI. Therefore, we evaluated the temporal profile of the systemic release of pro-inflammatory cytokines after mild, moderate and severe TBI for 28 days after experimental TBI in mice.

#### Methods

A total of 128 C57Bl/6 wildtype mice were randomly subjected to mild, moderate, or severe controlled cortical impact (CCI, tip diameter 2, 3 or 4mm, impact depth 0.5, 1, or 1mm, velocity 4, 6 or 8m/s for mild, moderate and severe CCI, respectively). On days one, three, seven and 28 after CCI (1dpi, 3dpi, 7dpi and 28dpi, respectively), the animals were sacrificed and blood was drawn for further analysis. Blood serum concentrations of 13 pro-inflammatory cytokines such as, e.g., Interleukin-1, Interleukin-6 or TNFα, were analyzed utilizing a flow cytometry based LEGENDplex™ immunoassay (BioLegend®, San Diego, USA).

#### Results

Interestingly, a higher trauma intensity in terms of the CCI parameters was not associated with increased concentrations of pro-inflammatory cytokines; in contrast, in many cases, the highest cytokine concentration could be detected in the mild TBI group (e.g., Interferon γ: 3.0 ± 0.7 pg/ml vs. 0.2 ± 0.2 pg/ml, p=0.002 for mild vs. severe CCI, respectively). While most cytokines showed a biphasic release pattern with highest concentrations 1dpi and 28dpi (e.g., Interleukin-6: 3.5 ± 1.1 pg/ml and 2.3 ± 0.1 pg/ml vs. 0.3 ± 0.3 pg/ml, p=0.024 and p=0.002 for moderate CCI 1dpi and 28dpi vs. 7dpi, respectively), GM-CSF, IL-1β and IL-17 peaked 28dpi only (e.g., Interleukin-17: 12.0 ± 4.3 pg/ml vs. 1.4 ± 0.6 pg/ml, 3.0 ± 1.0 pg/ml and 0.0 ± 0.0 pg/ml, p= 0.009, p=0.065 and p<0.001 for mild CCI 28dpi vs. 7dpi, 3dpi and 1dpi, respectively).

#### Conclusion

Higher trauma intensities induced by CCI were not associated with a more pronounced cytokine release. For most cytokines, a biphasic release pattern with peaks 1dpi and 28dpi could be observed underpinning the important role of the systemic immune reaction in both, the acute and chronic phase after experimental TBI.

# Trauma und Neurointensiv – Verschiedenes 1 | Neurointensive – Various 1

## V033

### Prognostische Bedeutung der KI-basierte Analyse intrazerebraler Blutungen unter Verwendung von Radiomics und klinischen Merkmalen bei intrazerebralen Blutungen.

***AI-based analysis of Intracerebral Hemorrhage using radiomics and clinical features as means for rigor decision making in intracerebral hemorrhage***

H. Krenzlin[1], K. Tsakmaklis[2,3], A. Sanner[4], A. Othman[4], F. Ringel[1], N. Keric[1]

[1]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[3]Translationale Onkologie (TRON), Mainz, Deutschland
[4]Universitätsmedizin Mainz, Klinik für Neuroradiologie, Mainz, Deutschland

#### Objective

Intracerebral hemorrhage (ICH) is associated with a significant disability-adjusted life years lost. Treatment decision-making largely dependents on clinical judgement of health care professionals lacking rigor and reproducibility. We hypothesized that that AI-based radiomics could guide unbiased prediction of hematoma expansion (HE) and clinical outcomes.

#### Methods

Patients with spontaneous ICB between 2015 – 2020, were enrolled in this large monocentric retrospective analysis. Modified Rankin Score (mRS) and Glasgow Outcome Scale Extended (GOSE) were used to determine functional outcome. 107 Radiomics features were extracted from non-contrast enhanced Computer Tomography (CT) slice images at the time of admission using 3D-Slicer (Open-Source-Python) together with PyRadiomics. Logistic regression, support vector machine, and random forest classifiers were built using the non-correlated selected radiomic, clinical, and dose features on the training dataset and performance was assessed in the testing dataset. The area under the curve (AUC) was used to assess the prognostic value.

#### Results

202 patients with intracerebral hemorrhage (ICH) were analyzed. Median age was 76 years (34 – 93 years), female:male ratio was 94:108. Mean hematoma volume on admission was 37.2±15ml. Early HE within 6h occurred in 52 patients (26%), HE within 48h in 10 patients (5%). 30-day mortality was 26%. At discharge, median GOSE was 3 (1-7) and median mRS was 4 (0-6). Overall, 61 patients (30.4%) reached a favorable outcome (GOSE 5-8) at time of discharge. AI-based analysis using clinical and radiomics features achieved good prediction performance for HE (AUC 0.746±0.159; 95%CI (0.481-0.878)). Further, the combined model achieved good discrimination of poor outcomes at the time of discharge (AUC 0.975±0.003; 95%CI (0.923-0.999)).

#### Conclusion

AI-based assisted analysis of ICH based on clinical and radiomic features is capable of predicting impending HE and poor short-term outcome. Unbiased prediction of the clinical course and outcome might help to increase therapeutic efficacy, rigorous decision making and ultimately improve treatment of patients with ICH.

# Trauma und Neurointensiv – Verschiedenes 1 | Neurointensive – Various 1

## V034

### Die Rolle der transkraniellen Ultraschallbildgebung in der intensivstationären Behandlung von Patienten nach dekompressiver Hemikraniektomie: Eine retrospektive Single-Center Analyse

***The role of transcranial ultrasound imaging in intensive care treatment of decompressive hemicraniectomy patients: A retrospective single-center analysis***

M. Petkov[1], R. Becker[2], M. Schneider[3], M. Hlavac[1], A. Knoll[3], C. R. Wirtz[3], T. Kapapa[3], A. Pala[1]

[1]University Hospital Ulm, Neurosurgical Department, Günzburg, Deutschland
[2]University Hospital Ulm, Department of Radiology, Neuroradiology Section, Günzburg, Deutschland
[3]University Hospital Ulm, Neurosurgical Department, Ulm, Deutschland

#### Objective

Patients undergoing decompressive hemicraniectomy often require prolonged intensive care treatment. For regular imaging assessments, computed tomography (CT) is considered the gold standard. However, an increased number of CT scans is associated with a poor clinical outcome. The purpose of this study was the evaluation of bedside transcranial ultrasound (TUS) as a potential imaging alternative to capture relevant anatomical structures and pathologies in critically ill patients.

#### Methods

16 post-hemicraniectomy patients who were treated in our neurosurgical intensive care unit (ICU) between January 1st and December 31st 2023 were analyzed. Retrospective evaluation was conducted separately by 6 experienced physicians of our department (3 former residents and 3 attending physicians of the neurosurgical ICU). 140 TUS sessions, including multiple freeze frames and video footages respectively, were analyzed. Evaluation included 7 different imaging categories, as listed below. Likert Scale (1 point: very good visualization; 5 points: insufficient visualization) was used for rating. Mean values and medians were identified and compared between both examiner groups.

#### Results

Ultrasound imaging was performed on average on 8.75 out of 21.19 days (mean inpatient stay) with a mean of 4.38 CT scans per patient and stay. TUS provided lowest Likert scores (mean; median) for imaging categories ventricular size (1.28; 1), midline shift (1.83; 2), subdural space (2.56; 2), intraventricular catheter placement (2.82; 3) and cortical gyration (2.95; 3). In 4 out of 6 patients with hydrocephalus, VP shunt indication could be established without additional CT scan. In terms of primary conditions, intracerebral hematomas (3.04; 3) could be visualized more effectively than infarct demarcation (4.75; 5) by both groups. In 6 out of 7 imaging categories, former residents reported a slightly inferior assessability resulting in higher scores on the Likert scale (0.21 – 0.81 mean difference compared to attending physicians).

#### Conclusion

Transcranial ultrasound is a safe, cost- and time-efficient method, potentially gaining relevance for indication setting and imaging of post-hemicraniectomy patients in intensive care treatment. The method seemed to be effective in evaluating hydrocephalus, intraventricular catheter placement, midline shift, and space-occupying lesions in our setting. Further improvement in image quality could potentially reduce the overall number of CT scans in post-hemicraniectomy patients.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V035

### Ein deep-learning basierter Ansatz für die automatisierte Planung thorakaler Pedikelschrauben
### *A deep learning approach for automated planning of thoracic pedicle screws*

P. Naser[1,2,3], K. Lisa[4,3], A. Ertl[4], S. Krieg[1,2], K. Maier-Hein[4,5,6,7,3], S. Moritz[1,2,3]

[1]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Medical Faculty, Heidelberg, Deutschland
[3]German Cancer Research Center (DKFZ), AI Health Innovation Cluster, Heidelberg, Deutschland
[4]German Cancer Research Center (DKFZ), Division of Medical Image Computing, Heidelberg, Deutschland
[5]German Cancer Consortium (DKTK), Partner site Heidelberg, Heidelberg, Deutschland
[6]National Center for Tumor Diseases (NCT/UCC), NCT Heidelberg, a partnership between DKFZ and the University Medical Center Heidelberg, Heidelberg, Deutschland
[7]Heidelberg University, Pattern Analysis and Learning Group, Department of Radiation Oncology, Heidelberg, Deutschland

#### Objective

Navigated spinal pedicle screw placement has significantly improved surgical outcomes and perioperative complications. Robotic spinal surgery promises to further improve those results. Manual screw planning, while crucial for robotic surgery, remains time-consuming. Deep-learning, and atlas-based methods for automated planning are commercially available for the lumbosacral segments, but not thoracic levels. This study aimed at developing a planning algorithm for the thoracic spine based on a convolutional neural network (CNN).

#### Methods

A CNN was trained on 1143 screws and the corresponding CT scans from patients operated in our center. The test set consisted of 114 thoracic screws. The automatically planned screws were compared to screws independently planned by two surgeons, with regards to intrinsic and geometric parameters. Additionally, the interrater and the intrarater (the same surgeon planning the screws with several weeks interval) variance were evaluated. ANOVA and t-test were used to compare groups, $p<0.05$ was considered significant.

#### Results

Automatic planning yielded clinically acceptable screws in all cases. A lateral pedicle breach was observed in 62 screws (mean 1.365±0.67mm), and a medial breach in four (mean 0.54 ±0.08). Planning time per screw was significantly reduced using automated planning (5.84 ± 2.3s vs 123±82.9s; $p<0.0001$). The distances between automatically and manually planned head and tip points were comparable to the intrarater comparison ($p=0.61$; $p=0.1$ respectively) and significantly lower than between two raters ($p<0.0001$). The deviation in direction was likewise significantly higher in the interrater comparison ($p<0.0001$).

While the automatically planned screws did not differ in length ($p=0.426$), the CNN planned markedly thicker screws than the surgeons ($p<0.0001$).

*Table 1: Variations in screw parameters between automatic and manual planning, as well as between different surgeons (interrater) and the same surgeon at different time points (intrarater)*

#### Conclusion

We developed and validated a robust CNN-based algorithm for automated thoracic pedicle screw planning. The screw plans were non-inferior to manually planned screws while markedly reducing the time expenditure. Four planned screws deviated medially, however, <2mm, and can therefore still be considered clinically acceptable.

While clinical testing and validation are necessary, our approach promises reliable automated pedicle screw planning.

Abb. 1

| | Automatic vs manual | Interrater | Intrarater |
|---|---|---|---|
| Δ Direction [°] | 6.507 ±3.357 | 8.323±4.241 | 6.923±3.773 |
| Δ Head[mm] | 3.689±1.738 | 4.627±2.332 | 3.899±2.352 |
| Δ Tip [mm] | 4,076±1,982 | 5,274±2,342 | 4,549±2.125 |
| Δ Diameter [mm] | 0.5542±0.3846 | 0.3967±0.4698 | 0.6225±0.4572 |
| Δ Length [mm] | 3.171±2.559 | 2.272±3.194 | 3.263±3.363 |

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V036

### Erste klinische Ergebnisse nach zementaugmentierter Ringosteosynthese bei osteoporotischen Pincer-Frakturen der Wirbelsäule - ein neues perkutanes minimal-invasives OP-Verfahren - als Alternative zu langstreckigen Instrumentierungen

***First clinical results after cement-augmented Ringosteosynthesis for osteoporotic pincer fractures of the spine – A new percutaneous minimally invasive surgical procedure – As an alternative to long segment instrumentations***

T. Miron[1], I. Moritz[1], Y. M. Ryang[1]

[1]Helios Klinikum Berlin-Buch, Nerochirurgie, Berlin, Deutschland

#### Objective

The treatment of osteoporotic vertebral body fractures is a major challenge due to their prevalence and impact on quality of life, especially in frail patients. The management of OF4-pincer fractures is particularly complex, as long-segment stabilisation with or without vertebral body replacement is usually recommended. Such invasive procedures are associated with significant perioperative risk. We present first clinical results of a new surgical procedure, minimally invasive percutaneous PMMA-augmented pedicle screw Ringosteosynthesis (ROS).

#### Methods

A cohort of 46 patients with osteoporotic OF4-pincer fractures between thoracal vertebrae 8 and lumbar vertebrae 5 was treated with ROS. Pre- and postoperative pain intensity (NRS) was assessed. In addition, intra- and postoperative complications, incidence of subsequent fractures, need for follow-up surgery and long-term pain intensity and quality of life during follow-up were investigated. Retrospective statistical data analysis.

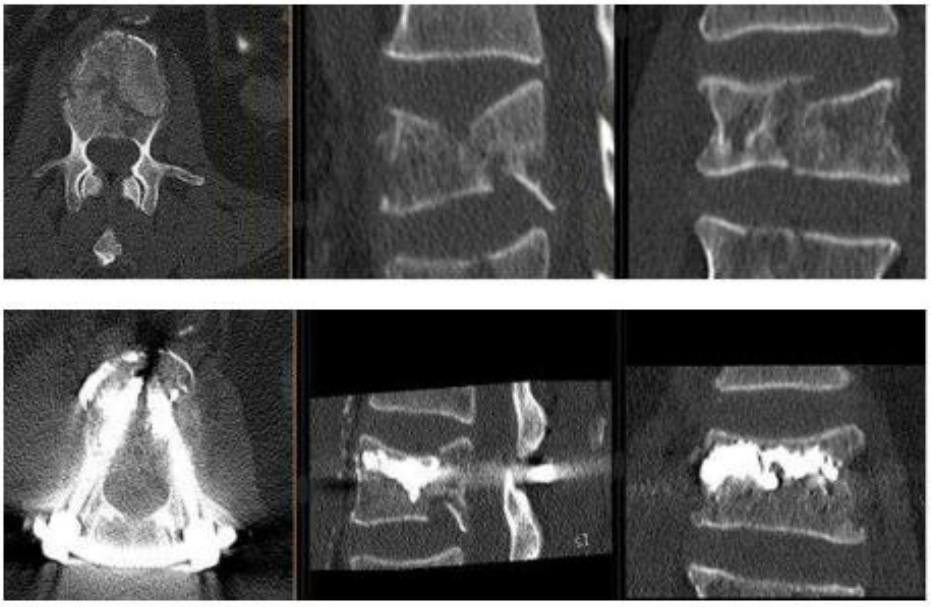
#### Results

31F and 15M with an average age of 77.7±6.5 years (52-91), BMI: 25.2±4.95 (18.4-40), ASA score: 2.5±0.65 (1-4) were operated on. After treatment with ROS, the NRS showed a significant reduction in pain by an average of 4.43±1.58 (1-9) points pre- to postoperatively (mNRS preop 7.88±1.51 (2-10); postop 3.44±1.55 (0-6); $p<0.05$). 69% of patients were followed up at 27.7±11.07(3-72) weeks on average, showing a long-term pain reduction of 5.6±1.58(0-7) points on the NRS compared to preop pain intensity. One intraoperative complication occurred with pedicle screw avulsion during rod placement. One patient had a subsequent fracture, 5 patients showed sintering in the fractured vertebral body on CT after 27.7±11.07(3-72) weeks.

#### Conclusion

This paper presents the clinical application of Ringosteosynthesis as a new minimally invasive surgical procedure as a promising alternative to long-segment stabilisation for thoracolumbar OF4 pincer fractures. Potential advantages of this minimally invasive technique include a reduced rate of union fractures, proximal junctional failure when instrumenting the fractured vertebral body alone, shorter operating time, less blood loss, faster recovery, shortened hospital stay and higher cost- efficiency. The significant reduction in pain intensity and the low rate of subsequent fractures and interventions indicate sufficient stability and effectiveness of Ringosteosynthesis in geriatric patients. Further long-term studies are required.

Abb. 1



# Spinal – Verschiedenes 2 | Spinal – Various 2

## V038

### Endoskopische tranforaminale Diskektomie bei lumbalen Rezidivbandscheibenvorfall
*Endoscopic transforaminal discectomy for recurrent lumbar disc herniation*

A. Baraka[1]

[1]Apex Spine Zentrum, Wirbelsäulenchirurgie, München, Deutschland

### Objective

Recurrent herniation is a significant problem as scar formation and progressive disc degeneration may lead to increased morbidity after traditional posterior reoperation. The advantage of the ETD could be that there is no need to go through the old scar tissue. The disadvantage may be a long learning curve for the spinal surgeon. The purpose of this prospective study is to review complications and results of the endoscopic transforaminal discectomy (ETD) for recurrent herniated discs.

### Methods

A prospective clinical study was enrolled of 262 consecutive patients over a four year period with a MRI proven disc-herniation in the lumbar spine with radicular symptoms, positive lasegué, numbness or adynamia in the leg that did not respond satisfactory to conservative treatment over 3 months. Previous surgery had been performed in our own centre in 82 cases, 180 patients had previous surgery performed elsewhere. First a discography of at least 2 levels was conducted. The prolapsed or ruptured part of the posterior disc segment was removed with special forceps and special curettes. The procedure was performed under local anaesthesia. The patients had a clinical evaluation 3 months after surgery and returned at two years an extensive questionnaire including VAS Score, MacNab Score as well as subjective satisfaction.

### Results

At two years 85,7% of the patients rated the result of the surgery as excellent or good. 9,7 % reported a fair and 4,6 % patients an unsatisfactory result. Patients recorded an average improvement of their back pain of 5,7 points and 5,9 points of their leg pain on the VAS scale(1-10). According to Mac Nab criteria 30,7% of the patients felt fully regenerated, 50 % felt their efficiency to be slightly restricted, 16,8% felt their efficiency noticeably restricted and 2,5% felt unaltered. All patients had a 3-month follow-up where possible complications were registered. The complication included: 3 nerve root irritations and 6 (2,3%) early recurrent herniations (<3 month). There was no case of infection or discitis. 11 patients have been reoperated for recurrence, after 3 months and within 2 years ( 4,6%).

### Conclusion

Endoscopic transforaminal discectomy appears to be an effective treatment with few complications and a high patient satisfaction for recurrent disc herniation.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V039

### Langzeituntersuchungen der Ergebnisse bei Patienten nach Dekompressionsoperationen bei lumbaler spinaler Stenose

*Long-term outcomes of decompression surgery for lumbar spinal stenosis*

M. Remensperger[1], S. D. Adib[1], M. Morgalla[1], M. Tatagiba[1]

[1]University of Tübingen, Department of Neurosurgery, Tübingen, Deutschland

#### Objective

Decompression surgery in case of lumbar spinal canal stenosis is the most common spinal operation in older patients. Goal of this study was to analyze the long-term outcome (10-12 years after surgery) via a survey.

#### Methods

104 patients who had undergone decompression surgery 10-12 years before the time of the survey were interviewed (Surgery period: 01/01/2010 – 12/31/2012). The inclusion criteria were an initial lumbar decompression at the specified level during the mentioned period and the capacity to provide consent. The patients were surveyed using a self-created general questionnaire including a numerical rating scale, the Zurich Claudication Questionnaire in its validated German form, and the Oswestry Disability Index. 26 patients from 2010, 34 patients from 2011, and 44 patients from 2012 were surveyed. 49.0% were female and 51.0% were male, with an average age of 76 years (youngest patient 51 years old, oldest patient 90 years old). The surgical methods include interlaminar fenestration, laminectomy with and without fusion, and hemilaminectomy.

#### Results

Overall, 91.35% (n=95) of all patients experienced a long-lasting improvement in their symptoms. Among them, those who underwent interlaminar fenestration were the most satisfied (91.66% experienced symptom improvement). 89.42% (n=93) of patients would recommend the surgery to someone else. A significant improvement in pain was observed even 10-12 years postoperatively. There was an average reduction of 4.59 points measured on the numerical rating scale (from 7.92 preoperatively to 3.34 postoperatively), which was statistically significant with a strong effect size. Long-term significant improvements were also noted in spinal claudication, paresis, and sensory disturbances. Opioid and NSAID intake were significantly reduced.

#### Conclusion

It appears that decompression surgery is a long-lasting (10-12 years) and effective method of improving symptoms in patients with spinal stenosis. Older patients also benefit from the procedure.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V040

### Vergleich von DEXA und CT-basierten Hounsfield units bei Patienten mit osteoporotischen Wirbelkörperfrakturen

*Diagnosis of osteoporosis using CT based hounsfield units*

I. Moritz[1], T. Miron[1], E. von Bronewski[2], C. Christoforou[1], S. Reißberg[3], Y. M. Ryang[1]

[1]Helios Klinikum Berlin-Buch, Neurochirurgie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[3]Helios Klinikum Berlin-Buch, Neuroradiologie, Berlin, Deutschland

#### Objective

Gold standard is the dual-energy X-ray absorptiometry (DEXA) and the resulting T-score. Some studies have already shown that the reliability of DEXA is defeated to other methods of bone densitometry in terms of diagnosis and predictive power for subsequent fractures. The aim of this study is to compare the correlation between measured DEXA values compared to "Hounsfield units" (HU) in patients with severe manifest osteoporosis with osteoporotic vertebral fractures.

#### Methods

From 2021 to 2023 we examined 230 patients with osteoporotic fractures of the spine (mean age 77 ± 6,5 years). All patients received CT imaging to evaluate the "OF classification." 72 patients were evaluted by Dexa measurement. The HU were evaluated axially in each of three non-fractured vertebral bodies of the lumbar spine. A ROI was measured for each vertebral body below the cover plate, in the central plate and above the base plate in the spongy bone. The HU cut off value was determined for an osteoporotic fracture on the basis of previous postulations of <110 and compared with the T-score of the DEXA.

#### Results

According to DEXA, only 46% of patients showed an osteoporosis (T- ≤-2,5). However, according to the HU, 97% of the examined patients presented an osteoporosis.While HU demonstrated a high sensitivity of 94% and specificity of 96% (positive predictive value (PPV): 95.6%, negative predictive value (NPV): 94.1%), comparatively DEXA showed a low sensitivity of 51% and specificity of 50% with a PPV of 46,5% and an NPV of 49,5%. In patients who did not show any osteoporotic fracture (>-1) in the T-score, the mean HU value showed: 73,53; in patients with a low suspicion (-1 to -2.5): 87,16 and with manifest osteoporosis (<-2.5): 78,53. After classification of the osteoporotic fracture via OF classification, a successive decrease in HU according to the severity of the osteoporotic fracture could be evaluated (OF2: 98,28; OF3: 91,83; OF4: 75,48; OF5: 68.297) with a significant correlation (p=0.03).

#### Conclusion

Although currently still the gold standard for bone densitometry and diagnosis of osteoporosis, DEXA does not seem to be suitable for reliably detecting manifest osteoporosis in the spine in contrast to HU. Based on our data, HU seem to be much more suitable to verify manifest osteoporosis.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V041

### Verbesserte automatisierte Schraubenplanung durch Kombination der Brust- und Lendenwirbelsäule im Training eines neuralen Netzwerkes zur automatisierten Schraubenplanung.

***Combining, rather than separating thoracic and lumbar vertebrae in training of a neural network for deep-learning-based pedicle screw planning yields higher anatomical accuracy***

P. Naser[1,2,3], K. Lisa[4,3], A. Ertl[4], S. Krieg[1,2], K. Maier-Hein[4,5,6,7,3], M. Scherer[1,2,3]

[1]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Medical Faculty, Heidelberg, Deutschland
[3]German Cancer Research Center (DKFZ), AI Health Innovation Cluster, Heidelberg, Deutschland
[4]German Cancer Research Center (DKFZ), Division of Medical Image Computing, Heidelberg, Deutschland
[5]German Cancer Consortium (DKTK), Partner site Heidelberg, Heidelberg, Deutschland
[6]National Center for Tumor Diseases (NCT/UCC), NCT Heidelberg, a partnership between DKFZ and the University Medical Center Heidelberg, Heidelberg, Deutschland
[7]Heidelberg University, Pattern Analysis and Learning Group, Department of Radiation Oncology, Heidelberg, Deutschland

#### Objective

Several methods for automated screw planning have been developed and tested for the lumbar spine. We recently trained a deep-learning-based algorithm on a dataset of lumbosacral screws, yielding clinically acceptable results. In this study, we extended training also incorporating thoracic screws and assessed, whether the planning accuracy of the novel nnUnet V2 on lumbosacral screws improved accordingly.

#### Methods

Two neural networks based on nnUnet V2 were trained on pedicle screws and the corresponding CT scans from patients operated on in our center. The lumbar-only (LO) network was trained on 526 lumbosacral screws. The combined network (CN) was additionally trained on 617 thoracic screws. We evaluated the performance on 130 lumbosacral segments, excluded from the training set, with regards to the Gertzbein Robbins (GR) classification, measured the maximal pedicle breach, and assessed facet joint violations. Additionally, the distances between DL-planned screws and manually planned reference screws were computed. The statistical tests are indicated in the results section, $p<0.05$ was considered statistically significant.

#### Results

Automatic screw planning succeeded in all desired cases and all screw plans were clinically acceptable (GR A-B). CN yielded a higher number of GR A screws compared to LO (95% A, 5% B vs 88% A, 12% B), though falling short of statistical significance ($X2$; p=0.07). The number of facet joint violations decreased significantly from 34/130 (26%) by LO training to 20/130 (15%) using CN planning ($X2$;p=0.03).

In cases where pedicle breaches were observed, screws planned by CN illustrated reduced breach extensions (paired t-test; p=0.035) and CN-planned screws showed a significantly reduced tip-point deviation from reference screws (paired t-test; p=0.001).

#### Conclusion

We compared results of two neural networks for automated screw planning regarding their performance on lumbosacral pedicle screws. While the network trained exclusively on lumbosacral screws was capable of planning clinically acceptable screws in all cases, the addition of thoracic vertebrae to the training dataset significantly improved the planning results. This may be the result of improved generalization due to a broader

exposure of the network during training. Advances in automated pedicle screw planning based on deep learning are promising and can facilitate the implementation of robotic assistance to spine surgery.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V042

### Der Stellenwert des intraoperativen Monitorings von D-Welle, MEPs und SSEPs für die Prädiktion des neurologischen Outcomes, der Feinmotorik und höheren Komplexfunktion der distalen oberen Extremität nach spinalen intramedullären tumorchirurgischen Eingriffen im oberen Halsmark – finale Ergebnisse

***Intraoperative D wave, MEPs and SSEPs monitoring for prediction of distal upper extremities' neurological outcome as well as fine-motor and complex function after high-cervical intramedullary spinal cord tumor (IMSCT) surgery – final results of a 7-year prospective trial***

S. Siller[1,2], S. Duell[2], J. Tonn[2], A. Szelényi[2]

[1]University Hospital Regensburg, Department of Neurosurgery, Regensburg, Deutschland
[2]LMU University Hospital of the Ludwig-Maximilians-University Munich, Neurosurgical Clinic, München, Deutschland

#### Objective

D wave is considered as gold standard to safely monitor the corticospinal tract (CST) function caudally to the level of its placement. While it is known that preserved D wave predicts long-term lower extremities' ambulation (even with lost MEPs), it is still unknown if i) D wave can also safely monitor the CST with regard to gross-motor outcome of the distal upper extremities (dUExs) in those patients undergoing high-cervical (hc) IMSCT resection (enabeling D wave placement above C5) and ii) if multimodal IONM can also predict fine-motor/complex hand function.

#### Methods

We prospectively assessed 20 patients undergoing IMSCT surgery above the C4/5-level (total resection in 90%) with recording of dUExs-MEPs, median (m)SSEPs and epidural D wave (placed caudally to the surgical level to safely cover C5 segment and down). The following permanent alterations were considered significant: D wave amplitude decline ≥50%, MEPs amplitude decline ≥80%, and SSEPs amplitude/latency decline ≥50%/2ms. dUExs' detailed gross- and fine-motor as well as complex function incl. Nine-Hole-Peg-Test (NHPT) was assessed preoperatively and during long-term FU (mean 30months).

#### Results

D wave monitoring was without intraoperative critical changes in all patients and none had any severe permanent postoperative motor deficits for the dUExs (and also lower extremities, LExs) with every patient being ambulatory at last FU. However, D wave was not able to predict the occurrence of mild permanent postoperative deficits affecting the fine-motor function which was the case in 8% for dUExs (and in 5% for the LExs). With a very low sensitivity (0%) and high false-positive rate (100%), dUExs-MEPs were also not able to predict short- and long-term fine-motor outcome. The complex dUExs' function assessed by NHPT (which reflects the complex interaction of motor/sensory function for the hand utilisability) was permanently deteriorated in 15% postoperatively and only the combination of D wave, dUExs-MEPs and mSSEPs was able to provide a viable predictive power with a specificity of 79%, sensitivity of 43%, but still a high false-positive rate of 70%.

#### Conclusion

In hcIMSCT surgery, unimpaired D wave reliably predicts preserved gross-motor function for all covered spinal segments (including dUExs). However, it fails to sufficiently cover dUExs' fine-motor and complex function, which still remains a challenge to monitor even with multimodal IONM.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## V043

### Der Langzeitverlauf des Outcome und der Lebensqualität nach stattgehabter IONM-gestützter mikrochirurgischer Resektion intramedulläre Rückenmarkstumore: Unterscheiden sich Patienten mit zervikal oder thorakal gelegenen Tumoren?

***Long-term outcomes and quality-of-life after IONM-aided microsurgical resection: Is there a difference between patients with cervical or throracic intramedullary spinal cord tumors?***

S. Siller[1,2], S. Duell[2], J. Tonn[2], A. Szelényi[2]

[1]University Hospital Regensburg, Department of Neurosurgery, Regensburg, Deutschland
[2]LMU University Hospital of the Ludwig-Maximilians-University Munich, Neurosurgical Clinic, München, Deutschland

#### Objective

Microsurgical resection is the therapy of choice for intramedullary spinal cord tumors (IMSCTs). While resection for cervical IMSCTs might be anatomically more challenging than for thoracic IMSCTs, it is still unknown if there is a difference in long-term postoperative outcome and quality-of-life (QoL) aspects.

#### Methods

We prospectively assessed 47 patients undergoing IMSCT surgery (excluding conus medullaris tumors) with intraoperative recording of MEPs, SSEPs, D Wave and free-running EMG. Detailed neurological status, McCormick Score (McC), as well as Short-Form-36 Health Survey Score for physical and mental aspects of QoL (SF-36-PCS and -MCS) were assessed pre- and immediately postoperatively as well as at long-term follow-up (FU: mean 24months) and compared between groups.

#### Results

40% of the tumors were located between the C1-C4-level (group 1), 28% between the C5-C7-level (group 2) and 32 between the Th1-Th10-level (group 3). Mean age was 45years (m/w:1.6/1) and preoperative motor deficits were present in 38%, sensory disturbances in 70% and gait ataxia in 36% with a median McC of 1 (range 1-4) in the overall cohort; QoL was slightly reduced compared to the healthy reference population with a SF-36-PCS/-MCS of 46±12/42±12. There were no sign. differences in these baseline characteristics between the three groups. Gross-total resection rates were 80% vs. 92% vs. 93% for group 1 vs 2 vs. 3. Immediately postoperatively, median McC deteriorated in all three groups to a median of 2 and returned to the baseline level (median of 1) during long-term FU. Equivalently in all three groups, physical aspects of QoL sign. deteriorated immediately postoperatively ($p<0.01$) and returned to baseline level at last FU (mean SF-36-PCS: 45±10), while mental aspects of QoL were stable during the whole postoperative course (mean SF-36-MCS at last FU: 45±12). For group 1 vs. 2 vs. 3, rates for individual improvement/deterioration in QoL aspects were 53%/47% vs. 54%/46% vs. 53%/47% for SF36-PCS and 58%/42% vs. 77%/23% vs. 73%/27% for SF-36-MCS (last FU vs. preoperative status) without sign. differences between the three groups. In uni- and multivariate analysis, tumor location (group 1 vs. 2 vs. 3) was also not sign. associated with long-term QoL outcome.

#### Conclusion

Postoperative neurological and QoL long-term outcomes do not differ between patients with higher-cervical, lower-cervical and thoracic IMSCTs with similar improvement rates of more than half of the patients.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

# V044

## Automatisiere Auswertung der Hämatomgröße und der Schweregradbewertung nach experimenteller Subarachnoidalblutung: Integration der RGB-Bildbasierten Hämatomerkennung

***Automated hematoma size calculation and severity assessment in experimental subarachnoid hemorrhage: integration of RGB-Image-Based hematoma detection***

B. N. Harapan[1,2], J. Schwarting[2], A. Cattaneo[2], N. Plesnila[2], N. Terpolilli[1,2]

[1]Klinikum der Ludwig-Maximilians-Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Institut für Schlaganfall- und Demenzforschung (ISD), München, Deutschland

### Objective

Subarachnoid hemorrhage (SAH) presents high morbidity and mortality with limited treatment options, emphasizing the importance of experimental research using animal models. The widely employed middle cerebral artery perforation model mimics key aspects of human SAH but faces challenges in objectively assessing severity. This study focuses on developing an automated algorithm, employing RGB-image processing, to enhance the objective calculation of hematoma size and severity assessment in experimental SAH.

### Methods

Following SAH induction, mouse brains (C57bl6, n = 15) were perfused, and high-resolution images were captured using a stereomicroscope. Automated analysis, previously validated,[1] utilized a custom JAVA code for ImageJ. Severity assessment employed a modified score by Sugawara et al.[2]

RGB color spaces were incorporated for further optimization, transforming the image into a three-dimensional matrix for efficient processing. The algorithm's effectiveness was evaluated based on R, G, and B values using bitwise and operations, calculating the ratio of selected bits to the whole brain surface area.

### Results

The established algorithm detected an average of 6.3% blood-covered area relative to the entire brain surface (mainly attributed to the central blood clot), while the optimized algorithm identified an average of 16.2% brain surface with blood (including correctly identified peripheral blood components at the skull base), resulting in approximately 10% more accurate quantification of hematoma portions on the skull base after the induction of SAH.

### Conclusion

Overall, the extent of SAH is better captured with RGB-image-based blood clot detection, which offers an improved and objective approach to hematoma size calculation and severity assessment in experimental SAH. This researcher independent assessment method therefore helps to improve blood clot detection and severity assessment, thus enhancing clinical translatability of the model.

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# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V045

### Myoblasten-vermittelte VEGF/PDGF-BB Bereitstellung zur Verbesserung der Kollateralisierung nach EMS bei alten Mäusen mit chronischer zerebraler Ischämie

***Myoblast-mediated VEGF/PDGF-BB delivery for augmentation of EMS collateralization in aged mice suffering from chronic cerebral hypoperfusion***

F. Werft[1], L. Wessels[1], M. Nieminen-Kelhä[1], I. Kremenetskaia[1], P. Böhm-Sturm[1], S. Müller[1], A. Banfi[2], R. Gianni Barrera[2], P. Vajkoczy[1], N. Hecht[1]

[1]Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[2]University of Basel, Department of Biomedicine, Basel, Schweiz

#### Objective

Indirect revascularization through an encephalomyosynangiosis (EMS) represents a technically simple and safe alternative to direct bypass surgery for flow augmentation in Moyamoya vasculopathy but lacks efficiency in arteriosclerotic cerebrovascular disease. Previously, we demonstrated that targeted growth factor delivery at the muscle / brain interface of an EMS can augment transpial collateralization during chronic cerebral hypoperfusion in young C57BL/6 mice. We now tested whether a new generation of monoclonal transduced myoblasts with stable VEGF/PDGF-BB co-expression could improve EMS collateralization in mice aged 18 months.

#### Methods

For simulation of chronic cerebral hypoperfusion, permanent unilateral internal carotid artery occlusion (ICAO) was performed in two groups of C57BL/6 mice aged 18 months, followed by ipsilateral EMS surgery and implantation of monoclonal transduced mouse myoblasts ($2.5x10^6$) expressing VEGF+PDGF-BB at a fixed ratio (VIP, n=10) or an empty vector (EV, n=9). As a young-aged control, C57BL/6 mice aged 12 weeks received an EMS+ICAO (n=6) with EV myoblast implantation. Hemodynamic impairment, neovascularization and pericyte recruitment were assessed by laser speckle imaging, immunofluorescence and iron-oxide nanoparticle contrast-enhanced MRI.

#### Results

From day 21 until 42, cerebrovascular reserve capacity (CVRC) in EV (control) mice recovered significantly better in young EV animals (young EV day 42: 14±4%) than in old EV animals (old EV day 42: 5±6%; $p<0.05$). In contrast, old mice that received VIP showed significant CVRC recovery from day 0 to day 42, (old VIP day 42: 9±5%; $p<0.01$), similar to the CVRC recovery pattern of young EV mice. Morphologically, this was paralleled by an improved EMS take-rate (young EV 17%, old EV 13%, old VIP 22%) and superior temporalis muscle perfusion in old VIP mice, as demonstrated by external carotid artery FITC-Lectin perfusion as well as iron oxide nanoparticle contrast-enhanced MRI on day 42. No difference was noted in baseline perfusion, microvascular density and pericyte coverage between groups.

#### Conclusion

Targeted myoblast mediated VEGF+PDGF-BB co-delivery might serve as an effective strategy to augment hemodynamic efficiency of EMS revascularization in aged patients suffering hemodynamic cerebrovascular disease other than Moyamoya vasculopathy.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V046

### Flusskapazität der Arteria temporalis superficialis in einer konsekutiven Serie von 100 Patienten mit STA-MCA-Bypass

***Flow capacity of a superficial temporal artery as a donor artery in a consecutive series of 100 patients with STA-MCA bypass***

M. Sebök[1], L. M. Höbner[1], J. Fierstra[1], T. Schubert[2], S. Wegener[3], A. Luft[3], Z. Kulcsar[2], L. Regli[1], G. Esposito[1]

[1]Universitätsspital Zürich, Klinik für Neurochirurgie, Zürich, Schweiz
[2]Universitätsspital Zürich, Klinik für Neuroradiologie, Zürich, Schweiz
[3]Universitätsspital Zürich, Klinik für Neurologie, Zürich, Schweiz

#### Objective

A superficial temporal artery to middle cerebral artery (STA-MCA) bypass is classically considered a low-flow bypass. It is known that the flow in the flow-augmentation STA-MCA bypass is influenced by the flow demand of the revascularized territory and can reach significantly higher values. We report our intraoperative flow measurement data in a consecutive series of 100 performed STA-MCA bypasses at our institution. Moreover, in the subanalysis, we show the postoperative bypass flow measured with quantitative non-invasive optimal vessel analysis (NOVA) qMRA.

#### Methods

Between January 2013 and October 2023, 100 patients with acute large vessel occlusion (LVO), chronic LVO or Moyamoya disease underwent a flow-augmentation STA-MCA bypass revascularization at our department with an intraoperative bypass flow measurement. Since May 2019 a consecutive subgroup of 37 patients received a postoperative (before discharge) bypass flow measurement with qMRA-NOVA imaging tool.

#### Results

The mean±SD intra-operative bypass flow in our consecutive series of 100 STA-MCA bypasses was 53.5±28.8 ml/min (range: 14-145 ml/min). In the subanalysis, there was no difference in the intraoperative flow capacity between the acute and chronic group and between the Moyamoya and acute group. Patients in the Moyamoya group showed significant higher flow in the STA-MCA bypass compared to the chronic group (63.0 ±30.2 ml/min vs. 48.4±26.5 ml/min, p=0.03). In 37 consecutive STA-MCA bypass cases, a postoperative flow measurement was performed using qMRA-NOVA showing a significant increase in the flow capacity of the performed STA-MCA bypass after surgery (73.4±29.9 ml/min vs. 111.3±51.4 ml/min, p=0.005).

#### Conclusion

Using intra-operative and post-operative quantitative flow capacity measurement of a superficial temporal artery, our data confirm that the flow in the flow-augmentation STA-MCA bypass is influenced by the flow demand of the revascularized territory and can reach high values if needed. Moreover, the significant flow increase in the postoperative flow measurement via NOVA-qMRA underlines the ability of the bypass flow to increase over time.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V047

### Der Effekt eines extensiven versus eines zurückhaltenden Managements von verzögerter zerebraler Ischämie auf das radiologische und funktionelle Outcome

***The effect of an extensive versus a restrained management for delayed cerebral ischemia on radiological and functional outcome***

A. Abdulazim[1], H. Roth[1], N. Riemann[1], M. Heilig[1], F. Wenz[1], K. Hackenberg[1], E. Neumaier-Probst[2], C. Groden[2], M. Vergouwen[3], G. Rinkel[1,3], N. Etminan[1]

[1]Universitätsmedizin Mannheim, Klinik für Neurochirurgie, Mannheim, Deutschland
[2]Universitätsmedizin Mannheim, Abteilung für Neuroradiologie, Mannheim, Deutschland
[3]UMC Utrecht Brain Center, University Medical Center Utrecht, Department of Neurology and Neurosurgery, Utrecht, Niederlande

#### Objective

The management of delayed cerebral ischemia (DCI) after aneurysmal subarachnoid haemorrhage (SAH) is heterogeneous and the appropriate management of DCI remains controversial. We compared radiological and functional outcome between two high-volume SAH centres with considerably different approaches for monitoring and treatment of DCI.

#### Methods

A prospective cohort of 379 consecutive SAH patients admitted to centre E(xtensive) between January 2016 and December 2022 was treated using a standardized protocol consisting of regular CT-perfusion monitoring and escalating treatment including induced hypertension and intra-arterial rescue therapies in case of persistent clinical or radiological features of DCI. This group was compared to 591 consecutive SAH patients admitted during the same period to centre R(estrained), which was treated using a restrictive approach based on mere clinical monitoring and treatment targeting physiological medical conditions, without induced hypertension or rescue therapy. We compared DCI-related infarction and unfavourable outcome (modified Rankin scale 3-6) at 3 months between the two cohorts. We calculated odds ratios (OR) with 95% confidence intervals and adjusted for age, WFNS grade, modified Fisher score (mFS), and aneurysm treatment modality (aOR*) and secondly added external ventricular drain (EVD) treatment to the adjustment model (aOR**).

#### Results

Compared to the cohort of centre R, the centre E cohort had a higher proportion of poor WFNS grade IV/V (40.1% vs. 31.1%; $p < 0.01$), lower mFS (centre E: 76.5% vs. centre R 83.1%; $p < 0.05$), and more often surgical aneurysm repair (centre E: 56.2% vs. centre R: 40.4%; $p < 0.001$) and application of an EVD (centre E: 75.7% vs. centre R: 33.8%; $p < 0.001$). The incidence of clinical DCI was significantly higher in the centre E cohort (42.0% vs. 25.7%; $p < 0.001$). The overall DCI-related infarction rate was 18.2% (centre E) vs. 18.8% (centre R) (OR: 0.96 [0.69-1.34]). The adjusted ORs were aOR*: 0.85 [0.60-1.22] and aOR**: 0.68 [0.46-1.00]. The overall rate of unfavourable outcome was 47.1% (centre E) vs. 40.3% (centre R) (OR: 1.32 [1.02-1.71]). The adjusted ORs were aOR*: 1.01 [0.74-1.39] and aOR**: 0.71 [0.50-1.02].

#### Conclusion

Extensive approaches for monitoring and treatment of DCI do not affect functional outcome per se. However, adjusting for covariables suggests that it may be beneficial for a subgroup of patients yet to be detected.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V048

### Interaktion der intra-arteriellen Spasmolyse mit dem optimalen zerebralen Perfusionsdruck und der Einfluss auf verzögerte zerebrale Infarkte und das Outome nach aneurysmatischer subarachnoidal Blutung

***Interaction of intra-arterial rescue therapy with optimal cerebral perfusion pressure and impact on delayed cerebral infarction and outcome after aneurysmal subarachnoid hemorrhage***

B. Kranawetter[1], T. Sheri[2], O. Mörer[3], V. Rohde[2], V. Malinova[2]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsmedizin Göttingen, Neurochirurgische Klinik, Göttingen, Deutschland
[3]Universitätsmedizin Göttingen, Anästhesiologie, Göttingen, Deutschland

#### Objective

Dysfunction of cerebral autoregulation (CA) and perfusion disturbances commonly occur after aneurysmal subarachnoid hemorrhage (aSAH). One method to evaluate CA is the calculation of the pressure reactivity index (PRx) for the definition of the optimal cerebral perfusion pressure (CPPopt), which was associated with better outcome after traumatic brain injury. The role of CPPopt in aSAH-patients, especially, in those undergoing intra-arterial rescue therapy (RT) has not been described yet. The aim of this study was to investigate CA before and after intra-arterial RT and its correlation with the incidence of delayed cerebral infarction (DCI) and functional outcome.

#### Methods

A retrospective analysis of a consecutive aSAH cohort treated at our institution between 2012 and 2020 was performed. PRx was calculated as the correlation coefficient of ICP and mean arterial pressure (MAP), whereas the CPPopt was the CPP-value at the lowest PRx-value. The incidence of DCI was documented. Functional outcome was assessed according to modified Rankin scale (mRS) at 3-month-follow up. PRx, CPPopt well as the deviation of the actual CPP from CPPopt in a 12-hour time window before intraarterial RT and after RT were correlated with DCI, and mRS.

#### Results

A total of 324 aSAH-patients were eligible and 14% (45/324) met the inclusion criteria of the study. The mean age was 51 years. Overall, CPP was significantly higher after RT (p=0.038). Patients with higher CPP and CPPopt values after RT were less likely to develop DCI (p=0.015 and p=0.009, respectively). Furthermore, a trend towards better outcome being associated with higher CPPopt values (p=0.057) post RT was demonstrated. The deviation of actual CPP from CPPopt was not significantly associated with DCI or the functional outcome.

#### Conclusion

Patients with higher CCP and CPPopt values after RT were less likely to develop DCI.

Abb. 1

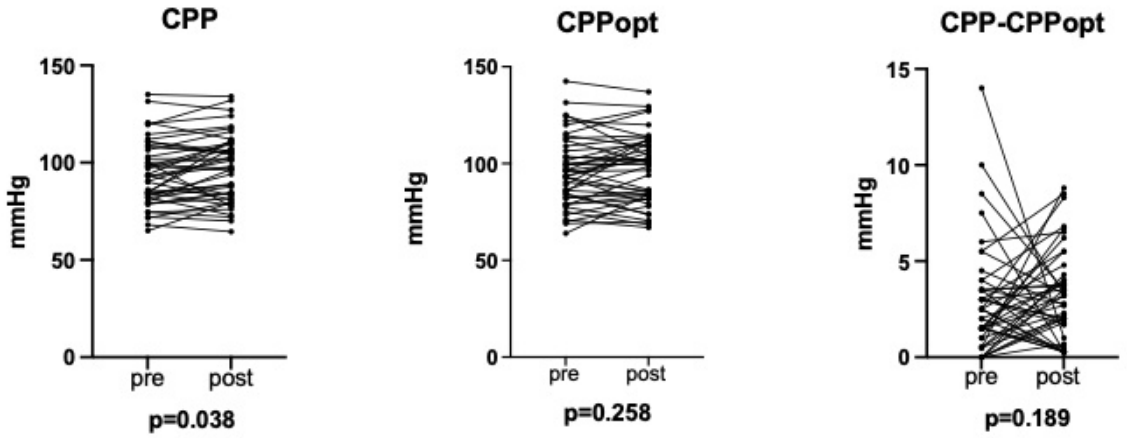
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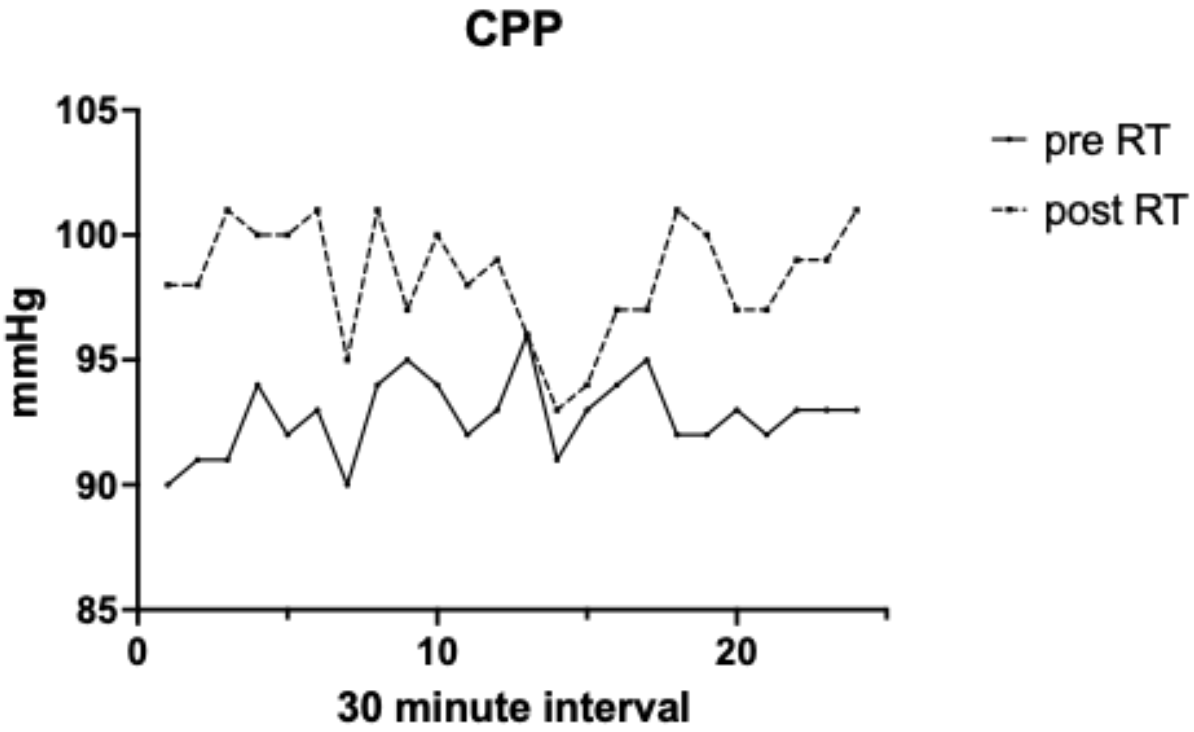
Abb. 2


CPP
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mmHg
0
10
20
30 minute interval
pre RT
post RT

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V049

### Erarbeitung zuverlässiger Indikatoren für die maligne Transformation eines ischämischen Schlaganfalls, der einedekompressive Hemikraniektomie erfordert - der Malignant Stroke Indicator

***Elaborating reliable indicators for malignant transformation of ischemic stroke requiring decompressive hemicraniectomy – The malignant stroke indicator***

X. Hautmann[1], A. Jamous[2], I. Maier[3], C. Bettag[1], S. Hernandez-Duran[1], M. S. Ernst[2], D. Mielke[1], V. Rohde[1], R. Muradzade[1], V. Malinova[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsmedizin Göttingen, Neuroradiologie, Göttingen, Deutschland
[3]Universitätsmedizin Göttingen, Neurologie, Göttingen, Deutschland

#### Objective

Decompressive craniectomy (DHC) has been demonstrated to effectively prevent mortality in patients with progressive brain edema associated with ischemic stroke (IS). Although several factors have been identified contributing to progressive edema no clear selection criteria have been established so far for a reliable and early identification of patients, who will develop malignant IS requiring DHC. The aim of this study was to assess the discrimination power of clinical and radiological parameters for indicating DHC after IS and to develop a scoring system indicating a high risk for malignant transformation.

#### Methods

A large interdisciplinary database of patients treated with IS at our center between 2010 and 2021 was retrospectively reviewed. Parameters, known to be associated with malignant IS possibly requiring DHC, were included in the initial correlation analysis: age, previous stroke, basal cistern effacement, midline shift, intravenous lysis, successful recanalization (TICI ≥ 2b), ASPECTS on native CT as well as on CT perfusion, NIHSS and glucose level on admission. ROC – analysis was done to determine the cutoff values for each parameter, that was included in the development of the scoring system.

#### Results

A total of 534 patients were included in the study, in 153 (29%) of whom DHC was performed. Based on the parameters that were significantly associated with the need for DHC, a scoring system (Malignant Stroke Indicator = MSI) was created for identification of patients, who will develop malignant stroke requiring DHC (table 1). The elaborated MSI-score ranging from 0 to 23 showed a strong correlation with the need for DHC ($r=0.69$, $p<0.0001$). After performing ROC-analysis a cutoff value of MSI-score > 7 was found to have the highest discrimination power between patients needing DHC and those who don"t (AUC 0.90, $p<0.0001$). Patients with a MSI-score > 7 had a 17-fold higher probability of requiring DHC compared to those with a MSI-score of ≤ 7 (OR 17.01, PPV 0.80, NPV 0.81, $p<0.0001$).

#### Conclusion

The MSI score is a reliable tool to predict the need for DHC at an early stage. The discrimination power is higher than that of comparable scores.

Abb. 1

**Table 1.** Malignant Stroke Indicator (MSI-score)

| Parameters | Presentation | Points |
|---|---|---|
| **Age** | ≥ 70 years<br>< 70 years | 0<br>4 |
| **Basal cistern effacement** | No<br>Yes | 0<br>3 |
| **Midline shift** | 0<br>0-3 mm<br>3-6 mm<br>6-9 mm<br>>9 mm | 0<br>1<br>2<br>4<br>7 |
| **Previous stroke** | No<br>Yes | 0<br>1 |
| **Successful recanalization (thrombectomy) TICI ≥ 2b** | No<br>Yes | 0<br>5 |
| **NCCT ASPECTS** | ≥7<br><7 | 0<br>1 |
| **CBV ASPECTS** | ≥6<br><6 | 0<br>1 |
| **NIHSS on admission** | ≤ 16<br>>16 | 0<br>1 |

TICI=thrombolysis in cerebral infarction, NCCT=native cranial computed tomography, CBV=cerebral blood volume, ASPECTS=Alberta Stroke Program Early CT Score, NIHSS=National Institutes of Health Stroke Scale

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V050

### Die Bestimmungsfaktoren des Infarktendvolumens bei Patienten mit malignem ischämischem Schlaganfall, die sich einer dekompressiven Hemikraniektomie unterziehen.

***Determinators of infarction end volume in patients with malignant ischemic stroke undergoing decompressive hemicraniectomy***

R. Muradzade[1], X. Hautmann[1], A. Jamous[2], I. Maier[3], D. Mielke[1], V. Rohde[1], V. Malinova[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsmedizin Göttingen, Neuroradiologie, Göttingen, Deutschland
[3]Universitätsmedizin Göttingen, Neurologie, Göttingen, Deutschland

#### Objective

Ischemic stroke is accompanied by the risk of malignant transformation with increasing infarction size resulting in high mortality and permanent disability. Decompressive hemicraniectomy (DHC) can reduce the mortality rate in patients with malignant stroke. However, the morbidity remains high. This study investigated factors associated with smaller infarction size and better functional outcome after performing DHC in patients with ischemic stroke.

#### Methods

A large interdisciplinary database of patients with ischemic stroke treated at our center between 2010 and 2021 was retrospectively reviewed. Parameters associated with malignant ischemic stroke requiring DHC like recanalization, ASPECTS score calculated based on native computed tomography scan (NCCT) as well as on CT perfusion were analyzed. The volumes of total hypoperfused tissue (ischemic core and penumbra) as well as of the end infarction were measured.

#### Results

A total of 534 patients with ischemic stroke were eligible. Malignant transformation requiring DHC occurred in 153 (29%) patients. Factors associated with a better outcome at 3 months follow-up were: younger age (r=0.21, p=0.007), lower NIHSS score (r=0.21, p=0.008), and smaller infarction end volume (r=0.28, p=0.01). A smaller infarction end volume in relation to the total hypoperfused tissue significantly correlated with a better outcome (r=-0.26, p=0.01). Successful mechanical reperfusion (r=0.22, p=0.04) and a smaller CBV ASPECTS score on admission (r=-0.23, p=0.03) were associated with smaller infarction end volume related to the total hypoperfused tissue after DHC. There was a trend to smaller infarction end volumes with higher collateral scores (r=-0.21, p=0.06).

#### Conclusion

Aside from age and clinical status on admission, the infarction end volume was a determinator of functional outcome at 3 months follow up in our study cohort. Successful recanalization and a smaller territory affected in the CBV ASPECTS were the main factors associated with smaller infarction volumes and should be considered while indicating DHC in this patient population.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V051

### Objektive Messung der Schwere von Hemifacialschmerzen durch Gesichtserkennung: Aufdecken von Korrelationen mit der Lebensqualität

***Objective measurement of hemifacial spasms severity via facial recognition: Unveiling correlations with quality of life***

A. Al Menabbawy[1,2], L. Ruhser[3], E. Elrefaee[4,5], M. Weidemeier[4], M. Matthes[4], H. W. S. Schroeder[4]

[1]University Medicine Greifswald, Neurochirurgie, Greifswald, Deutschland
[2]Cairo University, Neurosurgery, Cairo, Ägypten
[3]University Medicine Greifswald, Greifswald, Deutschland
[4]University Medicine Greifswald, Department of Neurosurgery, Greifswald, Deutschland
[5]Kasr Alainy school of Medicine, Neurosurgery, Kairo, Ägypten

#### Objective

Severity of hemifacial spasm impairs the quality of life of affected individuals. Although many classification and grading systems have been developed, they are almost always subjective without accurate quantification of the spasms. In this study we lever the usage of facial recognition and facial tracking technology in order to accurately quantify the spasms severity and be able to classify patients according to severity and distribution of the spasms.

#### Methods

Preoperative video recordings of the facial spasms with durations of at least 15 sec including the whole face were included. Videos were analyzed using Apple AR kit for facial tracking where after recognition of the face a mesh is allocated to specific biometric facial points. videos were then evaluated using Blender open-source software for measuring the amplitude and frequency of the spasms. Classification of the patients into groups was done using both divisive k-means and agglomerative hierarchical clustering. Correlation-Analysis with preoperative quality of Life (Qol) using SF-36 questionnaire scores was then performed.

#### Results

79 preoperative videos could be accurately analyzed. Both up-bottom and bottom-up clustering approaches clustered the patients into 3 different groups/clusters according to the 4 variables (eye closure, mouth distance change, rate, and repetition of the spasms). Correlation of the groups with the Qol was done only for 45/79 patients (57%). Group 1 (Mainly tonic affection of the mouth and sparing the eye). Group 2 (highest frequency and repitition (clonic group). Group 3 (severe tonic affection of both the eye and mouth). Group 2 (clonic group) showed better total average and emotional Qol score in comparison to the other two groups.

#### Conclusion

Using facial recognition and tracking technologies can accurately classify and quantify the facial spasms and their severity over time as well as pre with postintervention. Hemifacial spasms can be classified into three groups according to frequency and amplitude of the spasms. Group 2 (clonic group) has the best quality of life among the three groups.

# Vaskuläre Neurochirurgie – Schlaganfall | Vascular Neurosurgery – stroke

## V052

### Chirurgische Infarktvolumenreduktion und funktionelles Outcome in Patienten mit ischämischem Kleinhirninfarkt - Ergebnisse einer multizentrischen Studie

***Surgical infarct volume reduction and functional outcomes in patients with ischemic cerebellar stroke – Results from a multicentric retrospective study***

S. Hernandez Duran[1], J. Walter[2], B. Behmanesh[3], J. Bernstock[4], M. Czabanka[5], N. Dinc[6], D. Dubinski[3], T. Freiman[3], J. Konczalla[5], R. Melkonian[6], D. Mielke[1], P. Naser[2], V. Rohde[1], J. H. Schaefer[5], C. Senft[6], A. Unterberg[2], S. Y. Won[3], F. Geßler[3]

[1]Universitätsmedizin Göttingen, Klinik für Neurochirurgie, Göttingen, Deutschland
[2]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[3]Universitätsklinikum Rostock, Klinik für Neurochirurgie, Rostock, Deutschland
[4]Harvard Medical School, Boston, MA, Deutschland
[5]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[6]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

#### Objective

Recent work on ischemic cerebellar stroke has suggested that the resection of infarcted tissue may lead to improved functional outcomes when compared to decompressive surgery alone. Despite this, no studies have assessed the extent to which necrotic tissue should be resected or if there are any volumetric thresholds capable of predicting functional outcomes in this patient population.

#### Methods

This is a multicentric retrospective study of patients who underwent surgery for the management of ischemic cerebellar stroke. Volumetric analyses of infarcted tissue present on CT scans was performed before and after surgical intervention(s). Final infarct volume (FIV) was computed as a percentage of the initial infarct volume (i.e., postoperative infarct volume/preoperative infarct volume * 100). The primary endpoint was functional outcome at three months, as determined by the modified Rankin Scale (mRS); mRS was dichotomized as favourable for 0-2, and unfavourable for 3-6. Receiver operating characteristic (ROC) curves were used to explore the relationship between postoperative infarct volumes and FIV vs mRS, and Youden"s index was employed to estimate potential volumetric thresholds.

#### Results

A total of 91 patients were included in the study. Mean pre- and postoperative infarct volumes were 45.25 cm3 (SD 18.32) and 29.56 cm3 (SD 26.61), respectively. While postoperative infarct volumes of ≤17 cm3 yielded a sensitivity of 77% and a specificity of 68% with regard to the prediction of favourable outcome at three months, the resection of ≥50% of infarcted tissue was also predictive of favourable outcomes at three months (OR 7.7, 95% CI 2.7 – 21.8, p<.001).

#### Conclusion

Reduction of necrotic tissue volumes by at least 50%, and/or reduction of the infarct volume to ≤17 cm3 appears to predict favourable functional outcomes in patients with surgically managed ischemic cerebellar strokes.

# Tumor – Bildgebung | Tumour – Imaging

## V053

### Ein generativer KI-Ansatz für 18F-FET-PET durch multimodale MRT-Fusion bei Patienten mit niedriggradigen Gliomen

***A generative-AI approach to 18F-FET-PET via multimodal MRI fusion of lower-grade glioma patients***

E. Suero Molina[1,2], M. Tabassum[3], G. Azemi[3], Z. Özdemir[2], A. Valls Chavarria[2], W. Roll[4], C. Thomas[5], C. Russo[3], S. Liu[3], W. Stummer[2], A. Di Ieva[3]

[1]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Deutschland
[2]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[3]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[4]Universitätsklinikum Münster, Nuklearmedizin, Münster, Deutschland
[5]Universitätsklinikum Münster, Neuropathologie, Münster, Deutschland

#### Objective

The lack of availability of amino acid Positron Emission Tomography (PET) in many regions poses a challenge to comprehensive therapeutic decision-making in patients harboring lower-grade gliomas (LGG). To address this gap, we evaluated a novel generative artificial intelligence (AI) approach for the creation of synthetic 18F-FET-PET from magnetic resonance imaging (MRI).

#### Methods

In this study, we employ a Generative Adversarial Network framework (GAN) for the generation of $^{18}$F-FET-PET images from multimodal Magnetic Resonance Imaging (MRI). Configured for conditional image generation, the GAN maps observed MRI images (x) and random noise vectors (z) to output PET images (y), formulated as $G:\{x,z\}\rightarrow y$. Prior to integrating multimodal MRI sequences into our framework, a critical preprocessing stage is implemented to effectively align and standardize these modalities, given the inherent complexities associated with 3D NIFTI MRI volumes and the need for accurate pairing with PET modalities. We utilize a split-input fusion module for processing different MRI modalities, including T1, T1c, and FLAIR, through feature extraction, concatenation, and self-attention.

#### Results

MRI and PET images from 213 patients harboring lower-grade gliomas were included. Our evaluation of synthetic brain PET images generated by the proposed model utilizes three principal metrics: Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), and Root Mean Square Error (RMSE). The PSNR analysis indicates a prominent peak around 40 dB, highlighting high signal fidelity relative to noise. The SSIM demonstrates substantial structural congruence, with computed values skewing towards higher ranges, emphasizing the similarity of the generated images to real PET images. Additionally, RMSW analysis reveals a concentration of lower values, below 5.6, suggesting precise pixel intensity predictions by the model. Collectively, these results underscore the model's capability to generate synthetic PET images with high fidelity.

#### Conclusion

We demonstrate, for the first time, that the generation of synthetic 18F-FET-PET images out of multimodal MRI fusion of patients harboring LGG, including hotspot recreation, is feasible. Future studies will involve improving the model by exploring different advanced MRI sequences and using other generative AI methods.

# Tumor – Bildgebung | Tumour – Imaging

## V054

### Einfluss der O-(2-[18F]fluorethyl)-L-Tyrosin (18F-FET) PET-Bildgebung im Rahmen einer multimodalen Glioblastom-Therapie kombiniert mit der Vakzinierung mit Dendritischen Zellen

***Impact of O-(2-[18F]fluoroethyl)-L-tyrosine (18F-FET) PET imaging in the framework of multimodal glioblastoma therapy combined with dendritic cell vaccination***

N. Houedjissin[1], R. Sorg[2], J. Felsberg[3], B. Turowski[4], K. J. Langen[5], N. Galldiks[6], A. Stamsis-Datsi[2], G. Reifenberger[3], G. Stoffels[5], M. Sabel[1], M. Rapp[1]

[1]Universitätsklinikum Düsseldorf, Klinik für Neurochirurgie, Düsseldorf, Deutschland
[2]Universitätsklinikum Düsseldorf, Transplantationsdiagnostik und Zelltherapeutika, Düsseldorf, Deutschland
[3]Universitätsklinikum Düsseldorf, Neuropathologie, Düsseldorf, Deutschland
[4]Universitätsklinikum Düsseldorf, Neuroradiologie, Düsseldorf, Deutschland
[5]Forschungszentrum Jülich GmbH, Klinik für Nuklearmedizin, Jülich, Deutschland
[6]Universitätsklinikum Köln, Klinik für Neurologie, Neuroonkologie, Köln, Deutschland

#### Objective

Treatment of glioblastoma is becoming increasingly complex with the combination of surgery, radio-, chemotherapy and new approaches like dendritic cell vaccination (DC-V). Conventional MRI follow-up may reveal contrast-enhancing lesions, which cannot be reliably distinguished between therapy-induced changes (PsP) and disease progression (PD). This study investigates the impact of additional 18F-FET-PET imaging, subsequent to the suspicion of PD in the MRI follow-up in glioblastoma patients treated in the framework of the ongoing GlioVax DC-V study.

#### Methods

Patients enrolled in the GlioVax trial received 3 monthly MRI controls. 43 patients, of whom 23 received DC-V with radio-chemotherapy, with a suspicious MRI finding, additionally received in total 74 18F-FET-PET or 18F-DOPA PET scans for further differentiation. 67 18F-FET-PET results were analyzed and correlated with clinical data.

#### Results

In the vaccine group, positive 18F-FET-PET results were observed in 33,3% (n=13/39) and negative results in 28,2% (n=11/39) of cases. In the control group, positive results occurred in 46,4% (n=13/28) and negative findings in 25% (n=7/28) of cases. Further surgical investigation or follow up MRI without re-resection confirmed 18F-FET PET results in 83,3% (n=20/24) of cases for the vaccine group. Equivocal results occurred in 38,5% (n=15/39) of cases for the vaccine and in 28,6% (n=8/28) for the control group. We observed that the time from DC-V to MRI suspicious for PD significantly predicts the result equivocal (p=0,037). The frequency of additional PET imaging significantly differs from an expected equal distribution in context of the GlioVax trial with 1:1 stratification by MGMT promoter methylation status. We observed in cases with unmethylated MGMT promoter treated with DC-V a significantly (p=0,0159) higher incidence of MRI findings suspicious for PD, in 34,6% (9/26) with positive, in 23,1% (6/26) with negative and in 42,3% (11/26) with equivocal 18F-FET-PET results. Surgical investigation or follow up MRI without re-resection confirmed positive or negative FET PET results in 86,7%.

#### Conclusion

18F-FET-PET imaging provides additional information to characterize equivocal MRI results after DC-V and is beneficial for treatment decisions. Patients with unmethylated MGMT promoter who were treated with DC-V showed a significantly higher incidence of imaging findings indicating PsP. In cases for the vaccine group, equivocal 18F-FET-PET findings occurred most frequently early after DC-V.

# Tumor – Bildgebung | Tumour – Imaging

## V055

### Herausforderungen in der Bildgebung: Einfluss der Immuntherapie auf die diagnostische Genauigkeit von Aminosäure-PETs bei vermuteten progressiven Hirnmetastasen.

***Imaging challenges: Immunotherapy's influence on the diagnostic accuracy of amino acid PET in suspected progressive brain metastases***

L. Baumgart[1], C. Delbridge[2], B. Meyer[3], W. Weber[4], H. S. Meyer[1], J. Gempt[1], I. Yakushev[4]

[1]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Neuropathologie, München, Deutschland
[3]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[4]Klinikum rechts der Isar, Technische Universität München, Nuklearmedizin, München, Deutschland

#### Objective

Immunotherapy (IT) has gained increased significance as a systemic therapy option in the management of various types of metastatic cancer, including cases involving brain metastases (BMs). The differential diagnosis of progressive/relapsed BMs and treatment-related changes (TRC) is often based on imaging with amino acid (AA) PET, in addition to standard magnetic resonance imaging (MRI), as this has been established to provide higher diagnostic accuracy. However, diagnostic value of the AA-PET in the context of IT has not been studied so far. In this pilot study we quantified diagnostic accuracy of AA PET in patients with suspected progressive BMs under IT.

#### Methods

This retrospective study included patients with suspected progressive/relapsed BMs on MRI after radiotherapy (RT) between 04/2007 – 01/2023. Only patients with AA PET ≤ 4 weeks prior to surgery/biopsy of BMs were selected. AA PET results were compared with histopathological findings and distinctive features were highlighted.

#### Results

Out of 29 patients, 7 were treated with IT (IT+ group). Remaining patients (IT- group) were treated with chemotherapy, targeted therapy, a combination of both, or obtained no systemic therapy before PET. The groups did not differ regarding age, gender, initial number of BMs or time interval between PET and last RT. In the IT+ group, 6 patients had malignant melanoma and 1 patient urothelial carcinoma as primary tumor. The IT+ patients obtained ipilimumab, nivolumab, or pembrolizumab, sequentially, or in combination. In the IT+ and IT- group, 7 and 21 PET scans were read as suspicious for progressive/relapsed BMs, respectively. The rate of false-positive findings was 5/7 (71.4%) and 3/21 (14.3%), respectively (chi square test, p=0.008). Histopathological analyses revealed an inflammatory reaction with lymphocytic infiltrates in the examined tissue in the IT+ group.

#### Conclusion

There is a significantly higher rate of false-positive AA PET findings in patients with BMs who have been treated with IT. This observation may be explained by an immunologically mediated inflammatory reaction. Further immunological analyses of lymphocytic infiltrates could provide more information. In conclusion, until more data are available, caution should be exercised when diagnosing tumor recurrence using AA PET in patients who have previously received IT.

# Tumor – Bildgebung | Tumour – Imaging

## V056

### Diagnostik von Gliomen mittels färbefreier multiphotonen Bildgebung: Machine Learning zur Detektion der IDH1 Mutation

***Towards glioma diagnosis using label-free multiphoton imaging: Machine learning for IDH1 mutation detection***

L. V. Duncker[1], S. Richter[2], R. Galli[1], A. Temme[2], I. Y. Eyüpoglu[2], O. Uckermann[1]

[1]TU Dresden, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

#### Objective

Multiphoton microscopy, which integrates coherent anti-Stokes Raman scattering (CARS) for lipid assessment, second harmonic generation (SHG) for collagen visualization, and two-photon excited fluorescence (TPEF) for autofluorescence analysis, allows the morphochemical evaluation of tissues. This advanced technique, coupled with machine learning, enables the discrimination of brain tumors and non-tumor brain. In this study, we aim to investigate if this approach can be extended to classify glioma samples according to IDH1 mutation status.

#### Methods

The study involved the examination of 29 samples of human glioma, including astrocytoma, IDH1-mutant WHO 2-4 (n=9), oligodendroglioma IDH1-mutant WHO 2-3 (n=6), and glioblastoma, IDH1-wildtype (n=14). Multimodal CARS/TPEF/SHG images were acquired from unstained cryosections, resulting in a total of 3600 images. Texture parameters (mean, standard deviation, kurtosis, skewness, entropy, contrast, correlation, energy, homogeneity) were extracted and linear discriminant analysis was employed for discrimination of IDH1-mutant and IDH1-wildtype glioma using a leave-one-patient-out approach.

#### Results

Visual inspection of the images revealed considerable interpatient variability. However, prominent lipid droplets, reduced autofluorescence, and the presence of SHG-active extracellular matrix were associated with glioblastoma. The combined analysis of texture parameters of CARS and SHG images proved to be the most effective in distinguishing images of IDH1-mutant gliomas from IDH1-wildtype gliomas (AUC 0.89), while adding texture parameters of TPEF images did not improve classification accuracy (AUC 0.84). This approach allowed to correctly predicting the IDH1 mutation status for 86% (25/29) of the patients. Importantly, both astrocytoma WHO 4 cases in the cohort were correctly identified as IDH-mutant.

#### Conclusion

The analysis of combined CARS/SHG images of human brain tumors yields reliable information on tissue type, even in the context of high intra- and interpatient variability. In combination with miniaturized multiphoton endoscopes, this approach holds great promise for intraoperative brain tumor delineation and characterization, potentially allowing intraoperative diagnosis and aiding surgeons in optimizing patient therapy.

# Tumor – Bildgebung | Tumour – Imaging

## V057

### Die T1/T2-Tumorvolumen-Ratio ist bei Patientinnen und Patienten mit IDH.mutierten, ZNS WHO Grad 2 und 3 Astrozytomen mit dem Resektionsausmaß assoziiert

***The ratio of T1 to T2 tumor volume (T1/T2 ratio) is associated with resectability in patients with IDH-mutant astrocytomas CNS WHO grades 2 and 3***

J. Weller[1], E. de Dios Perez[2], S. Katzendobler[1], A. Corell[3], A. Dénes[3], M. Schmutzer-Sondergeld[1], N. Javanmardi[4], N. Thon[1], J. Tonn[1], A. S. Jakola[3]

[1]Klinikum der Ludwig-Maximilians-Universität München, Klinik für Neurochirurgie, München, Deutschland
[2]Sahlgrenska Universitätsklinikum, Klinik für Radiologie, Gothenburg, Schweden
[3]Sahlgrenska Universitätsklinikum, Klinik für Neurochirurgie, Gothenburg, Schweden
[4]Sahlgrenska Universitätsklinikum, Institut für Neurowissenschaften, Gothenburg, Schweden

#### Objective

Diffuse lower-grade gliomas (dLGG), histologically IDH-mutant astrocytomas CNS WHO grade 2 and 3, show heterogenous appearance on MRI. The discrepancy between T1 hypointense and T2 hyperintense tumor volume might be a marker for diffuse tumor growth (Fig. 1). Data from pre-molecular era suggest that T1/T2 discrepancy is associated with larger tumor residuals and short survival. In molecular defined dLGG, we set out to investigate if the ratio between T1 and T2 tumor volume (T1/T2 ratio) was associated with neurosurgical resectability and overall survival.

#### Methods

Patient data from two centers (Sahlgrenska University Hospital, Gothenburg, Sweden, Center A; LMU University Hospital, Munich, Germany, Center B) were collected retrospectively. Inclusion criteria were: pre- and postoperative MRI scans available for volumetric analysis (I), diagnosis of an IDH-mutant astrocytoma between 2003 and 2021 (II) and tumor resection at initial diagnosis (III). Tumor volumes were manually segmented. The T1/T2 ratio was calculated and correlated with extent of resection, residual tumor volume and overall survival.

#### Results

The study comprised 134 patients with 65 patients included from Center A and 69 patients from Center B. The median overall survival was 134 months and did not differ between the cohorts (p=0.29). Median follow-up was 67 months. There were no significant differences between the centers in patient age (p=0.43), KPS (p=0.11), number of patients with contrast enhancement (p>0.99), initial T2 tumor volume (p=0.96), postoperative T2 volume (p=0.14) or the distribution of CNS WHO grades (p=0.86). Median T1/T2 ratio was 0.79 (range 0.15-1.0). Tumors displaying a T1/T2 ratio of 0.33 or lower showed significantly larger, residual tumor volume postoperatively (median 17.9 cm3 versus 4.6 cm3, p=0.03) (Fig. 2). The extent of resection in these patients was 65% as opposed to 90% in patients with a ratio above 0.33 (p=0.03). The ratio itself did not correlate with overall survival. In multivariable analyses, larger postoperative tumor volume was associated with shorter survival times (HR 1.02, 95 CI 1.01-1.03, p<0.01).

#### Conclusion

The T1/T2 ratio might be a good indicator for diffuse tumor growth on MRI and is associated with resectability and in patients with IDH-mutant astrocytoma. This ratio might aid in selecting patients for tumor resection and planning alternate initial strategies.

Abb. 1

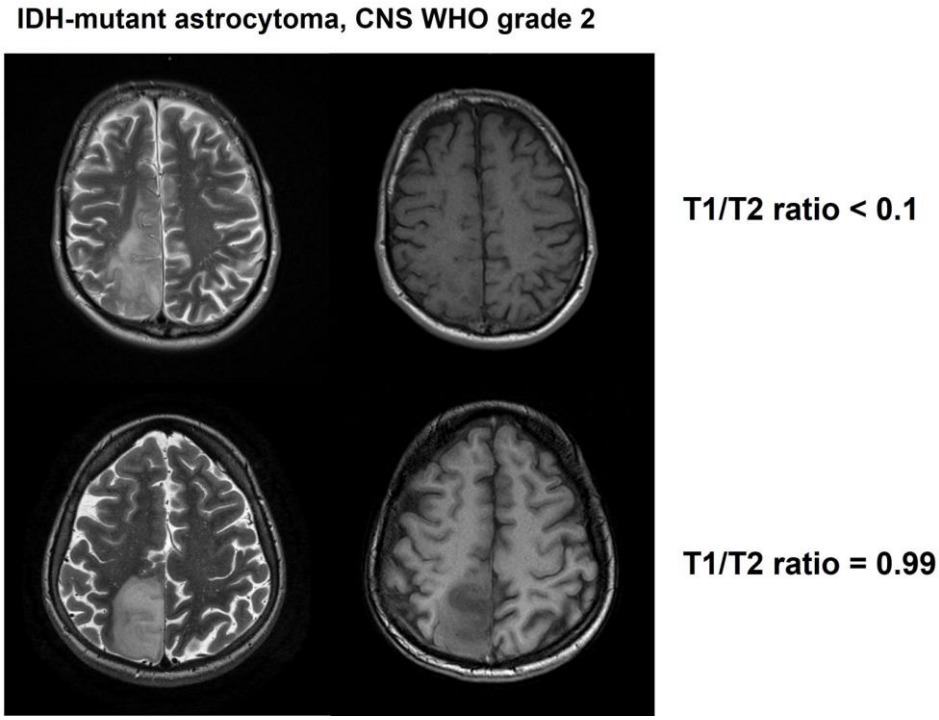
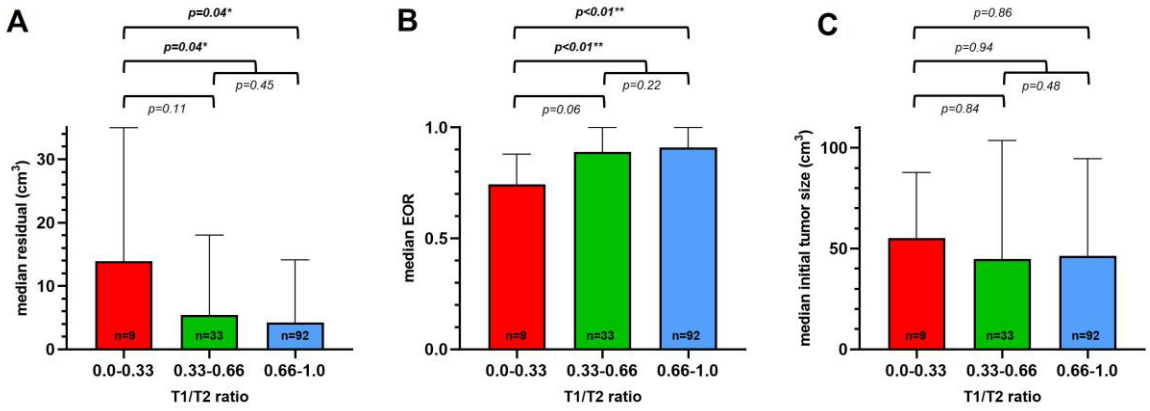

IDH-mutant astrocytoma, CNS WHO grade 2
T1/T2 ratio < 0.1
T1/T2 ratio = 0.99

Abb. 2


A
p=0.04*
p=0.04*
p=0.45
p=0.11
median residual (cm³)
30
20
10
0
n=9
n=33
n=92
0.0-0.33
0.33-0.66
0.66-1.0
T1/T2 ratio
B
p<0.01**
p<0.01**
p=0.22
p=0.06
median EOR
1.0
0.5
0.0
n=9
n=33
n=92
0.0-0.33
0.33-0.66
0.66-1.0
T1/T2 ratio
C
p=0.86
p=0.94
p=0.48
p=0.84
median initial tumor size (cm³)
100
50
0
n=9
n=33
n=92
0.0-0.33
0.33-0.66
0.66-1.0
T1/T2 ratio

# Tumor – Bildgebung | Tumour – Imaging

## V058

### Rezidivmuster bei Patienten mit Grad 4 Gliomen und primären multifokalen FLAIR-Anomalien
*Recurrence patterns in patients with grade 4 Gliomas and primary multifocal FLAIR abnormalities*

J. Farzullayev[1], V. Malinova[1], T. Hasan[1], D. Mielke[1], V. Rohde[1], A. Tammam[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland

#### Objective

Background: The utility of T2-weighted Fluid-Attenuated Inversion Recovery (FLAIR) sequences in high-grade gliomas has not been definitively proven. This study investigates the recurrence patterns in patients with grade IV gliomas who demonstrated multifocal manifestations of abnormalities in FLAIR sequences at first diagnosis.

#### Methods

Methods: A consecutive cohort of 432 patients with grade IV gliomas from 2010 to 2021 was retrospectively investigated. Patients with multifocal enhancing lesions and those with incomplete images were excluded. MR imaging (MRI) at diagnosis was analyzed to identify patients with multifocal changes in FLAIR sequences in correlation to the contrast-enhancing lesions. In these patients, MRI at recurrence was evaluated to identify the localization of new enhancing lesions in comparison to the primary changes in the FLAIR sequence.

#### Results

Results: Fifty-four (12.5%) patients showed multifocal FLAIR changes at diagnosis. The mean age at initial diagnosis was 60 years. Ipsilateral FLAIR abnormalities near the contrastenhancing lesion in the same lobe (with distance to the local FLAIR surrounding enhancing lesion, group 1) were the most common FLAIR change recognized at initial MRI in 53% of the patients. Twenty-nine percent exhibited distant FLAIR abnormalities on the ipsilateral side (group 2), and 26.3% distant FLAIR abnormalities on the contralateral side (group 3). The mean progression-free survival (PFS) was 6.6 months. FLAIR changes could predict recurrent enhancing lesions in all groups; group 1 with a specificity of 85% and sensitivity of 77%, p=0.001, group 2 with a specificity of 100% and sensitivity of 73%, p<0.001, and group 3 with a specificity of 90% and a sensitivity of 53%, p=0.002. Notably, 13% of cases had new enhancing lesions in areas initially FLAIR-negative. Molecular markers like MGMT and IDH mutation status did not significantly alter recurrence patterns or PFS.

#### Conclusion

Conclusion: In grade IV glioma patients with primary multifocal FLAIR abnormalities, the location of recurrent enhancing lesions correlates significantly with initial FLAIR changes, highlighting the importance of FLAIR in predicting recurrence patterns and informing treatment strategies.

# Tumor – Bildgebung | Tumour – Imaging

## V059

### Präoperatives FET-PET zur Vorhersage von 5-ALA Gewebefluoreszenz in diffusen niedrig-gradigen Gliomen
***Predicting intraoperative 5-ALA fluorescence in diffuse lower-grade glioma using preoperative FET-PET***

M. Müther[1], W. Roll[2], L. König[2], M. Weckesser[2], M. Schäfers[2], W. Stummer[1]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Universitätsklinikum Münster, Klinik für Nuklearmedizin, Münster, Deutschland

#### Objective

Previous studies have revealed the potential utility of 5-aminolevulinic acid (5-ALA) as a surgical adjunct and prognostication tool in diffuse lower-grade gliomas (DLGG). However, besides contrast enhancement, a reliable means of identifying which DLGG will fluoresce has not been established. Amino acid PET with [18F]-fluoroethylthyrosine ([18F]-FET-PET) can inform delineation of metabolically active tumor components and guide decisions on surgical strategy. This study aims at evaluating the value of [18F]FET-PET for predicting intraoperative 5-ALA-derived tissue fluorescence.

#### Methods

Retrospectively, all therapy-naive patients diagnosed with with a WHO grade II (WHO CNS 2016) glioma 2012-2021 were screened for preoperative [18F]FET-PET imaging and 5-ALA fluorescence guided microsurgical resection. All diagnoses were updated for the current 2021 classification of CNS tumors. [18F]FET-PET/CT or PET/MRI were quantitatively analyzed, relevant positivity for [18F]FET was defined as TBRmax > 1.8. In cases in which dynamic imaging was available, late uptake kinetics were graded as increasing vs. indifferent/decreasing.

#### Results

Information on intraoperative fluorescence was available from 56 patients, of which 36 % presented with intraoperative fluorescence. Nineteen patients were diagnosed with oligodendroglioma (47% of which with intraoperative fluorescence) and 36 patients with IDH-mutant astrocytoma (28% of which with intraoperative fluorescence). Additional 20 patients were diagnosed with a molecular glioblastoma of IDH-wiltdype, without imaging or histopathological criteria of malignancy (8% of which with intraoperative fluorescence). Contingency analyses of neither [18F]FET-PET positivity (P .07, Fisher"s exact) nor [18F]FET-PET kinetics (P .99, Fisher"s exact) did point on a dependency of [18F]FET-PET and intraoperative 5-ALA-derived fluorescence. In line with previous studies, only gadolinium contrast enhancement is associated with intraoperative fluorescence (P .001).

#### Conclusion

Besides being helpful for surgical tumor sampling by depicting tumor heterogeneity, preoperative [18F]FET-PET is of prognostic importance. The same holds true for 5-ALA fluorescence. This study provides indirect evidence, that both methods provide information on tumor heterotegeity in DLGG but do not share a mutual mechanism of action.

# Tumor – Bildgebung | Tumour – Imaging

## V060

### Entwicklung und Anwendung eines maschinenlernbasierten Ansatzes zur quantitativen Hyperspektralen Führung bei der Resektion von Hirntumoren

***Towards machine learning-based quantitative hyperspectral image guidance for brain tumor resection***

D. Black[1], D. Byrne[1], A. Walke[2,3], S. Liu[4], A. Di Ieva[4], S. Kaneko[2,5], W. Stummer[2], S. Salcudean[1], E. Suero Molina[4,2]

[1]University of British Columbia, Vancouver, Kanada
[2]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[3]Core Unit Proteomics, Interdisciplinary Center for Clinical Research, Münster, Deutschland
[4]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[5]Hokkaido University Graduate School of Medicine, Department of Neurosurgery, Sapporo, Japan

#### Objective

Complete resection of malignant gliomas is hindered by the difficulty in distinguishingtumor cells at the infiltration zones. Fluorescence guidance with 5-ALA assists in reaching this goal. In previous work, we characterized five fluorophore emissions that accurately represent any spectrum measured from human brain tumor biopsies with a wide-field hyperspectral device. We performs four classification tasks using fluorescence spectroscopy, aiming to use the abundances of the five fluorophores to differentiate between (1) tumor and tissue types (e.g., glioblastoma, meningioma, etc.), (2) WHO grades, (3) between solid tumor, infiltrating zone, and reactively altered non-tumor brain tissue and (4) between IDH-mutant and IDH-wildtype glioma.

#### Methods

In this study, the effectiveness of these five spectra was explored for different tumor classification tasks in 891 hyperspectral widefield measurements of 184 patients harboring low- (n=30) and high-grade gliomas (n=115), non-glial primary brain tumors (n=19), radiation necrosis (n=2), miscellaneous (n=10) and metastases (n=8), which corresponds to up to 15000 spectra for a given test. The statistical differences in fluorophore abundances between classes were determined and visualized using dimensionality reduction techniques, including principal component analysis (PCA) and t-distributed stochastic neighbor embedding (t-SNE). We employed random forest and multilayer perceptron as classification models, considering various hyperparameters for the analysis.

#### Results

Four machine-learning models were trained to classify tumor type, WHO grade, glioma margins (solid tumor, infiltration zone and reactive brain tissue), and IDH mutation. Using random forests and multilayer perceptrons, the classifiers achieved average test accuracies of 84-87%, 96.1%, 86%, and 93% respectively. All five fluorophore abundances varied between tumor margin types and tumor grades ($p < 0.01$). For tissue type, at least four of the five fluorophore abundances were found to be significantly different ($p < 0.01$) between all classes.

#### Conclusion

These results demonstrate the fluorophores' differing abundances in different tissue classes and the value of the five fluorophores as potential optical biomarkers, opening new opportunities for intraoperative classification systems in fluorescence-guided neurosurgery. The potential value of translating this models to the operating room is immense.

# Tumor – Bildgebung | Tumour – Imaging

## V061

### Perfusions-MRT zur Differenzierung zwischen Progress und Therapie-assoziierten Veränderungen bei Glioblastompatienten nach Strahlentherapie mit Protonenboost

***Perfusion MRI for differentiation between progressive disease and therapy related change in proton-boost irradiated glioblastoma patients***

H. Gött[1], L. Singer[2], T. Struffert[3], E. Uhl[1], M. Stein[4]

[1]Universitätskliniken Gießen und Marburg, Klinik für Neurochirurgie, Gießen, Deutschland
[2]Universitätsklinikum Erlangen, Klinik für Neuroradiologie, Erlangen, Deutschland
[3]Universitätskliniken Gießen und Marburg, Klinik für Neuroradiologie, Gießen, Deutschland
[4]Universitätskliniken Gießen und Marburg, Neurochirurgie, Gießen, Deutschland

#### Objective

Increase in contrast enhancement or T2-FLAIR hyperintensity is frequently observed in glioblastoma (GBM) patients after radiation therapy (RT). These therapy related changes (TRC) are difficult to differentiate from a true progressive disease (PD). Perfusion MRI (PMRI) has been shown to be a helpful tool in distinguishing between PD and TRC after photon RT. Nevertheless, data investigating the usefulness of PMRI after proton tRT in GBM is still lacking. This study aims to evaluate PMRI for the differentiation between PD and TRC in GBM patients after proton-boost RT.

#### Methods

MRI scans (n=130) of 37 patients with newly diagnosed GBM, who received either photon RT or photon RT with proton-boost were retrospectively analyzed. T1 contrast enhancement, T2-FLAIR hyperintensity, and correlating leakage-corrected relative CBVmax (rCBVmax) values of the contrast enhancing, or T2-FLAIR hyperintense areas in a ratio to a corresponding ROI in the contralateral white matter were evaluated. Whether scans showed PD or TRC was defined depending on histology after biopsy or re-resection or increase of T1 contrast enhancement or T2-FLAIR hyperintensity in the serial follow up scans. Groups were compared with Mann-Whithney U-Test. For rCBVmax values a ROC analysis was performed.

#### Results

MRI scans of patients after proton RT showed more often an increase of T1 contrast enhancement (59.34%) compared to patients after photon RT (46.15%). However, these differences were not statistically significant (p=0.1001). rCBVmax of the T2 FLAIR hyperintense area was not significantly correlated with PD after photon RT. To predict PD after proton-boost RT the cut-off value for the rCBVmax of the FLAIR hyperintense area was >86.3% (AUC: 0.701, sensitivity 81.82%, specificity 58.7%, Youden index 0.405, p=0.0009). For prediction of PD the rCBVmax of contrast enhancing areas the cut-off value after photon RT was >145.8% (AUC: 0.754, Sensitivity 66.67%, specificity 84.21%, Youden index 0.509, p=0.0037). PD after proton-boost RT could be predicted with a cut-off value of the rCBVmax of 180.7% (AUC: 0.73, sensitivity 60.61%, specificity 86.21%, Youden index 0.468, p=0.0003).

#### Conclusion

For the prediction of PD PMRI, hyperperfusion in rCBVmax in T2-FLAIR is not very specific. In contrast, hyperperfusion in T1 contrast enhanced areas is highly specific for PD after proton-boost RT. PMRI is a very cost-effective technique that could be a useful tool to determine PD for patients after proton-boost therapy.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V062

### Die Verwendung direktionaler Elektroden bei der tiefen Hirnstimulation: Ergebnisse einer europaweiten Umfrage der EANS

***Directional electrodes in Deep Brain Stimulation: Results of a survey by the European Association of Neurosurgical Societies (EANS)***

P. Krauss[1], P. Duarte-Batista[2], M. Hart[3], J. Avecillas-Chasin[4], M. Bercu[5], V. Hvingelby[6], F. Massey[7], L. Ackermans[8], P. Kubben[8], N. van der Gaag[8,9], M. Krüger[7,10], .. EANS Functional Section[11]

[1]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland
[2]North Lisbon University Hospital Centre, Lissabon, Portugal
[3]University of London & St George's University Hospitals NHS Foundation Trust, London, Vereinigtes Königreich
[4]University of Nebraska Medical Center, Omaha, Vereinigte Staaten
[5]Helen DeVos Children's Hospital, Grand Rapids, MI, Vereinigte Staaten
[6]Aarhus University, Aarhus, Dänemark
[7]National Institute of Neurology and Neurosurgery, London, Vereinigtes Königreich
[8]Maastricht University Medical Center, Maastricht, Niederlande
[9]Haga Teaching Hospital, The Hague, Niederlande
[10]University Medical Center Freiburg, Freiburg i. Br., Deutschland
[11]EANS Functional Section, N/A, Europäische Union

#### Objective

Directional Leads (dLeads) represent a new technical tool in Deep Brain Stimulation (DBS), and a rapidly growing population of patients receive dLeads. The European Association of Neurosurgical Societies(EANS) functional neurosurgery Task Force on dLeads conducted a survey of DBS specialists in Europe to evaluate their use, applications, advantages, and disadvantages.

#### Methods

EANS functional neurosurgery and European Society for Stereotactic and Functional Neurosurgery (ESSFN) members were asked to complete an online survey with 50 multiple-choice and open questions on their use of dLeads in clinical practice.

#### Results

Forty-nine respondents from 16 countries participated in the survey (n=38 neurosurgeons, n=8 neurologists, n=3 DBS nurses). Five had not used dLeads. All users reported that dLeads provided an advantage (n=23 minor, n=21 major). Most surgeons (n=35) stated that trajectory planning does not differ when implanting dLeads or conventional leads. Most respondents selected dLeads for the ability to optimize stimulation parameters (n=41). However, the majority (n=24), regarded time-consuming programming as the main disadvantage of this technology. Innovations that were highly valued by most participants included full 3T MRI compatibility, remote programming, and closed loop technology.

#### Conclusion

Directional leads are widely used by European DBS specialists. Despite challenges with programming time, users report that dLeads have had a positive impact and maintain an optimistic view of future technological advances.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V063

### Closed-Loop epidurale Rückenmarkstimulation zur Behandlung chronischen Schmerzes bei Raynaud Phänomen. Eine prospektive, monozentrische Pilotstudie.

***Closed-loop spinal cord stimulation for the treatment of chronic pain associated with Raynaud's Phenomenon. A prospective, single-center pilot study***

G. Bara[1], P. Karakostas[2], B. Dietz[3], V. Schäfer[2], J. Maciaczyk[1]

[1]Universitätsklinikum Bonn, Stereotaxie und Funktionelle Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Rheumatologie, Bonn, Deutschland
[3]Saluda Medical Research, Harrogate, Vereinigtes Königreich

#### Objective

Raynaud's phenomenon (RP) is an episodic vasospasm of the peripheral arteries that causes cyanosis, erythema, pain, paraesthesia"s, and sometimes ulceration of the fingers and/or toes. There are few reports, mostly case series, on the benefits of spinal cord stimulation (SCS) for the treatment of RP. However, there is a lack of objective evidence on SCS induced modulation of the sympathetic system (e.g., vasodilation) in this condition.

#### Methods

This is a prospective, single-centre pilot study to evaluate the efficacy of ECAP-controlled closed-loop SCS (Evoke® SmartSCS, Saluda Medical, Australia) in the treatment of RP. Patient outcomes such as Raynaud Severity/Condition Score, Cochin Hand Function Scale, SHAQ RP VAS, EQ-5D-5L, PGIC, stimulation parameters, and objective peripheral blood flow assessments and neurophysiological measurements were collected at baseline, trial end, 1-month, 3-months, and 6-months.

#### Results

The mean age ± standard deviation (±SD) patients is 45.5±15.5 years (n=10), and 80% are female.

The mean baseline (±SEM; n=9) weekly attack frequency was 21.8±5.9 and decreased to 12.6±4.6 6-months after implantation (n=8; Figure 2A). The mean baseline (±SEM; n=9) severity of attacks was 6.7±0.4 which decreased to 3.3±0.6 6-months after implantation (n=8; Figure 2A). The mean baseline (±SEM; n=9) Raynaud's condition score was 6.6±0.7 and decreased to 2.6±0.7 6-months after implantation (n=8; Figure 2A).

The mean baseline (±SEM; n=9) cochin hand function scale score was 31.6±8.2 and decreased to 17.4±7.7 6-months after implantation (n=8; Figure 2B). The mean patient global impression of change score at 6-months after implantation was 2.3±0.4 (±SEM; n=8; Figure 2C).

#### Conclusion

In conclusion, ECAP-controlled closed-loop-SCS alleviates RP symptoms and improves peripheral blood flow.

Abb. 1

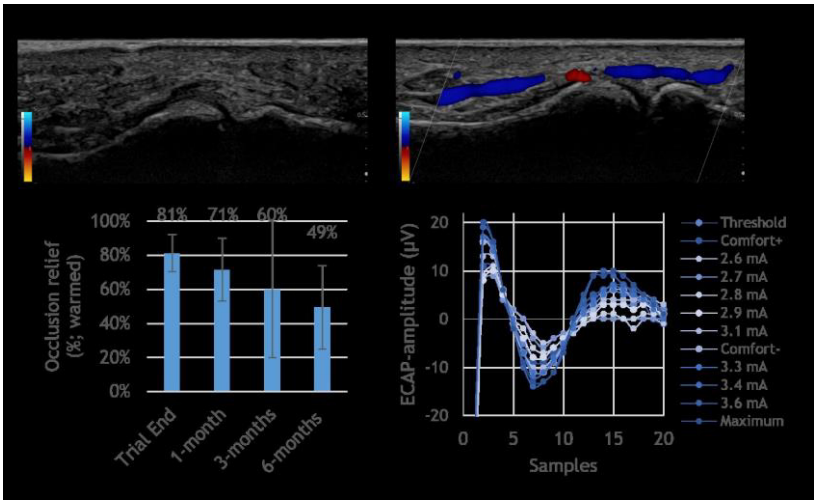
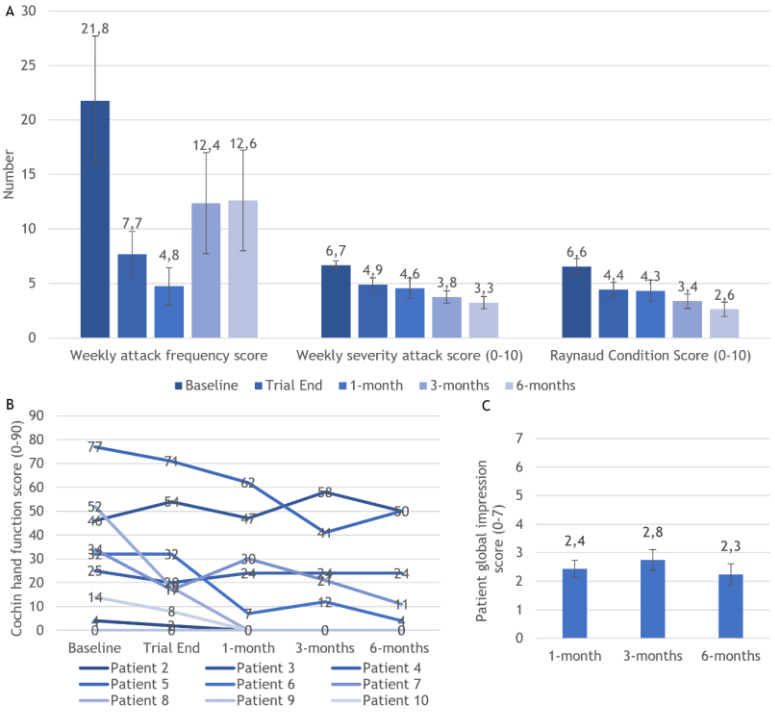

Occlusion relief (%; warmed)
100%
80%
60%
40%
20%
0%
81%
71%
60%
49%
Trial End
1-month
3-months
6-months
ECAP-amplitude (µV)
20
10
0
-10
-20
0
5
10
15
20
Samples
Threshold
Comfort+
2.6 mA
2.7 mA
2.8 mA
2.9 mA
3.1 mA
Comfort-
3.3 mA
3.4 mA
3.6 mA
Maximum

Abb. 2


A
Number
21,8
7,7
4,8
12,4
12,6
6,7
4,9
4,6
3,8
3,3
6,6
4,4
4,3
3,4
2,6
Weekly attack frequency score
Weekly severity attack score (0-10)
Raynaud Condition Score (0-10)
Baseline
Trial End
1-month
3-months
6-months
B
Cochin hand function score (0-90)
Baseline
Trial End
1-month
3-months
6-months
Patient 2
Patient 3
Patient 4
Patient 5
Patient 6
Patient 7
Patient 8
Patient 9
Patient 10
C
Patient global impression score (0-7)
2,4
2,8
2,3
1-month
3-months
6-months

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V064

### Evaluation von Behandlungs- und Re-Behandlungsstrategien der klassischen Trigeminusneuralgie mittels mikrovaskulärer Dekompression, Thermokoagulation und stereotaktischer Radiochirurgie: Eine Matched-Pair-Analyse zur Bewertung des Behandlungserfolgs und der Lebensqualität.

***Evaluation of treatment and re-treatment strategies for classic trigeminal neuralgia with microvascular decompression, radiofrequency ablation, and stereotactic radiosurgery: A matched-pair analysis evaluating treatment success and quality of life***

T. Greve[1], M. Kuklinski[1], A. Muacevic[2], J. H. Mehrkens[1]

[1]LMU Klinikum, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]European Cyberknife Center Munich-Grosshadern, München, Deutschland

#### Objective

For classical trigeminal neuralgia (TN), microvascular decompression (MVD), radiofrequency ablation (RA) and stereotactic radiosurgery (SRS) are established therapeutic approaches. We aimed to compare treatment and re-treatment modalities regarding pain relieve and quality of life (QoL) in a cross-sectional study design.

#### Methods

Between 2010 and 2021, 626 patients receiving MVD, RA or SRS were screened for inclusion. 350 patients could be interviewed using a standardized questionnaire. Parameters included pain severity (BNI score 0-5, <4: no neuralgia or controlled with drugs, 5: uncontrolled neuralgia despite drugs), QoL using the Q-5D-Y-5L questionnaire (1 maximal QoL, 0 death, <0 QoL worse than death) and complications. Values were recorded preoperatively, 4 weeks postoperatively and at the time of assessment. Matched pairs were compared based on age, sex, TN characteristics, previous procedures, follow-up (FU), branch affected, and pain intensity.

#### Results

Thirty-six triplets, totaling 108 patients, were matched with no significant differences in: age 68.5±9.6 years; sex 69% female; FU 5.2±4.1 years; symptom duration 8.3±6.4 years; preoperative scores: BNI-Score 5; QoL -0.19±0.23. Immediate pain relief was observed in 83.3% (MVD), 77.7% (RA), and 5.5% (SRS) ($p = 0.001$). Median time to pain relief for SRS was 3.1 months. Recurrences were seen in 39.4% (MVD), 50% (RA), and 34.4% (SRS) of cases ($p = 0.443$).

In cases of recurrence or persistent symptoms (39 and 13 cases, respectively), 24 and 6 cases underwent one or more additional treatments. In total, pain control (BNI < 4) was achieved in 81/108 (75%) cases, without differences in initial treatment modality or sequence of treatments.

Overall QoL at last FU was 0.64±0.28. For those with initial improvement and no recurrence, QoL was 0.73±0.16. In cases of initial improvement with recurrence and at least one additional treatment, QoL was 0.75±0.14; without additional treatment, QoL was 0.39±0.34. In cases of no improvement after first treatment and at least one more treatment, QoL was 0.71±0.10; without additional treatment, QoL was 0.11±0.36.

#### Conclusion

This is the first cross-sectional study showing that the key to long-term pain control in treatment failure is to receive additional treatment, regardless of the initial treatment modality or specific sequence of modalities. If all

patients with uncontrolled pain were re-treated, the potential overall control rate would be 91%, significantly higher than the 75% achieved.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V065

### Funktionelle Netzwerkaktivität bei akutem Schmerz und Capsaicin-induzierter Hyperalgesie als Ansatz zur Identifizierung von potentiellen Targets in der neuromodulatorischen Therapie

***Functional network interaction in acute pain and capsaicin-induced hyperalgesia: An approach to uncover potential brain targets for neuromodulatory therapy***

B. Kretzschmar[1], A. Rupp[2], M. M. Hajiabadi[1], S. Krieg[1], R. Ahmadi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Neurologie, Heidelberg, Deutschland

#### Objective

Understanding chronic pain is challenging due to limited knowledge about the underlying neural circuits. In acute pain, various brain regions are activated but they are only partially specific. Research on functional network organization is still in its beginning and has predominantly relied on functional magnetic resonance imaging (fMRI), which provides relatively low temporal resolution. Many questions about the rapid rhythmic fluctuations between distinct brain regions remain unanswered. Electrophysiological approaches, especially magnetoencephalography (MEG), with its excellent temporal resolution and source-space estimation capabilities, are gaining importance. Our study aims to uncover functional coupling between brain regions during acute phasic pain and experimentally induced hyperalgesia to gain a better understanding of the underlying mechanisms.

#### Methods

Evoked fields and spectral connectivity of 16 volunteers were analyzed using MEG. Noxious laser pulses were applied to the dorsum of the left hand. To investigate sensitization processes, hyperalgesia was induced by topical application of a high-concentrated capsaicin patch. Pain ratings were collected after each laser pulse before and after capsaicin.

#### Results

Post-capsaicin, pain ratings significantly increased ($t(15)=3.91$, $p=0.0033$). The source reconstruction identified evoked source activity in the contralateral primary (S1) and secondary somatosensory cortex (S2), as well as in the anterior (aIC) and posterior insula (pIC). Grand-average waveforms showed a significant peak in the pre-capsaicin condition in all sources (S1: 186ms, $t(15)=-22.0$, S2: 171ms, $t(15)=-31.3$, pIC: 174ms, $t(15)=-13.0$, aIC: 162ms,$t(15)=-10.2$; $p<0.01$). We found no significant differences in laser-evoked fields (LEF) between pre- and post-capsaicin. Connectivity analyses revealed coherence, particularly in the gamma-frequency range (30–90Hz; *precaps*: pIC—S2: 0.32, $t(15)=4.79$; pIC—aIC: 0.10, $t(15)=5.05$; *postcaps*: pIC—S2: 0.34, $t(15)=5.17$; aIC—S2: 0.14, $t(15)=4.44$; pIC—aIC: 0.13, $t(15)=6.02$; $p<0.01$), contrasting with a seeded source in the primary visual cortex (V1) as a control.

#### Conclusion

Our findings revelaed enhanced interaction of aIC during hyperalgesia and demonstrate functional segregation of aIC and pIC in pain. In conclusion, these methods represent a new step toward understanding the pain network and might have the potential to identify specific cortical target regions for neuromodulatory pain therapy.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V066

### Interdisziplinäre laparoskopische Implantation von Neuromodulationselektroden am Plexus sacralis (ILIAS) als therapeutische Option bei chronischen Beckenschmerzen und neurogener Blasenfunktionsstörung bei Endometriose

***Interdisciplinary Laparoscopic Implantation of neuromodulAtion leadS (ILIAS) to the sacral plexus as therapeutical option of chronic pelvic pain and neurogenic bladder dysfunctions***

F. P. Schwarm[1], J. Nagl[2], E. Uhl[2], I. Meinhold-Heerlein[3], F. Zeppernick[3], M. A. Kolodziej[2]

[1]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[2]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[3]Justus-Liebig-Universität Gießen, Klinik für Gynäkologie und Geburtshilfe, Gießen, Deutschland

#### Objective

After endometriosis and endometriosis treatment a therapy-associated chronic pelvic pain (CPP) and bladder/bowel dysfunctions may remain due to the damage of neural structures. Interdisciplinary Laparoscopic Implantation of neuromodulAtion leadS (ILIAS) to the sacral plexus could relief pain and improve the bladder/bowel function simultaneously after one surgical procedure. The aim of this study is to show the effect of this interdisciplinary procedure in relation to pain relief, improvement of quality of life and bladder dysfunction.

#### Methods

22 patients suffering from chronic pelvic pain and, bladder and bowel dysfunction underwent laparoscopic exposure and nerve identification with the help of electrophysiological neuromonitoring. A lead was placed laparoscopically in direct contact with the affected nerves (L5-S3). Bladder function, pain medication history, outpatient clinics visits, pain intensity (numerous ranking scale [NRS]), generic health status (EQ-5D-5L), Becks Depressions Inventory (BDI-V), Pain Catastrophizing Scale (PCS), and Client Satisfaction Questionnaire (CSQ-8) were assessed pre- and postoperatively as well as 3 and 6 months after surgery. Statistical analysis was performed using Mann-Whitney U and Wilcoxon rank-sum test.

#### Results

The average age of the patients was 32.8 years. A significant improvement in bladder function and a reduction in pain medication were achieved. Compared to baseline values, NRS ($p<0.001$), EQ-5D-5L ($p<0.001$), BDI-V ($p<0.001$), and PCS ($p<0.001$) showed significant improvement. The number of outpatient clinic visits by patients decreased due to adequate therapy and improvement in quality of life. In addition, the CSQ-8 showed that patients were satisfied with the treatment.

#### Conclusion

The ILIAS method is an effective treatment option for chronic pelvic pain and bladder dysfunctions. Significant pain reduction, improvement of quality of life and depressive mood, as well as improvement of the bladder function was achieved. Further, a significant reduction of the pain medication was seen. The method requires further evaluation of cost savings after the surgery compared to the conventional therapy.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V067

### Real-World Ergebnisse mit Tiefe Hirnstimulationssysteme: Platzierung der Elektroden im Wachzustand versus im Schlaf

***Real-World outcomes with directional Deep Brain Stimulation (DBS) systems: Awake versus asleep lead placement***

J. Vesper[1], G. Edward[2]

[1]Universitätsklinikum Düsseldorf, Klinik für Neurochirurgie, Sektion Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland
[2]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

#### Objective

In this report, we compared real-world outcomes of Parkinson's disease (PD) patients using Deep Brain Stimulation (DBS) Systems based on patients being awake or asleep during lead placement procedures.

#### Methods

This is a prospective, on-label, multi-center, international real-world where subjects received multiple-source, constant-current directional DBS systems (Boston Scientific) for the treatment of PD. Based on sites" standard-of-care and preferred technique, DBS procedures were performed with subjects awake or asleep during lead placement. Subjects were followed up to 3-years post-implantation and quality-of-life and PD motor symptoms was evaluated. Clinical endpoints evaluated at baseline and during study follow-up included Unified Parkinson's disease Rating Scale (UPDRS), MDS-UPDRS III (converted), Parkinson's disease Questionnaire (PDQ-39), and Global Impression of Change.

#### Results

A total of 633 implanted patients in the study were analyzed based on being awake or asleep during lead placement procedures. Of these, 173 patients (mean age = 61.4 ± 8.3 years, 68% male) were asleep during lead placement and 460 (mean age= 60.6 ± 8.5 years, 66% male) were awake. Improvement in quality-of-life as assessed by PDQ-39 was noted in both groups with the asleep group reporting a 5.3- point improvement (n = 111) and awake group reporting a 4.2-point improvement (n = 356) at 1-year. Similarly, a 19.1- and 21.5-point improvement in converted MDS-UPDRS III scores (meds off) was noted in the asleep and awake groups, respectively.

#### Conclusion

Preliminary results show that motor function-related, and quality-of-life outcomes show little to no difference between groups who received leads during DBS procedures whether awake versus asleep (i.e., under general anesthesia). Asleep DBS procedures can shorten the total time taken for DBS procedures. However, RCTs comparing asleep versus awake techniques are needed.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V068

### Strukturelle Konnektivitätsunterschiede bei tiefer Hirnstimulation des Nucleus basalis Meynert bei Alzheimer-Patienten

***Structural connectivity differences of nucleus basalis Meynert deep brain stimulation in Alzheimer's disease patients***

P. Andrade[1], R. Schmahl[1], R. Loução[1], P. Heiden[1], J. C. Baldermann[2], J. Kuhn[3], V. Visser-Vandewalle[1]

[1]Universitätsklinikum Köln, Klinik für Stereotaxie und funktionelle Neurochirurgie, Köln, Deutschland
[2]Universitätsklinikum Köln, Department of Neurology, Köln, Deutschland
[3]Alexianer Krankenhaus Köln, Department of Psychiatry, Köln, Deutschland

#### Objective

The nucleus basalis Meynert (NBM) holds a significant cholinergic neuron population projecting to the entire cortical mantle, olfactory tubercle, and amygdala, linked to dementia disorders like Alzheimer's disease (AD). We studied AD patients undergoing NBM deep brain stimulation (DBS) to analyze connectivity network profiles based on anatomical stimulation site and clinical outcomes.

#### Methods

Eleven AD patients operated for NBM DBS at University Hospital Cologne were included. Clinical data, including MMST and ADAS-cog were collected preoperatively and postoperatively at 6, 12, and 18 months. Connectivity analysis involved NBM segmentation into anterior, intermediate, and posterior section, as well as medial and lateral. We calculated the volume of tissue activated and conducted tractography analysis using a normative connectome.

#### Results

Anterior fibers projected 39% to orbitofrontal cortex (OFC), 27% to dorsolateral prefrontal cortex (DL-PFC), 20% to temporal region (TR), and 7% to dorsomedial PFC (DM-PFC). Posterior fibers projected 10% to OFC, 7% to DL-PFC, 15% to TR, and 5% to DM-PFC. IL had 33% to DL-PFC, 27% to OFC, 33% to TR, and 9% to DM-PFC. Stimulation of anterior-intermediate-lateral and posterior-intermediate-lateral regions led primarily to fibers projecting to fornix and hippocampus. Furthermore, the projection to these structures from the posterior regions was more specific than in the anterior stimulated leads. After 18 months, anterior bilateral regions showed significant clinical negative correlation, while posterior bilateral regions showed a significant positive correlation, indicating slower cognitive deterioration in both MMSA and ADAS-cog scores.

#### Conclusion

Intermediate-lateral stimulation exhibited higher connectivity to DL-PFC, DM-PFC, and OFC compared to anterior and posterior regions. The fornix, also targeted in AD DBS, could be modulated with NBM DBS. NBM DBS of posterior regions correlated positively with better cognitive outcomes after 18 months follow-up.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## V069

### Prädiktoren für die Reaktion auf die tiefe Hirnstimulation (DBS) bei Patienten mit Zwangsstörung (OCD): Eine Meta-Analyse

***Predictors of deep brain stimulation (DBS) response in patients with obsessive compulsive disorder (OCD): A meta-analysis***

S. G. Thavarajasingam[1,2,3,4,5], A. P. Divanbeighi Zand[3,4], D. S. C. Ramsay[2], J. Eraifej[5], V. K. Sajeenth[2], D. Jankovic[1], A. Kramer[1], M. Glaser[1], A. L. Green[3,4,5], F. Ringel[1]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich
[3]John Radcliffe Hospital, Oxford Functional Neurosurgery, Oxford, Vereinigtes Königreich
[4]University of Oxford, Nuffield Department of Surgical Sciences, Oxford, Vereinigtes Königreich
[5]University of Oxford, Nuffield Department of Clinical Neurosciences, Oxford, Vereinigtes Königreich

#### Objective

Obsessive-compulsive disorder (OCD) is a chronic and debilitating condition, often resistant to conventional treatments. Deep brain stimulation (DBS) emerges as a promising intervention, but its efficacy varies among patients, underscoring the need to understand the predictive factors influencing its outcomes. This study aims to to evaluate and compare disease and patient characteristics in their ability to response to DBS in OCD patients.

#### Methods

All major databases were searched for original studies. This study differentiated responders, partial responders, and non-responders based on absolute post-treatment Y-BOCS score changes and pre-defined Y-BOCS cut-off scores. Clinical predictors were assessed using qualitative synthesis, univariate analysis, stepwise and regularisation-tuned multivariate linear and logistic regression analyses.

#### Results

The meta-analysis, with an overall pooled sample size of 289 patients from 28 studies showed higher baseline Y-BOCS scores and elevated mood/hypomania significantly predicted improvement in the long term ($p = 0.00129$ and $p = 0.04637$, respectively). Aggression/intrusive thoughts baseline symptomology was a significant negative predictor in the short-term ($p = 0.0499$) and long-term ($p = 0.04765$). Antidepressant use was a significant negative predictor in the long-term response ($p = 0.00468$). Symmetry/hoarding/perfectionism baseline significantly predicted non-response in the short term ($p = 0.0017$) and long term ($p = 0.00185$). Disease duration, gender and age did not predict DBS response ($p>0.05$).

#### Conclusion

This study found that a heightened baseline severity of OCD symptoms and specific OCD mood dispositions significantly enhance the efficacy of DBS therapy, while the presence of specific compulsive behaviours and concurrent antidepressant treatment hinder long-term response. This study highlights the heterogenous clinical picture of DBS treatment for OCD, suggesting a trajectory toward more personalised treatment strategies.

Abb. 1

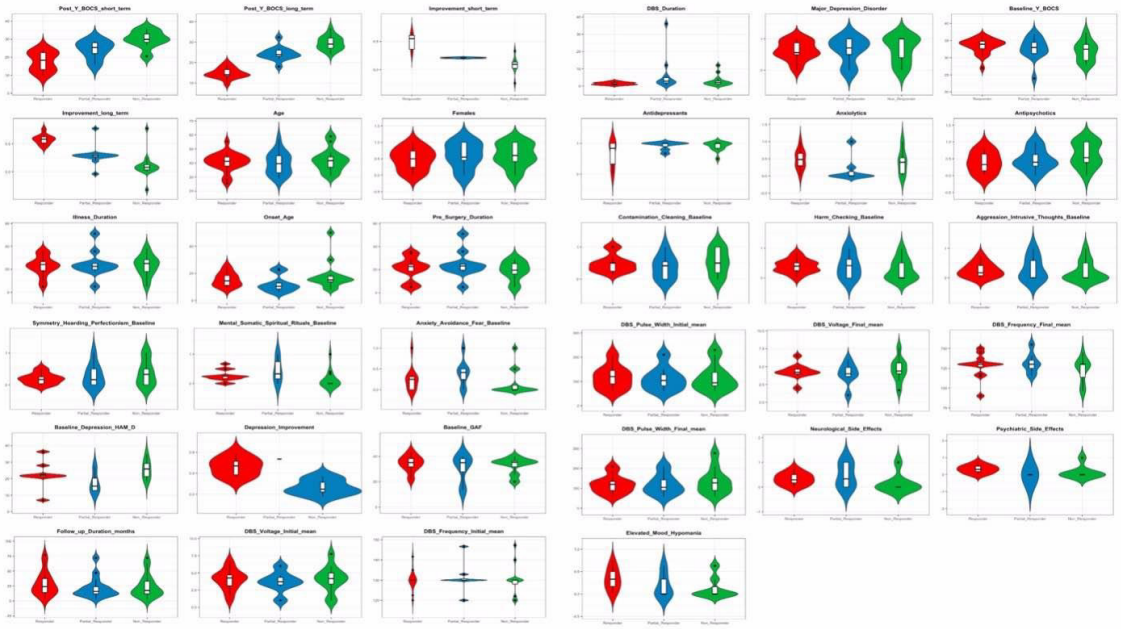
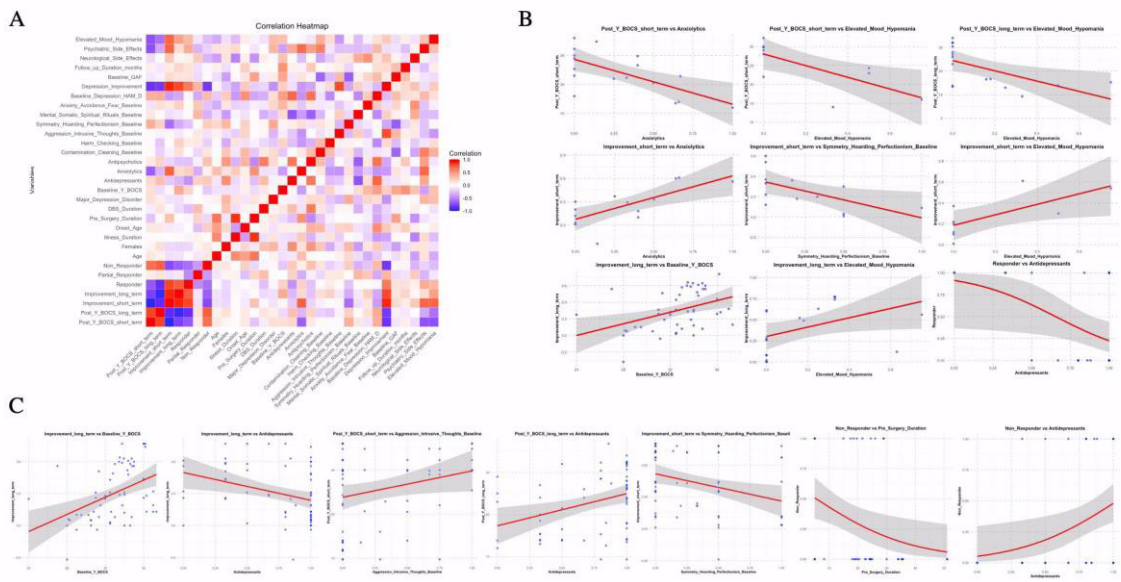

Post_Y_BOCS_short_term
Post_Y_BOCS_long_term
Improvement_short_term
DBS_Duration
Major_Depression_Disorder
Baseline_Y_BOCS
Improvement_long_term
Age
Females
Antidepressants
Anxiolytics
Antipsychotics
Illness_Duration
Onset_Age
Pre_Surgery_Duration
Contamination_Cleaning_Baseline
Harm_Checking_Baseline
Aggression_Intrusive_Thoughts_Baseline
Symmetry_Hoarding_Perfectionism_Baseline
Mental_Somatic_Spiritual_Rituals_Baseline
Anxiety_Avoidance_Fear_Baseline
DBS_Pulse_Width_Initial_mean
DBS_Voltage_Final_mean
DBS_Frequency_Final_mean
Baseline_Depression_HAM_D
Depression_Improvement
Baseline_GAF
DBS_Pulse_Width_Final_mean
Neurological_Side_Effects
Psychiatric_Side_Effects
Follow_up_Duration_months
DBS_Voltage_Initial_mean
DBS_Frequency_Initial_mean
Elevated_Mood_Hypomania

Abb. 2


A
Correlation Heatmap
Correlation
B
C

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## BO-03

***Closed-loop spinal cord stimulation for the treatment of chronic pain associated with Raynauds phenomenon. A prospective, single-center pilot study***

G. Bara[1], P. Karakostas[2], B. Dietz[3], V. Schäfer[2], J. Maciaczyk[1]

[1]Universitätsklinikum Bonn, Stereotaxie und Funktionelle Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Rheumatologie, Bonn, Deutschland
[3]Saluda Medical Research, Harrogate, Vereinigtes Königreich

### Objective

Raynaud's phenomenon (RP) is an episodic vasospasm of the peripheral arteries that causes cyanosis, erythema, pain, paraesthesia"s, and sometimes ulceration of the fingers and/or toes. There are few reports, mostly case series, on the benefits of spinal cord stimulation (SCS) for the treatment of RP. However, there is a lack of objective evidence on SCS induced modulation of the sympathetic system (e.g., vasodilation) in this condition.

We hypothesize that ECAP-controlled closed-loop SCS may relieve pain and reduce the severity and frequency of Raynaud's attacks. Furthermore, we hypothesize that the retrograde effects of ECAP-controlled closed-loop SCS may improve peripheral blood flow. Here, we will present objective results on the effects on peripheral circulation and subjective changes in the frequency and severity of Raynaud's attacks.

### Methods

This is a prospective, single-centre pilot study to evaluate the efficacy of ECAP-controlled closed-loop SCS (Evoke® SmartSCS, Saluda Medical, Australia) in the treatment of RP. Patient outcomes such as Raynaud Severity/Condition Score, Cochin Hand Function Scale, SHAQ RP VAS, EQ-5D-5L, PGIC, stimulation parameters, and objective peripheral blood flow assessments and neurophysiological measurements were collected at baseline, trial end, 1-month, 3-months, and 6-months.

### Results

The mean age ± standard deviation (±SD) patients is 45.5±15.5 years (n=10), and 80% are female.

The mean baseline (±SEM; n=9) weekly attack frequency was 21.8±5.9 and decreased to 12.6±4.6 6-months after implantation (n=8; Figure 2A). The mean baseline (±SEM; n=9) severity of attacks was 6.7±0.4 which decreased to 3.3±0.6 6-months after implantation (n=8; Figure 2A). The mean baseline (±SEM; n=9) Raynaud's condition score was 6.6±0.7 and decreased to 2.6±0.7 6-months after implantation (n=8; Figure 2A).

The mean baseline (±SEM; n=9) cochin hand function scale score was 31.6±8.2 and decreased to 17.4±7.7 6-months after implantation (n=8; Figure 2B). The mean patient global impression of change score at 6-months after implantation was 2.3±0.4 (±SEM; n=8; Figure 2C).

### Conclusion

This study demonstrates for the first time that RP-related pathological arterial occlusions and Raynaud symptoms can be treated effectively with a novel ECAP-controlled closed-loop-SCS system.

In conclusion, ECAP-controlled closed-loop-SCS alleviates RP symptoms and improves peripheral blood flow.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V070

### Zusammenhang von Flüssigkeitsbilanz und Hämoglobinabfall mit neurologischem Outcomenach aneurysmatischer Subarachnoidalblutung

***Association of fluid balance and hemoglobin decline with neurological outcome after aneurysmatic subarachnoid hemorrhage***

P. Truckenmüller[1], S. Wolf[1], D. Wasilewski[1], P. Vajkoczy[1], A. Früh[1,2]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH Biomedical Innovation Academy, BIH Charité Junior Digital Clinician Scientist Program, Berlin, Deutschland

#### Objective

Fluid overload and anemia predict poor neurological outcome in aneurysmal subarachnoid hemorrhage (aSAH). This study investigates if hypervolemia leads to hemoglobin decline and whether anemia and hypervolemia independently forecast unfavorable neurological outcome in aSAH patients.

#### Methods

This secondary analysis of the prospective randomized controlled EARLYDRAIN trial investigates fluid balance and hemoglobin levels during the initial eight days post-aSAH. Thresholds for unfavorable outcome were determined using receiver operating characteristic curves. The interplay of fluid balance and hemoglobin levels as well as their impact on secondary infarctions and 6-month outcome using the modified Rankin Scale (mRS) was assessed employing linear mixed-effect models and generalized estimation equations. Propensity score matching was used as a sensitivity analysis to account for the severity of the disease.

#### Results

Patients with unfavorable outcome after six months (mRS > 2) exhibited greater hemoglobin decline [-0.20 (IQR -0.34 to -0.06) vs. -0.09 (IQR -0.21 to 0.05) g/dl/d; $p$<0.001] and increased cumulative fluid balance [659 (IQR 332 to 1262) vs. 331 (IQR 39 to 792) ml/d; $p$<0.001]. An inverse relationship was observed between fluid balance and hemoglobin decline (Pearson's correlation coefficient: -0.41, CI -0.51 to -0.30, $p$<0.001). Thresholds for unfavorable outcome were 10.4g/dl hemoglobin and 4894ml cumulative fluid balance in the first 8 days. Fluid balance remained significantly associated with unfavorable outcome (OR 1.18; CI 1.05 to 1.13; $p$=0.006), while the influence of hemoglobin diminished (OR 0.93; CI 0.78 to 1.10; $p$=0.39). Fluid balance also showed an almost significant impact on secondary infarctions (OR 1.11; CI 0.99 to 1.25; $p$=0.07), which was lost after propensity score matching (OR 1.07; CI 0.96 to 1.19; $p$=0.22). Hemoglobin, when considered alongside fluid balance, did not exhibit an association with infarctions (OR 1.00; CI 0.86 to 1.16; $p$=0.97). Transfusion was associated with unfavorable outcome (OR 2.73; CI 0.99 to 7.57; $p$=0.05).

#### Conclusion

Increased fluid balance following aSAH appears to play the more decisive role and influences hemoglobin decline through hemodilution. The results suggest aiming for euvolemia and prioritizing the use of vasopressors. A modest hemoglobin decline may be tolerated, and it may be advisable to adopt a more restrictive approach to transfusions, as they can potentially have a negative effect on outcome.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V071

### Hydrocortison versus Dexamethason in der Prophylaxe des zerebralen Salzverlustsyndroms nach nicht traumatischer subarachnoidaler Blutung

***Hydrocortisone vs. dexamethasone in the prophylaxis of post-subarachnoid hemorrhage cerebral salt wasting syndrome***

L. Steger[1], B. Liquet[2], K. Agyemang[3], M. Freistühler[4], A. Di Ieva[2], C. Ertmer[5], W. Stummer[1], E. Suero Molina[2,1]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[3]Macquarie University Hospital, Department of Neurosurgery, Sydney, Australien
[4]Universitätsklinikum Münster, Münster, Deutschland
[5]Universitätsklinikum Münster, Klinik für Anästhesiologie, Münster, Deutschland

#### Objective

Cerebral salt wasting syndrome (CSW) leads to hyponatremia and is frequently observed in aneurysmal subarachnoid hemorrhage (SAH) patients. Although standards for the diagnosis "CSW" are controversial, it is known that CSW leads to excessive natriuresis and decreased extracellular fluids that result in hyponatremia and hypovolemia. The administration of corticosteroids to SAH patients has proven to be an effective prophylactic treatment. Dexamethasone has been used in patients as a prophylactic deterrent to possible brain swelling. Previous studies that investigated the effect of corticosteroids on hyponatremia development after non-traumatic SAH showed effective prevention by using Hydrocortisone. In this retrospective study, we compare Hydrocortisone and Dexamethasone for the prophylaxis of CSW-associated hyponatremia after non-traumatic SAH.

#### Methods

We analyzed data from 510 non-traumatic SAH patients who had been admitted to the University Hospital of Münster, Germany, from October 2009 to December 2019. During treatment, hyponatremia was defined as blood sodium levels <130mmol/L. The cohorts included patients treated with Dexamethasone (Dexa) (N=188) and Hydrocortisone (Hydro) (N=322). We compared the administrated dose and the length of the treatment among both cohorts. Criteria for CSW diagnosis were defined as blood sodium levels <135 mmol/L and a simultaneous negative fluid balance of the same day. We utilized Poisson and Negative Binomial models with explanatory variables to analyze hyponatremia events, employing a log link function and a Generalized Linear Mixed Model with random slope for Bernoulli trials to account for dependence in observations across time for each patient.

#### Results

In total, 87 patients (N=47, 25% Dexa patients and N=40, 12.4% Hydro patients) developed hyponatremia (Na(s) <130 mmol/L). Patients received Dexa for a median of 9 days (IQR: 5-15) and Hydro for a median of 10 days (IQR: 8-12.75) with an average dose of 9.21 mg (± 4.32) Dexa per day and 114.27 mg (± 81.88) Hydro per day. Of 510 patients, 210 (41.2%), 95 Dexa patients (50.5% of the Dexa group), and 115 Hydro patients (35.7% of the Hydro group) showed simultaneous negative fluid balance and sodium levels <135 mmol/L.

#### Conclusion

Our findings demonstrate that Hydro is a highly effective drug for the prophylactic treatment of CSW-associated hyponatremia development following non-traumatic SAH and demonstrate its effectiveness and superiority to Dexa.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V072

### Visualisierung der Clearance von roten Blutkörperchen und Immunzellen mittels 19F-Magnetresonanztomographie nach experimenteller Subarachnoidalblutung

***Visualization of red blood cell and immune cell clearance via 19F magnetic resonance imaging in experimental subarachnoid hemorrhage***

F. Schoknecht[1], K. Tielking[1], P. Pötschner[1], S. Liu[1], S. Brandenburg[1], S. Müller[2], S. P. Koch[2], Z. B. Tiren[3], S. Temme[3], U. Flögel[4], P. Böhm-Sturm[2], P. Vajkoczy[1], R. Xu[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Department of Experimental Neurology and Center for Stroke Research Berlin, Berlin, Deutschland
[3]University Hospital Düsseldorf, Department of Anaesthesiology, Düsseldorf, Deutschland
[4]Heinrich Heine University Düsseldorf, Cardiovascular Research Institute Düsseldorf, Düsseldorf, Deutschland

#### Objective

Subarachnoid hemorrhage (SAH) to bleeding in the subarachnoid space (SAS), followed by secondary brain injury and inflammatory events originating from extravasated blood and immune cells. Intravenously injected nanoemulsions prepared from perfluoro-5-crown-15-ether (PFCE) have been shown to preferably label circulating inflammatory cells. We aimed to visualize immune cell and erythrocyte clearance after SAH using Rhodamine-labelled PFCE in combination with 19F MRI.

#### Methods

A filament perforation surgery was performed to induce SAH in C57BL/6 mice and Sham operation was done for the matching control group (ntotal=40). Immediately after surgery, mice received an intravenously injected PFCE nanoemulsion (150 µL, 40% v/v). Accumulation of 19F particles was visualized at different time points *in vivo* by 1H/19F 7T MRI, registered to Allen Brain Atlas and a custom SAS atlas and evaluated by volume-of-interest analysis and incidence maps. Immunofluorescence staining for nuclei, arachnoid cells, microglia, macrophages, and neutrophils was analyzed by confocal imaging to elucidate the histological location of rhodamine labeled PFCEs (Fig. 1A). Characterization of 19F particle phagocyting immune cells was performed using flow cytometry.

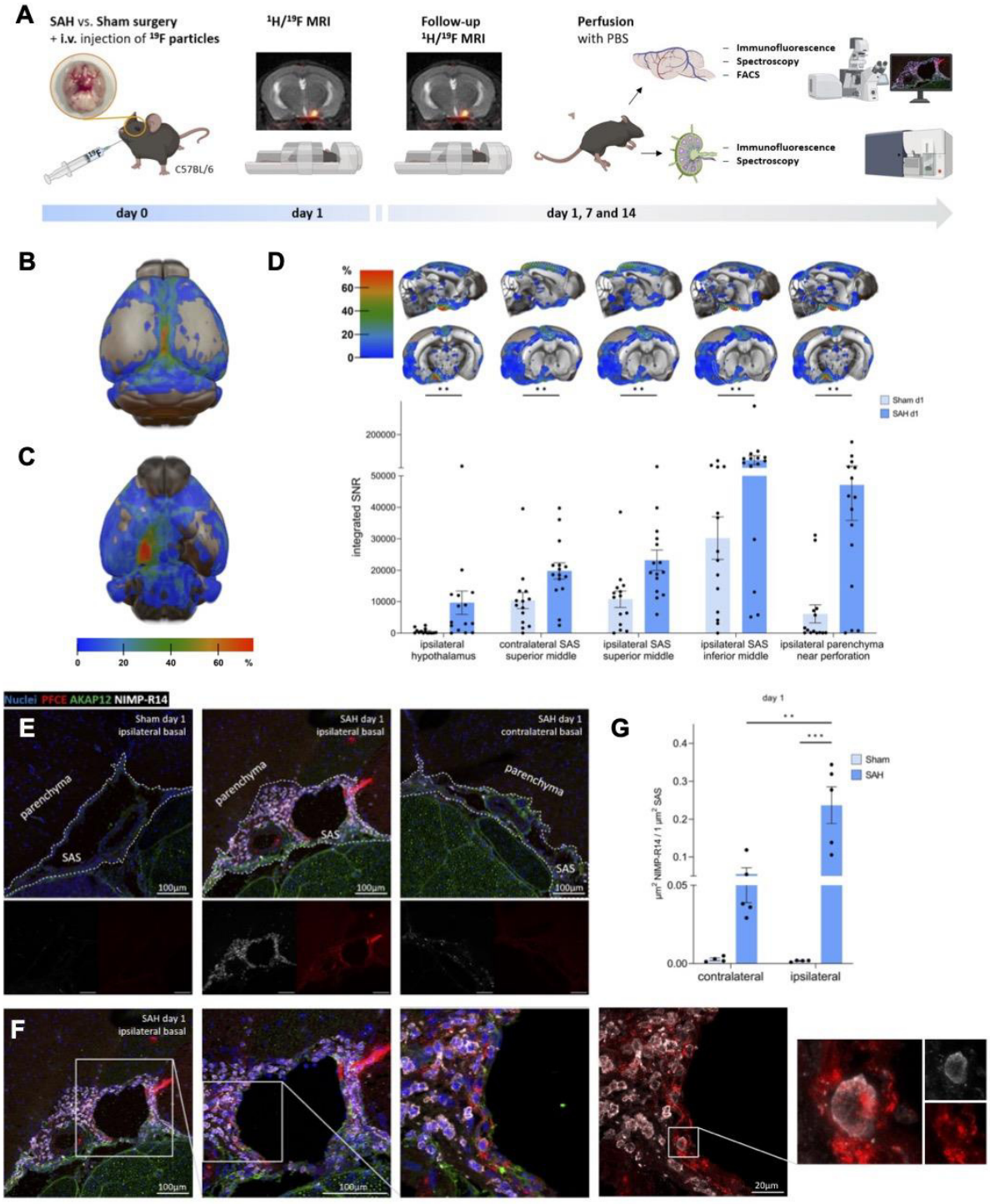
#### Results

Comparing integrated signal-to-noise ratio (SNR) and subtractive incidence maps, 1H/19F MRI revealed increased 19F signal in the hypothalamus and basal brain parenchyma bordering the perforated vessel, as well as leptomeningeal infiltration of PFCEs into the ipsilateral inferior and superior parts of the SAS after SAH (Sham day 1 vs. SAH day 1: 6,092.2 ±2,848.7 vs. 47,110.7 ±11,269.4; p=0.001; Fig. 1B-C). Over time, clearance of PFCE particles from the rostral and occipital SAS was evident in both subtractive incidence maps and analysis of integrated SNR, elucidating lymphatic drainage of the SAS via detection and clearance of leptomeningeal PFCEs following SAH (SAH day 1 vs. SAH day 7: 17,165.6 ±3,859.0 vs. 4,396.2 ±2,214.4; p=0.008). Confocal imaging verified the accumulation of PFCEs in the ipsilateral basal SAS and basal brain parenchyma, and showed spatial affinity of 19F particles to microglia, macrophages, and neutrophils after SAH (Fig. 1E-G).

#### Conclusion

PFCE nanoemulsions generate positive 19F MRI contrast for visualization of immune cell and blood accumulation, imaging of SAH-associated inflammation and elucidating lymphatic drainage of the SAS following SAH. PFCEs may enable monitoring of immune cell activation and blood clearance after SAH.

Abb. 1


A
SAH vs. Sham surgery
+ i.v. injection of ¹⁹F particles
C57BL/6
¹H/¹⁹F MRI
Follow-up
¹H/¹⁹F MRI
Perfusion
with PBS
Immunofluorescence
Spectroscopy
FACS
Immunofluorescence
Spectroscopy
day 0
day 1
day 1, 7 and 14
B
C
D
integrated SNR
Sham d1
SAH d1
ipsilateral hypothalamus
contralateral SAS superior middle
ipsilateral SAS superior middle
ipsilateral SAS inferior middle
ipsilateral parenchyma near perforation
Nuclei PFCE AKAP12 NIMP-R14
E
Sham day 1 ipsilateral basal
SAH day 1 ipsilateral basal
SAH day 1 contralateral basal
parenchyma
SAS
100µm
G
day 1
Sham
SAH
contralateral
ipsilateral
F
SAH day 1 ipsilateral basal
100µm
20µm

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V073

### Individualisierte clearance von intrakraniellem Blut nach SAB. Eine 5-jährige prospektive Beobachtungsstudie zur DCI-Prävention.

***Patient-specific blood clearance after aneurysmal subarachnoid hemorrhage. A 5-year prospective observation of DCI prevention***

R. Roelz[1], J. Beck[1], C. Scheiwe[2], P. C. Reinacher[3]

[1]University Medical Center Freiburg, Department of Neurosurgery, Freiburg i. Br., Deutschland
[2]University Medical Center Freiburg, Department of Neurosurgery, Freiburg i. Br., Deutschland
[3]University Medical Center Freiburg, Department of Stereotactic and Functional Neurosurgery, Freiburg i. Br., Deutschland

#### Objective

Delayed cerebral infarction (DCI) is a severe and common complication after aneurysmal subarachnoid hemorrhage (aSAH). Clearance of cisternal and ventricular blood targets the root cause of cerebral vasospasm (CVS) and may reduce the risk for DCI. We have introduced four methods for cisternal and ventricular blood clearance into the management of aSAH patients. Here, we report the results of a patient-tailored use of these methods in a prospective aSAH population.

#### Methods

220 aSAH patients were admitted between 01/2019 and 12/2023 and included in a prospective registry. We excluded patients who were not at risk for DCI (30 patients with early mortality/withdrawal of care <4 days) and 2 patients with admission delay who presented with DCI initially. We excluded 7 patients who were enrolled in a clinical trial on intracranial blood clearance and randomized to conservative therapy (i.e. per se not eligible for blood clearance).

78 of 181 patients (43%) were considered at risk for DCI and selected for intracranial blood clearance. According to individual patient characteristics, intracranial blood clearance was enabled by either of these methods: 1) n=35 (19%): stereotactic or endoscopic catheter ventriculocisternostomy (STX-VCS/eVCS), 2) n=20 (11%) intraoperative placement of a cisterno-ventricular catheter via the fenestrated lamina terminalis (oVCS), 3) n=19 (10%) lumbo-ventricular (LVL), 4) n=4 (2%) lumbo-lumbar lavage (LLL). Continuous lavage therapy was performed using the fibrinolytic urokinase and, upon detection of vasospasm, nimodipine. The primary endpoint was delayed cerebral infarction as assessed according to the Vergouwen criteria by independent rating.

#### Results

We observed signs of overdrainage in 3 patients selected for LVL. Otherwise, no procedure-related complications were noted. Delayed infarcts occurred in 13 of 181 patients (7.2%). DCI was minor in 5 (3%) and moderate or severe in 8 (4%) patients.

#### Conclusion

We developed and implemented four interventions for intracranial blood clearance to prevent delayed infarction after aSAH. This patient-specific paradigm lead to a very low rate of DCI.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V121

### Auswirkung der Argn-Ventilation in der Akutphase der SAB im Rattenmodell
***Effects of argon in the acute phase of subarachnoid hemorrhage in an endovascular perforation model in rats***

H. Krenzlin[1], D. Wesp[1], A. Korinek[1], J. Masomi-Bornwasser[1], H. Ubbens[1], J. Volland[1], K. Filipski[2], D. Mole[1,2], C. Sommer[2], B. Alessandri[3], F. Ringel[3], N. Keric[3]

[1]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Institut für Neuropathologie, Mainz, Deutschland
[3]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Subarachnoid hemorrhage (SAH) is a devastating disease with high morbidity and mortality. Neuroprotective effects of the noble gas Argon have been shown in animal models of ischemia. The aim of this study was to investigate the effects of Argon in the immediate early phase of SAH in a rat model.

#### Methods

55 male Wistar rats were randomly assigned to 3 treatment groups. SAH was induced using the endovascular filament perforation model. CBF, mean arterial blood pressure (MAP) and body temperature were measured continuously. Group A received 2 hours of ventilation by 50% Argon/50% O2 immediately following SAH. Group B underwent a sham operation, and was also ventilated by Argon/O2. Group C received a SAH but no further treatment. Pre- and postoperatively neurological and behavioral testing was performed. Histology and immunohistochemistry were used to evaluate the extent of brain injury and vasospasm.

#### Results

The CBF dropped in both treatment groups after SAH induction (SAH: 63.0±11.6% of baseline; SAH + argon: 80.2±8.2 % of baseline) and recovered incompletely in all groups. During SAH MAP increased (135.2±10.5%) compared to baseline (85.8±26.0mmHG) and normalized thereafter. MAP in both groups showed no significant differences (p=0.3123). The vessel diameter of the basilar artery in sham operated animals was 234.1±38.0 µm, in those with SAH 296.5±11.4 µm indicating vasodilation (p=0.0096). In those animals with SAH + argon, vessel diameter was 195.3 µm±11.1 µm (p=0.11). Immunohistochemical staining for NeuN demonstrated a decrease of hippocampal immunoreactivity after SAH in the CA 1-3 region compared to baseline (p=0.0127). Animals in the argon ventilated group showed less neuronal loss compared to untreated SAH animals (p<0.0001). Iba-1 staining showed a decreased accumulation after SAH + argon (CA1: 2.57±2.35%; CA2: 1.89±1.89%; CA3: 2.19±1.99%; DG: 2.6±2.24%) compared to untreated SAH animals (CA1: 5.48±2.39%; CA2: 4.85±4.06%; CA3: 4.22±3.01%; DG: 3.82±3.23%). Less microglia accumulation indicated less activation in the argon ventilated group (p=0.0007). The Neuroscore assessment revealed a deterioration after SAH (p=0.0141), however no treatment effect was detected (p=0.385).

#### Conclusion

In the present study neuroprotective effects of argon occurred early after SAH. However, in the early phase of SAH, neurological deterioration was similar in the pre- and absence of Argon. It remains uncertain if neuroprotective effects of Argon translate in improved outcome over time.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V075

### Optische Bildgebung von Perfluorcarbon-Nanoemulsionen in CX3CR1-Mäusen mittels kranialem Schädelfenster nach experimenteller Subarachnoidalblutung

***Optical imaging of perfluorocarbon nanoemulsions in CX3CR1 mice via chronic cranial window after experimental subarachnoid hemorrhage***

P. Pötschner[1], F. Schoknecht[1], A. Nitzsche[1], S. Brandenburg[1], Z. B. Tiren[2], U. Flögel[3], S. Temme[2], P. Böhm-Sturm[4], P. Vajkoczy[1], R. Xu[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]University Hospital Düsseldorf, Department of Anaesthesiology, Düsseldorf, Deutschland
[3]Heinrich Heine University Düsseldorf, Cardiovascular Research Institute Düsseldorf, Düsseldorf, Deutschland
[4]Department of Experimental Neurology and Center for Stroke Research Berlin, Berlin, Deutschland

#### Objective

Secondary brain injury after Subarachnoid Hemorrhage (SAH) is one major cause for the poor outcome after bleeding, originating initially from extravasated erythrocytes and inflammatory cascades following SAH. Recently, it has been shown that 19F perfluoro 5-crown-15-ether (PFCE) nanoparticles label inflammatory cells via phagocytosis. The aim of this project is the *in vivo* visualization of PFCE labeled immune cells via cranial window, intending to depict the *in vivo* clearance of erythrocytes and immune cells after SAH.

#### Methods

A filament perforation surgery was performed to induce SAH in CXCR1 mice and Sham operation was done for the matching control group. Two subgroups were established where chronic cranial window operation with PFCE injection was done either one day before SAH or directly after (n total=16). Two photon microscopy was performed at different time points post SAH, tracking the rhodamine PFCE positive cells *in vivo*. CX3CR1GFP/wt transgenic mice are used to identify microglia and macrophages, and investigate their interaction with PFCEs and blood vessels via Quantum Dots. To further examine the lymphatic clearance of rhodamine PFCE positive cells, whole mount immunostaining of meninges was performed (Fig. 1A).

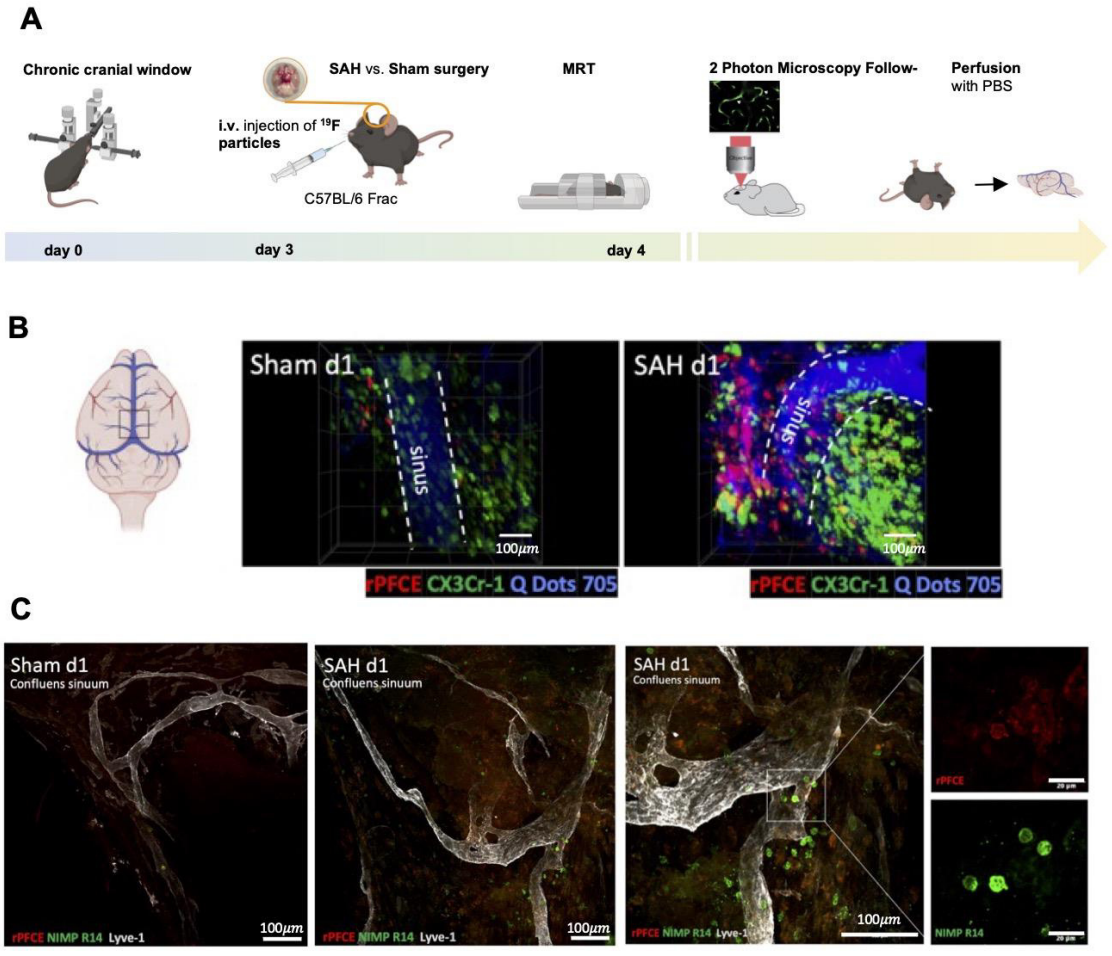
#### Results

*In vivo* two photon microscopy revealed an accumulation of rhodamine-labelled PFCEs in the superior subarachnoid space and the attached leptomeninges after SAH calculated as means of summed up intensity levels in defined z-stacks (Fig. 1B). Confocal imaging verified accumulation of PFCEs in the ipsilateral SAS after SAH (Sham day 1 vs. SAH day 1: 0.0003 ±0.0002 µm2 PFCE/µm2 SAS vs. 0.0418 ±0.0107 µm2 PFCE/µm2 SAS; p=0.002). Rhodamine-labelled nanoparticles were found to be located inside of CX3CR1 positive cells, indicating phagocytosis of PFCEs by activated immune cells. Furthermore, whole mount immunofluorescence staining showed co-labelling of PFCE cells in Lyve-1-positive lymphatic vessels (Fig. 1C).

#### Conclusion

The utilization PFCE nanoparticles in chronic cranial window aids in visualizing red blood cell turnover and their association with the vasculature and immune cells after SAH *in vivo*, representing an imaging tool to study new treatment modalities.

Abb. 1


A
Chronic cranial window
SAH vs. Sham surgery
i.v. injection of 19F particles
C57BL/6 Frac
MRT
2 Photon Microscopy Follow-
Perfusion with PBS
day 0
day 3
day 4
B
Sham d1
sinus
100µm
rPFCE CX3Cr-1 Q Dots 705
SAH d1
sinus
100µm
rPFCE CX3Cr-1 Q Dots 705
C
Sham d1
Confluens sinuum
rPFCE NIMP R14 Lyve-1
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# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V076

### Nimodipin reduziert Mikrovasospasmen nach experimenteller Subarachnoidalblutung
***Nimodipine reduces microvasospasms after experimental subarachnoid hemorrhage***

B. N. Harapan[1,2], J. Schwarting[2], N. Plesnila[2], N. Terpolilli[1,2]

[1]Klinikum der Ludwig-Maximilians-Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Institut für Schlaganfall- und Demenzforschung (ISD), München, Deutschland

#### Objective

Nimodipine, a L-type calcium channel inhibitor, remains the singular established pharmacological intervention that enhances outcomes in patients with aneurysmal subarachnoid hemorrhage (SAH). Despite its demonstrated efficacy, the intricate neuroprotective mechanisms of nimodipine in SAH remain elusive. Recent investigations have brought to light the potential significance of spasms in the cerebral microcirculation, indicating their pivotal role in post-SAH reduced cerebral perfusion and overall outcome. This study assessed the effect of nimodipine on microcirculatory dysfunction with special focus on microvasospasm formation.

#### Methods

Male C57Bl/6 N mice (n=3–5/group) underwent SAH induction through the middle cerebral artery perforation model. Six hours post-SAH, a cranial window was surgically created, allowing for real-time assessment of cortical microvessel diameters via 2-photon microscopy before, during, and after nimodipine application.

#### Results

In the analysis, 85 spastic vessel segments (average diameter: 16±7 µm; median microvasospasms: 2, IQR: 1) from the vehicle group (n=5) and 37 spastic vessel segments (average diameter: 18±7 µm; median microvasospasms: 2, IQR: 1) from the nimodipine group (n=3) were examined. Nimodipine treatment significantly reduced microvasospasms after SAH compared to the control group. Within 35 minutes of drug application, the treatment group exhibited nearly complete elimination of microvasospasms, whereas the vehicle-treated mice showed no significant changes over time (P=0.02). While all examined vessels gradually dilated (P=0.192), there was no notable difference between the nimodipine and control groups. Nimodipine exhibited a statistically significant reduction in posthemorrhagic microvasospasms, while non-spastic vessel diameters remained unaffected.

#### Conclusion

The efficacy of nimodipine in diminishing microvasospasms contributes novel insights into its neuroprotective mode of action, refining our comprehension of this decades-long SAH treatment. Furthermore, our findings suggest potential involvement of L-type Ca2+ channels in microvasospasm pathophysiology, hinting at a broader understanding of the drug´s multifaceted impact. This research not only enhances our understanding of nimodipine's neuroprotective effects but also provides a foundation for potential future therapeutic advancements in SAH management.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V077

***Blick in die Tiefe: Untersuchung der infratentoriellen peritrunkalen Blutunganteilen und deren Auswirkungen auf das Outcome bei aneurysmatischen Subarachnoidalblutungen***
***Delving deeper: Exploring infratentorial peritruncal hemorrhage and its impact on outcomes in aneurysmal subarachnoid hemorrhage***

M. Neyazi[1], I. Fischer[1], Y. Abusabha[1], K. Beseoglu[1], S. Muhammad[1], D. Hänggi[2], J. F. Cornelius[1], B. B. Hofmann[1]

[1]Medical Faculty & University Hospital Düsseldorf, Heinrich Heine University Düsseldorf, Department of Neurosurgery, Düsseldorf, Deutschland
[2]International Neuroscience Institute, Department of Neurosurgery, Hannover, Deutschland

### Objective

Despite the crucial roles played by the brain stem, prevailing radiological outcome scores for aneurysmal subarachnoid hemorrhage (aSAH) primarily focus on supratentorial blood components (e.g. the mFisher score). We propose that infratentorial peritruncal blood, often overlooked, may also impact patient outcomes post-aSAH. This study aims to investigate possible connections between infratentorial peritruncal blood in aSAH and patient outcomes, with the goal of identifying opportunities to improve existing prognostic scores.

### Methods

We retrospectively analyzed infratentorial cisternal and ventricular blood volumes (including Cisternae interpeduncularis, praepontina, praemedullaris, magna, and Ventriculi tertius and quartus) in 526 aSAH patients. Correlations with trichotomized outcomes (modified Rankin Scale (mRS) at discharge and after 6 months: good≤2; poor=3-5; dead=6) were assessed. Individual cisternal blood volumes, the sum of intraventricular blood, total infratentorial blood volume (all measured cisterns and ventricles), and a simplified unweighted infratentorial bleeding score (total score: presence of bleeding in a ventricle or cistern→1 point; Range 0-6) were examined. The diagnostic utility of the unweighted infratentorial bleeding score, considering age, mFisher score, and WFNS score, was explored using logistic regression.

### Results

The volume of each individual infratentorial cistern exhibited a significant correlation with outcomes at discharge and after 6 months (both $p<0.001$). Total infratentorial cisternal and ventricular blood volumes (in ml±SD; good=5.5±3.0; poor=7.8±2.6; dead=8.7±2.2; $p<0.001$ at discharge / post 6 months) and infratentorial ventricular blood volume (in ml±SD; good=1.2±1.7; poor=2.5±1.8; dead=3.1±1.7; $p<0.001$ at discharge / post 6 months) demonstrated a significant association with poorer outcomes. The simplified unweighted infratentorial bleeding score also significantly correlated with outcomes at discharge ($p>0.001$) and after 6 months ($p=0.046$), with logistic regression just falling short of statistical significance ($p=0.056$).

### Conclusion

The study suggests that the volume of infratentorial peritruncal hemorrhage in aSAH significantly impacts outcomes. Even a simplified unweighted infratentorial bleeding score shows nearly comparable prognostic effectiveness to established scores like mFisher and WFNS. Exploring infratentorial peritruncal blood volume in aSAH patients has the potential to enhance the current clinical utility of Fisher scores.

# Vaskuläre Neurochirurgie – Subarachnoidalblutung | Vascular Neurosurgery – subarachnoid hemorrhage

## V078

### Die Akutbehandlung der Subarachnoidalblutung in Hessen: Das Hessische Schlaganfallprojekt
*The acute treatment of subarachnoid hemorrhage in Hesse: The Hessian stroke project*

M. Stein[1], B. Misselwitz[2], J. Berkefeld[3]

[1]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[2]Qualitätssicherungsstelle Hessen, Eschborn, Deutschland
[3]Johann-Wolfgang Goethe Universität, Institut für Neuroradiologie, Frankfurt a. M., Deutschland

#### Objective

The current data on the acute treatment of non-traumatic subarachnoid hemorrhage (SAH) shows a deficit of studies and guideline recommendations with a high level of evidence. Quality assurance registers (QSR) can provide important information on treatment processes and acute therapy for SAH. The Hessian QSR for acute stroke is the first QSR in Germany that recorded data of patients with SAH in a separate registration form.

#### Methods

Patients with SAH were identified using the specific ICD-10 codes and the query in the QSR for evidence of intracranial aneurysm. Data of short-term transfer patients with double registration in the QSR were removed before analysis. Only centers with ≥10 patients with SAH were included in the final analysis. An unfavorable outcome at the end of acute therapy was defined as mRS 3-6.

#### Results

Between 2017 and 2022, 1471 cases were identified according to the defined inclusion criteria. The average age was 59.2 years (20 – 94 years). Arterial hypertension was present in 54.5% and diabetes mellitus in 6.3%. The average annual case number in the ten included specialized centers ranges from 13 to 58 cases per year. We could not find a significant correlation between caseload and clinical outcome after adjusting for the initial WFNS grade. Most patients were treated in an intensive care (92.8%). In 1359 of 1471 cases with suspected aneurysmal SAH, an aneurysm was detected angiographically. In 112 cases (7.6%), no aneurysm was found despite clinical suspicion. Of the cases with a detected aneurysm, 28.8% were treated surgically, and 59.6% endovascularly. In 144 cases (9.8%), no aneurysm therapy was performed. The average length of stay was 21 days (1 – 120 days). At discharge in 28.9% of cases a good clinical outcome (mRS 0 – 2) was documented. The observed intrahospital mortality was 23%.

#### Conclusion

The Hessian QSR is presenting acute care data of patients with non-traumatic SAH over a period of six years for the first time. The majority of patients in Hessen were treated in specialized centers. Despite different a different caseload no significant correlations between the number of cases and unfavorable clinical outcome. The data collected is suitable for mapping the care structure and for developing potential SAB specific quality indicators.

# Tumor – Meningiome | Tumour – Meningeomas

## V079

### Medikamenten-Kombinationsscreening identifiziert Carfilzomib und Enzalutemid für die Behandlung von aggressiven Meningeomen.

***Combinatorial drug screening identifies carfilzomib and enzalutamide for the treatment of aggressive meningiomas***

G. Jungwirth[1,2], V. Braun[1,2], A. D. Nalçakan[1,2], R. Warta[1], A. Abdollahi[3], S. Krieg[1], A. Unterberg[1], C. Herold-Mende[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, AG Präzisionsmedizin für aggressive Meningeome, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Translationale Radioonkologie, Heidelberg, Deutschland

#### Objective

The goal of combinatorial therapy is to improve the effectiveness of treatment by targeting multiple aspects of cancer cells or overcoming resistance to single drugs. In search of effective synergistic drug combinations for the treatment of meningiomas, we performed an automated combinatorial drug screening in meningioma cell lines and patient-derived tumor organoids.

#### Methods

Three grade 3 meningioma cell lines (NCH93, IOMM-Lee, and KT21-MG1) were stably transduced with blue, green, and red fluorescence proteins. The cell lines were multiplexed into 384-well plates and treated in 5x5 dose-response (0-1000 nmol/l) matrices for 48 h by the automated liquid handler Hamilton MicroLAB STAR®. The drug library consisted of 166 FDA-approved anticancer drugs. To demultiplex cell viability from a single well, the fluorescence signal was used as a surrogate marker for viability. Patient-derived tumor organoids (TOs) were established from single cell suspensions of freshly resected meningioma tissue (total n=20; grade 2 n=1; n=3 recurrent tumors). The cell viability was measured by CellTiterGlo3D. Drug synergism was calculated by the ZIP synergy finder model.

#### Results

This drug screening effort generated 13,695 unique drug-drug combinations per cell line. Most synergistic combinations were observed in IOMM-Lee (n=157, 1.14%), followed by KT21-MG1 (n=122, 0.88%), and NCH93 (n=75, 0.54%). Next, we validated the 110 most effective drug combinations in wild-type meningioma cells. 75 drug combinations demonstrated a positive most synergistic area (MSA) score, indicating synergistic effects. Next, we selected the 16 most promising combinations based on synergy scores and literature evidence for screening in TOs. The drug combination of proteasome inhibitor carfilzomib and the androgen receptor inhibitor enzalutamide exhibited the highest MSA scores in TOs. In 40% (n=8/20) of the cases, the combination showed strong synergism (MSA>10) resulting in an overall average MSA of 7.36. This was followed by carfilzomib and neratinib, and romidepsin and gemcitabine with average MSAs of 5.49, and 4.32, respectively. Furthermore, carfilzomib and enzalutamide induced apoptosis in TOs assessed by Caspase-3/7 ($p<0.01$).

#### Conclusion

This comprehensive combinatorial drug screening identified the synergistic combination of the proteasome inhibitor carfilzomib and androgen receptor inhibitor enzalutamide that can be an effective treatment option for selected meningioma patients.

# Tumor – Meningiome | Tumour – Meningeomas

## V080

### Molekulare Muster und genomische Divergenz bei sporadischen multiplen Meningeomen
***Molecular characterization and genomic divergence in sporadic multiple meningiomas***

I. Prilop[1], M. Alkhatib[1], S. Herold[2], M. Meinhardt[2], G. Schackert[1], I. Y. Eyüpoglu[1], T. Juratli[1,3]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Institut für Pathologie, Dresden, Deutschland
[3]Massachusetts General Hospital, Department of Neurosurgery, Boston, MA, Vereinigte Staaten

#### Objective

Multiple meningiomas are rare and pose distinct management challenges. While the mutational landscape of single meningiomas has been extensively explored, the molecular pathogenesis of sporadic multiple meningiomas is not fully understood. The objective of this study is to elucidate the genetic characteristics of sporadic multiple meningiomas.

#### Methods

In our retrospective cohort from 2002 onwards, we identified 24 patients who underwent surgery for at least two sporadic separated meningiomas, totaling 57 meningiomas. Neurofibromatosis type 2 was excluded in all cases. We examined the genetic alterations in these tumors using a next generation sequencing (NGS), targeting a comprehensive set of genes frequently mutated in meningiomas, including *AKT1, ATRX, CDKN2A, KLF4, NF1, NF2, PIK3CA, PIK3R1, POLR2A, PTEN, SMARCB1, SMO, STAG2, SUFU, TP53, TRAF7*, and the *TERT* promotor. A radiological evaluation of MRI scans took place, applying a software with an automatic algorithm for segmentation (Brainlab AG, Munich, Germany).

#### Results

The average age at initial diagnosis was 57 years (ranging from 34 to 82 years). The majority of these multiple meningiomas (94.7%) were classified as WHO grade 1. Within individual patients, no shared driver mutations were observed between separate tumors. Nearly all cases exhibited distinct hot spot mutations in well-known meningioma-driver genes, including *TRAF7* (n=14), *NF2* (n=9), *KLF4* (n=5), *PIK3CA* (n=4), *AKT1* (n=4), NF1 (n=1), *SMO* (n=2), *SMARCB1* (n=1), *POLR2A* (n=1), *PTEN* (n=2), and the *TERT* promoter (n=1). Furthermore, meningiomas from the same patient frequently presented as different histopathological subtypes. Consistent with previous studies, separate tumors from the same patient displayed different driver mutations, suggesting independent origins and distinct genomic drivers. The review of an average of 2.6 MRI scans conducted prior to surgery revealed a median preoperative tumor size of 12.14 $cm^3$ (ranging from 0.33 to 122 $cm^3$). The smallest meningioma were those, which harbored a *TRAF7* mutation (range from 0.33 to 36 $cm^3$, average volume 5.7 $cm^3$), while the largest meningiomas exhibited a *NF2* mutation (range from 0.72 to 122 $cm^3$, average volume 59.6 $cm^3$).

#### Conclusion

Overall, our molecular analysis supports the notion of genomic divergence and the presumed independent origin of sporadic multiple meningiomas. This condition seems to exhibit both inter- and intra-personal heterogeneity.

# Tumor – Meningiome | Tumour – Meningeomas

## V081

### Genetische Charakterisierung und klinische Merkmale von Olfaktoriusrinnenmeningeomen: eine multizentrische Studie

***Genetic characterization and clinical features of olfactory groove meningiomas: A multi-institutional study***

M. Alkhatib[1], L. Hua[2], S. Herold[3], L. Günther[4], D. P. Cahill[5], P. K. Brastianos[6], J. H. Juratli[7], Y. Gong[2], S. Jeyaretna[8], S. Fujio[9], D. Podlesek[1], T. Pinzer[1], G. Schackert[1], I. Y. Eyüpoglu[1], T. Juratli[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Fudan University, Neurosurgery, Shanghai, China, Volksrepublik
[3]Universitätsklinikum Carl Gustav Carus Dresden, Pathologie, Dresden, Deutschland
[4]Technische Universität Dresden, Medizin, Dresden, Deutschland
[5]Massachusetts General Hospital Cancer Center, Neurosurgery, Boston, MA, Vereinigte Staaten
[6]Massachusetts General Hospital Cancer Center, Medicine, Boston, MA, Vereinigte Staaten
[7]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Hals-, Nasen- und Ohrenheilkunde, Dresden, Deutschland
[8]Oxford University Hospitals, Department of Neurosurgery, Oxford, Deutschland
[9]Kagoshima university, Department of Neurosurgery, Kagoshima, Japan

#### Objective

This study aims to explore the link between the clinical and radiological characteristics of olfactory groove meningiomas (OGM) and their molecular profiles, with a focus on identifying oncogenic mutations through genomic studies.

#### Methods

We conducted targeted next-generation sequencing on 119 OGM samples from three international institutions, covering key meningioma genes. We then compared the molecular findings with clinical and radiographic features of the tumors. Additionally, we retrospectively collected and analyzed patient and tumor data, including age, sex, radiological features, and tumor location.

#### Results

Our cohort included 76 females and 33 males. Most tumors (106 out of 119, 89%) were classified as WHO grade 1 meningioma, with the rest being WHO grade 2 and 3. Notably, 87.5% of patients (104 out of 119) had significant driver mutations. The most frequent mutations were SMO/SUFU (35 cases, 29.4%) und AKT1 (34 cases, 28.5%), followed by PIK3CA/PIK3R1 (16 cases, 13.4%), TRAF7 alone (7 cases, 5.9%), POLR2A (4 cases, 3.4%), and TRAF7/KLF4 (3 cases, 2.5%). The median age at diagnosis was 62 years (range 25-87 years), with PIK3CA-mutant patients being the youngest group (median age 52, range 29-78 years). The sex distribution across all molecular groups was similar (female to male ratio of 2.1:1). The average overall survival was 154.9 months (95% confidence interval [CI]: 123.7 – 165 months). Patients with SMO mutations had significantly lower survival (average 92.6 months, 95% CI: 72.5 – 112.7 months) compared to those with AKT1 mutations (average 150 months, 95% CI: 150.1 – 136.9 months, p= 0.008). The median tumor volume at initial diagnosis was 16,500 mm3. SMO-mutant OGMs had the largest median tumor volume (19,102 mm3), followed by PI3K-mutant OGMs (13,500 mm3). AKT1-mutant and TRAF7/KLF4-mutant OGMs had the smallest volumes (7,587 mm3 and 3,300 mm3, respectively).

#### Conclusion

Our findings confirm the presence of significant actionable mutations in most OGM cases. The association of specific genetic alterations with tumor characteristics could have important implications for developing personalized treatment strategies in the future.

# Tumor – Meningiome | Tumour – Meningeomas

## V082

### Erstellung eines pharmakologischen Atlas von Meningeomen
*The pharmacological atlas of meningiomas*

G. Jungwirth[1,2], Y. Pan[1,2], A. D. Nalçakan[1,2], R. Warta[1], A. Abdollahi[3], S. Krieg[1], A. Unterberg[1], C. Herold-Mende[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, AG Präzisionsmedizin für aggressive Meningeome, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Translationale Radioonkologie, Heidelberg, Deutschland

### Objective

There are no systemic treatment options for patients with recurrent or refractory meningioma. The objective is to create a pharmacological atlas of all FDA-approved oncology drugs in a large cohort of patient-derived meningioma organoids.

### Methods

Patient-derived meningioma organoids (TOs) were generated from single cell suspensions from freshly resected meningiomas. TOs were treated with semi-logarithmic concentrations spanning from 10 nmol/l to 30 µmol/l by the automated liquid handler Hamilton MicroLAB STAR®. The drug library AODX from the National Cancer Institute consisted of 179 FDA-approved anticancer drugs. The viability was measured with the RealTimeGlo (Promega). Half-maximal inhibitory concentrations (IC50) were calculated by GraphPad Prism software. Categorization into sensitive and resistant drug–response groups was based on the IC50 values and each drug"s peak serum concentration (*C*max).

### Results

We created a pharmacological atlas of meningiomas by generating dose-response curves of all 179 current FDA-approved oncology drugs in patient-derived tumor organoids from 32 meningioma patients. The cohort consisted of 28 WHO grade 1, and 4 grade 2 meningiomas, including 4 recurrent tumors. In total, 27% (n=50/179) of the drugs demonstrated a median IC50 value below 30 µmol/l, with specific and significant enrichment for topoisomerase, RNA/protein synthesis, proteasome, mTOR, and HDAC inhibitors. The top five drugs with the lowest IC50 values were romidepsin, dactinomycin, carfilzomib, plicamycin, and omacetaxine with median values of 10, 27, 170, 326, and 330 nmol/l. Dimension reduction methods of IC50 data revealed somehow linear changes in drug sensitivities between meningiomas rather than drug sensitivity clusters. When considering the *C*max/IC50 ratio as a potential predictive marker of treatment response (>1), the HDAC inhibitors belinostat (74.5), romidepsin (69.7), the proteasome inhibitor carfilzomib (34.6), and the anthracycline epirubicin (2.6), and doxorubicin (1.8), and the PI3K inhibitor idelalisib (1.6) are the most promising drug candidates for further *in/ex vivo* evaluation.

### Conclusion

We provide the first comprehensive insight into the pharmacological landscape of meningiomas. This data might serve as the foundation for future clinical studies on the systemic treatment of aggressive meningiomas.

# Tumor – Meningiome | Tumour – Meningeomas

## V083

### Trends für Überleben und funktionelle Erholung bei strahleninduzierten Meningeomen
*Trends for survival and functional recovery in radiation-induced meningiomas*

L. Schmidt[1], S. G. Thavarajasingam[1], E. Schmidt[1], F. Ringel[1], D. Kalasauskas[1]

[1]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgische Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Meningiomas are the most common intracranial neoplasms, accounting for 37.6% of intracranial malignancies. Rarely, tumorigenesis might be induced by radiotherapy, which is often used in the setting of pediatric central nervous system (CNS) malignancies. Although radiation-induced meningiomas are a known complication of CNS radiotherapy, there is a paucity of information to guide treatment decisions. This study aimed to determine the clinical characteristics of radiation-induced meningiomas, recurrence and postoperative functional status.

#### Methods

A single-center retrospective study including patients undergoing resection of intracranial meningiomas between 2007 and 2018 was performed. Patients with intracranial radiation exposure were identified using hospital records and compared with non-radiation induced cases. We performed 1:3 propensity score matching between patients being exposed to radiotherapy and non-exposed patients using WHO grade, Simpson class and age. Comparison between the groups was performed using Mann-Whitney, Chi-Squared test and Cox regression analysis.

#### Results

During this period 841 meningioma patients with sufficient medical records were identified. Radiation-induced meningiomas were present in 33 cases. Propensity score matching with 99 unexposed cases resulted in homogeneous, comparable groups with respect to the variables used. Mean age at diagnosis was 25.8±12.6 years, mean CCI was 1.4±1.5. WHO grade 1 tumors were present in 63.63%, grade 2 in 33.3% and grade 3 in 3.03% of cases. Simpson class 1 resection was achieved in 42.42%, 2 in 18.93%, 3 in 17.42% and 4 in 21.21%. There was better recovery of functional status at 6 months and at last follow-up (mean KPS -1.59 vs -2.24 $p<0.001$; 2.98 vs -2.58 $p<0.001$) but the clinical relevance is questionable. Median 5-year progression free survival was significantly lower in radiation exposed cases (43.5 vs 62.1% p=0.035). In multivariate Cox regression analysis, radiation exposure (HR 2.58 95%CI 1.29-5 p=0.008) and WHO grade (2.04 95%CI 1.09-3.8 p=0.025) were the only significant risk factors for recurrence.

#### Conclusion

In our age, Simpson- and CNS WHO-grade matched cohort, radiation-induced meningiomas exhibited a shorter progression-free survival compared to naïve tumors, independent of known predictors. This suggests unknown differences in pathogenesis requiring further scrutiny.

# Tumor – Meningiome | Tumour – Meningeomas

## V084

### Zielgerichtete Therapie gegen Tumor-assoziierte Makrophagen im Immun-Microenvironment von Meningeomen
*Targeting tumor-associated macrophages in the immune-microenvironment of meningiomas*

C. Lotsch[1], R. Warta[1], P. Dao Trong[1], S. Krieg[1], F. Sahm[2], A. Unterberg[1], C. Herold-Mende[1]

[1]Universitätsklinikum Heidelberg, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Heidelberg, Deutschland

#### Objective

Meningioma represents the most common primary brain malignancy in adults with a subset of tumors exhibiting aggressive clinical behavior. Immunotherapy might present a new treatment strategy but is highly dependent on the immunological composition of the tumor microenvironment. Our previous data have shown that tumor-associated macrophages (TAMs) make up the main immune cell population in meningiomas with a negative impact on patient outcome. In this study, we investigated whether TAMs from meningioma tissue can be reprogrammed to an immunologically active and tumoricidal phenotype.

#### Methods

CD11b+ sorted macrophages derived from tumor samples from > 40 patients including clinically aggressive meningiomas were treated with small molecule inhibitors targeting the colony-stimulating factor-1 receptor (CSF-1R). In a first analysis, the direct treatment response of patient-derived macrophages has been investigated by various techniques including flow cytometry and bulk RNA-sequencing of treated TAMs and further analysis of the macrophage-conditioned media after treatment. In addition, we studied the influence of CSF-1R-targeted macrophage treatment on the phenotype and functional activity of T cells to assess a potential indirect treatment response in the tumor microenvironment.

#### Results

Our data revealed that CSF-1R-targeted treatment of CD11b+ TAMs induced significant changes in the protein and gene expression of macrophage polarization markers towards a more immunologically active state and a significantly higher metabolic nitric oxide production as another sign of immunological activation. Subsequent analysis of indirect effects on T cells showed not only a significantly increased expression of the T cell activation marker CD69+, but also a significantly increased tumor cell killing by autologous T cells after macrophage-targeted treatment.

#### Conclusion

Together these data suggest both a direct and indirect CSF-1R-targeted macrophage treatment response in the local tumor microenvironment and give first promising results on the efficacy of macrophage-targeted immunotherapy in human meningiomas.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V085

### Prävention von Spreading Depolarization assoziierter später Infarktprogression mittels Ketamin bei experimenteller Ischämie

***Ketamine-induced prevention of spreading depolarization associated late infarct progression in experimental ischemia***

A. Zdunczyk[1], L. Schumm[1], S. Helgers[2], M. Nieminen-Kelhä[1], X. Bai[1], S. Major[3], J. P. Dreier[3], N. Hecht[1], J. Woitzik[2]

[1]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland
[2]Carl-von-Ossietzky Universität Oldenburg, University Clinic for Neurosurgery, Oldenburg, Deutschland
[3]Charité – Universitätsmedizin Berlin, Department of Neurology, Berlin, Deutschland

#### Objective

Spreading depolarizations (SD) occur frequently in patients with malignant hemispheric stroke. In animal-based experiments, SDs have been shown to cause secondary neuronal damage and infarct expansion during the initial period of infarct progression. In contrast, the influence of SDs during the delayed period is not well characterized, yet. Here, we analyzed the impact of SDs in the delayed phase after cerebral ischemia and the potential protective effect of ketamine.

#### Methods

Focal ischemia was induced by distal occlusion of the left middle cerebral artery in C57BL6/J mice. 24 hours after occlusion, SDs were measured using electrocorticography and laser-speckle imaging in three different study groups: control group without SD induction, SD induction with potassium chloride, and SD induction with potassium chloride and ketamine administration. Infarct progression was evaluated by sequential MRI scans.

#### Results

24 hours after stroke onset we observed spontaneous SDs with a rate of 0.33 SDs/hour which increased during potassium chloride application (3.37 SDs/hour). The analysis of the neurovascular coupling revealed prolonged hypoemic and hyperemic responses in this group. Stroke volume increased even 24 hours after stroke onset in the SD-group. Ketamine treatment caused the hypoemic response to revert to a less hypoemic response and prevented infarct growth in the delayed phase after experimental ischemia.

#### Conclusion

Induction of SD with potassium was significantly associated with stroke progression even 24 hours after stroke onset. Therefore, SD might be a significant contributor to delayed stroke progression. Ketamine might be a possible drug to prevent SD-induced delayed stroke progression.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V086

### Beurteilung der prognostischen Relevanz der Auflösungszeit des "Lateral Spreads" bei der Mikrovaskulären Dekompression für Spasmus Hemifazialis

***Assessing the prognostic significance of lateral spreads resolution-time in microvascular decompression for hemifacial spasm***

A. Al Menabbawy[1,2], M. Eisold[1], E. Elrefaee[3,4], H. W. S. Schroeder[3]

[1]University Medicine Greifswald, Neurochirurgie, Greifswald, Deutschland
[2]Cairo University, Neurosurgery, Cairo, Ägypten
[3]University Medicine Greifswald, Department of Neurosurgery, Greifswald, Deutschland
[4]Kasr Alainy school of Medicine, Neurosurgery, Kairo, Ägypten

#### Objective

Lateral Spread Reflex (LSR) can be usually identified in individuals experiencing hemifacial spasm. The prognostic significance of LSR over the long-term result of microvascular decompression (MVD), specifically whether they resolve or persist, has been a topic of debate and inquiry. Nonetheless, the correlation between the timing of LSR disappearance and overall outcomes has not yet been extensively explored. This study seeks to assess the prognostic impact on spasms improvement following MVD, considering the timing of LSR relief.

#### Methods

Prospective documenting of the state of lateral spread reflex (LSR) during the procedure, alongside our routinely collected data was done. Reassessing the persistence or disappearance of (LSR) was done at certain milestones of the procedure. These milestones encompassed the skin incision, craniotomy, dural opening, and the opening of the cisterns (opening phase). Second phase involved arachnoid dissection on the cranial nerves to expose the facial nerve, while the third phase entailed the active decompression of the nerve using Teflon or Gortex. Evaluation of outcomes (improvement vs no improvement) occurred at a follow-up of at least 3 months.

#### Results

220 patients were enrolled with mean age(SD) of 54.7±(11.7) years and a follow-up(SD) of 22.8±(18.2) months. Male-to-female ratio is 1.7:1.No LSRs were detected in 38 patients (17.3%), and they exhibited 92.1% improvement. LSRs persisted in 6 patients (2.7%), yet theses patients demonstrated a 100% improvement. In 16 patients (7.3%), LSR vanished during the initial stages of the procedure (opening phase), with 100% final improvement. 44 patients (20%) lost their lateral spreads during arachnoidal dissection, experiencing improved spasms of 90.9%. Decompression led to the disappearance of spasms in 90 patients (40.9%), correlating with a clinical improvement of 85.9%. Finally, during the closure 26 patients (11.8%) witnessed the resolution of lateral spreads and 100% improvement.

#### Conclusion

While all the patients" groups demonstrated a notable improvement in spasms exceeding 85%, those in whom the LSRs vanished during the decompression phase exhibited comparatively poorer outcomes than those whose LSR disappearance occurred in the predecompression phase of the procedure.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V087

### Risikofaktoren für ein schlechtes Outcome im Falle von nicht-aneurysmatischen Subarachnoidalblutungen
***Risk factors for an unfavorable functional outcome after a non-aneurysmal spontaneous subarachnoid hemorrhage***

E. Kurz[1], D. Kalasauskas[1], A. Steklecova[2], D. Netuka[2], W. Maria[3], A. Carolin[3], W. Silke[3], E. Baki[3], R. Laurèl[3], R. Jabbarli[3], U. Sure[3], C. Thomé[4], C. Preuss-Hernandez[4], A. Al Awadhi[5], E. Cochard[5], J. Haemmerli[5], K. Schaller[5], F. Becker[6], A. Schulze[7], F. Ringel[1]

[1]Universitätsmedizin Mainz, Neurochirurgie, Mainz, Deutschland
[2]Military University Hospital Prague, Prague, Tschechien
[3]Universitätsklinikum Essen, Essen, Deutschland
[4]Universitätskliniken Innsbruck, Innsbruck, Österreich
[5]Hôpitaux Universitaires de Genève, Geneva, Schweiz
[6]Leibniz Institut, Tübingen, Deutschland
[7]Institut für Medizinische Biometrie, Epidemiologie und Informatik, Mainz, Deutschland

#### Objective

Spontaneous subarachnoid hemorrhages(sSAH) are mostly caused by rupture of cerebral aneurysms. However, in ≈15% the bleeding source cannot be determined in imaging. These non-aneurysmal sSAH(nSAH) are known for lower complication rates and a more favorable outcome. But, cases with a complicated clinical course are not uncommon and difficult to predict. Aim of our study was to analyze patients" and imaging characteristics to identify predictors of a poor outcome after nSAH.

#### Methods

Retrospectively, all patients with nSAH (2010-2021) from 6 neurosurgical departments were analyzed. Demographics, the H&H, Fisher(FS) and WFNS grades, Systemic Inflammatory Response Syndrome (SIRS) and ASA scores were analyzed. Comorbidities, diagnostics, risk factors, treatment methods, complications (cerebral vasospasm(CV), hydrocephalus) and the blood distribution (perimesencephalic vs. diffuse) were analyzed. The outcome was assessed by the modified Rankin Scale(mRS) at 6 months defining an unfavorable outcome as mRS≥3.

#### Results

474 cases (59.5% male, n=282) with a mean age of 54.5±12.1 years were included. Mean ASA was 2.1±0.73, mean HH,WFNS and FS were 1.6±0.87,1.3±0.86 and 2.7±0.9. 60.3% had diffuse blood distribution. Acute CSF diversion was needed in 16.5% (n=78), a shunt(VP) in 4.2% (n=20). CV were detected in 16.7%(n=79). 11 patients developed DCI(2.3%). 90.2% had a favorable outcome (mRS≤2).In univariate analysis the risk for an unfavorable outcome was increased by hypertension(0.0001), diabetes(p<0.0001), cardiac congestion(p<0.0001), peripheral vascular disease(p<0.0001), cerebral insults(p=0.0007), renal failure(p=0.003), leucemia(p=0.0007), ASA(<0.0001), HH(p<0.0001), WFNS(p<0.0001), SIRS(p<0.0001), FS(p<0.0001), intracerebral blood(p<0.0001) a diffuse blood distribution(p<0.0001), DCI(p=0.02) and the need for a VP(p<0.0001). In multivariate analysis exclusively the HH(p=0.03,OR=3.2) correlated significantly with an unfavorable outcome. Intracerebral blood(p=0.06,OR=3.6) and SIRS(p=0.08,OR=2.2) showed a trending association.

#### Conclusion

In nSAH, several comorbidities, common scores, typical complications, and the blood distribution are associated with an unfavorable outcome. However, in multivariate analysis only the HH was identified as independent

predictor. Despite the high number of cases further predictors previously discussed as high-risk parameters as a diffuse blood distribution, CV and the need for VP were not confirmed as significant factors for the outcome after nSAH.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V088

### Prävalenz unrupturierter intrakranieller Aneurysmen: Eine Metanalyse mit Betonung aufKomorbiditäten und Risikofaktoren

***Prevalence of unruptured intracranial aneurysms: A meta-analysis with emphasis on comorbiditiesand risk factors***

J. Dremel[1,2], A. Ziebart[3], S. Hetjens[1], N. Etminan[2], G. Rinkel[2]

[1]Universitätsmedizin Mannheim, Mannheim, Deutschland
[2]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland
[3]Universitätsklinikum, Neurochirurgie, Ulm, Deutschland

#### Objective

In a previous review on the prevalence of UIA published in 2011, the overall prevalence was 3,2%, with higher risks for women and for persons with polycystic kidney disease or a positive family history of subarachnoid haemorrhage, but not for persons with atherosclerosis. Data were insufficient to assess time trends and the influence of smoking and arterial hypertension. With greater availability of intracranial imaging, we expected many more studies on healthy populations, in more regions and in persons with other diseases. We therefore updated the previous version of the meta-analysis, with emphasis on risk factors and co-morbidities to detect potential new subgroups of patients who may benefit from screening.

#### Methods

We updated the literature research until 2021 using the same search strategy as previously. Data on mid-year of study, age, sex, co-morbidities, risk factors, and on numbers of participants and aneurysms were extracted by two reviewers independently from each other. Prevalence and risk ratios were calculated using univariable analysis.

#### Results

We included 45 new studies; the total number of included studies was 113, which described 132 study populations, 227.655 patients and reported on 6.132 patients with aneurysms. The overall prevalence was 4,66% (95%CI 4,08 – 5,28), the prevalence in persons without co-morbidities was 2,23% (95%CI 1,72 – 2,81) and that for persons with a connective tissue disease 14,27% (95% 9,90 – 19,28). Risk ratio"s were for female sex 1,94 (95%CI 1,79 - 2,10), for hypertension 1,11 (95%CI 1,01 – 1,23), and for smoking 1,02 (95%CI 0,91 – 1,14).

#### Conclusion

Women have a higher prevalence than men, and hypertension was found to be a risk factor in persons without comorbidities, but smoking not. Patients with a connective tissue disease have a high prevalence of UIA, and may benefit from screening.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V089

### Ruptur kleinere Aneurysmen bei Patienten mit multiplen intrakraniellen Aneurysmen - Eine Analyse der kleinen bösen Geschwisterchen

***The rupture of smaller counterpart aneurysms in patients with multiple intracranial aneurysms – An analysis of the evil little siblings***

T. F. Dinger[1], M. Chihi[1], M. Darkwah Oppong[1], M. Gümüs[1], C. Rieß[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

In the case of multiple unruptured intracranial aneurysms (MUIA), deciding which intracranial aneurysms should be treated and which at first can be challenging. The most accepted risk factor in making these decisions is IA size. However, a smaller counterpart IA (SCIA) and not the largest IA in patients with MIA might cause subarachnoid hemorrhage (SAH). By falsely assessing an SCIA as benign and withholding treatment, these patients are put at risk for SCIA rupture before treatment. Therefore, there is a paramount need to improve the identification of more rupture-prone SCIA, especially regarding the improved accessibility to intracranial imaging leading to increasing incidences of patients with (M)IA.

#### Methods

From our institutional observational cohort, containing data of all patients with IA treated between 01/2003 and 06/2016, 285 patients with MIA who were hospitalized for acute aSAH were identified. In 261 patients, the largest of their IA ruptured, and in 24 patients, a SCIA ruptured (defined by a size difference of ≥ 2mm). Different demographic, clinical, laboratory and radiographic characteristics of patients and IA were collected. Univariate and multivariate binary regression analyses (UVA, MVA) were performed to identify putative risk factors for the rupture of SCIA.

#### Results

In the final MVA, the total number of IA ($p=0.043$; aOR=1.61) and the intake of multiple antihypertensive drugs ($p<0.001$; aOR=3.96) showed a statistically significant association with the ruptured status of SCIA. In contrast, smoking, radiographic risk factors (i.e., daughter sack, IA irregularities), arterial hypertension, and blood examinations did not show a statistically significant regression with the rupture of SCIA (all $p>0.05$).

#### Conclusion

This study found statistically significant putative risk factors to identify IA rupture factors that might overweight IA size in certain situations. Thereby, a subgroup of MIA patients could be identified who suffer from difficult-to-treat arterial hypertension or have a high number of IA that might benefit from a simultaneous treatment of more than one UIA in a single session to prevent the rupture of SCIA. Further studies are needed to verify these results and improve the identification of dangerous SCIA.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – various 3

## V090

### Mikrochirurgisches Clipping von unrupturierten Aneurysmen der vorderen Zirkulation - eine globale multizentrische Untersuchung des perioperativen Outcomes

***Microsurgical clipping of unruptured anterior circulation aneurysms – A global multicenter investigation of perioperative outcomes***

J. Sauvigny[1], R. Drexler[1], T. Pantel[1], F. Ricklefs[1], J. Catapano[2], J. Wanebo[2], M. Lawton[2], A. Sanchin[3], N. Hecht[3], P. Vajkoczy[3], K. Raygor[4], D. Tonetti[4], A. Abla[4], K. El Naamani[5], S. Tjoumakaris[5], P. Jabbour[5], B. Jankowitz[6], M. Salem[6], J. K. Burkhardt[6], A. Wagner[7], M. Wostrack[7], J. Gempt[1], B. Meyer[7], M. Gaub[8], J. Mascitelli[8], P. Dodier[9], G. Bavinzski[9], K. Roessler[9], N. Stroh[10], M. Gmeiner[10], A. Gruber[10], E. Figueiredo[11], A. da Silva Coelho[11], A. Bervitskiy[12], E. Anisimov[12], J. Rzaev[12], H. Krenzlin[13], N. Keric[13], F. Ringel[13], D. Park[14], M. C. Kim[14], E. Marcati[15], M. Cenzato[15], L. Krause[16], M. Westphal[1], L. Dührsen[1], T. Sauvigny[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[2]St. Joseph's Hospital and Medical Center, Barrow Neurological Institute, Phoenix, AZ, Vereinigte Staaten
[3]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland
[4]University of California, Department of Neurological Surgery, San Francisco, CA, Vereinigte Staaten
[5]Thomas Jefferson University Hospital, Department of Neurological Surgery, Philadelphia, PA, Vereinigte Staaten
[6]Hospital of the University of Pennsylvania, Department of Neurosurgery, Philadelphia, PA, Vereinigte Staaten
[7]Klinikum rechts der Isar, Technical University of Munich, Department of Neurosurgery, München, Deutschland
[8]University of Texas Health Science Center, Department of Neurosurgery, San Antonio, TX, Vereinigte Staaten
[9]Medical University of Vienna, Department of Neurosurgery, Wien, Österreich
[10]Kepler University Hospital, Johannes Kepler University, Department of Neurosurgery, Linz, Österreich
[11]Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, Division of Neurological Surgery, São Paulo, Brasilien
[12]Federal Center of Neurosurgery, Novosibirsk, Russische Föderation
[13]University Hospital Mainz, Department of Neurosurgery, Mainz, Deutschland
[14]Pohang Stroke and Spine Hospital, Department of Neurosurgery, Pohang, Südkorea
[15]Grande Ospedale Metropolitano Niguarda, Department of Neurosurgery, Milan, Italien
[16]University Medical Center Hamburg-Eppendorf, Department of Medical Biometry and Epidemiology, Hamburg, Deutschland

#### Objective

Despite the latest technical innovations and improvements in endovascular therapy options microsurgical aneurysm repair is still of great importance, particularly due to the high and durable occlusion rates. Aim of this study was to investigate current global microsurgical treatment practice of aneurysms of the anterior circulation and to identify patient- and surgery-related risk factors for postoperative morbidity and neurological outcome.

#### Methods

Fifteen neurosurgical centers in the US, Europe, Asia and South America participated in this retrospective cohort study. Consecutive patients who underwent elective microsurgical clipping of untreated unruptured intracranial aneurysm between January 2016 and December 2020 were included. Posterior circulation aneurysms were excluded. Outcome parameters were postsurgical complications and neurological deterioration (defined as decline on the modified Rankin Scale) at discharge and during follow-up. Multivariate regression analyses were performed adjusting for all described patient characteristics.

#### Results

A total of 2192 patients with aneurysms of the anterior circulation were included in this study. Regression analysis identified hypertension ($p<0.02$), aneurysm diameter ($p<0.001$), neck diameter ($p<0.05$), calcification ($p<0.01$), and morphology ($p=0.002$) as pre-existing risk factors for postsurgical complications and neurological deterioration at discharge. In addition, intraoperative aneurysm rupture ($p<0.01$) and simultaneous clipping of more than one aneurysm ($p<0.01$) were found to be associated with an increased risk of postoperative

complications. Microsurgical treatment showed excellent occlusion rates at discharge (complete occlusion in 95.3%) and during follow-up (94.7%). Analysis of the volume-outcome relationship showed comparable complication rates (p=0.61) in all 15 participating centers.

## Conclusion

Our data demonstrate an excellent efficacy of neurosurgical aneurysm occlusion in patients with anterior circulation aneurysms in a large multicenter cohort and indicate pre-existing and surgery-related risk factors for postoperative complications and neurological deterioration. These results may help in deciding on the optimal treatment regimen for unruptured anterior circulation aneurysms.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V091

### Palliativversorgung in der Neuroonkologie: Eine deutsche Perspektive
*Benchmarking palliative care practices in neurooncology: A german perspective*

A. C. Lawson McLean[1], A. Lawson McLean[1], T. Ernst[1], M. T. Forster[2], C. Freyschlag[3], J. Gempt[4], R. Goldbrunner[5], S. J. Grau[6], B. van Oorschot[7], S. Rosahl[8], C. Senft[1], U. Wedding[1], C. Jungk[1,9], M. A. Kamp[1]

[1]Universitätsklinikum Jena, Jena, Deutschland
[2]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[3]Universität, Innsbruck, Österreich
[4]Universitätsklinikum Hamburg-Eppendorf, Klinik für Neurochirurgie, Hamburg, Deutschland
[5]Universitätsklinikum, Köln, Deutschland
[6]Klinikum Fulda, Klinik für Neurochirurgie, Fulda, Deutschland
[7]Universiätsklinikum, Würzburg, Deutschland
[8]Helios Klinikum Erfurt, Klinik für Neurochirurgie, Erfurt, Deutschland
[9]Universitätsklinikum, Heidelberg, Deutschland

#### Objective

Palliative medicine goes beyond end-of-life care, prioritizing the improvement of life quality through comprehensive suffering management within a multi-professional team. Suffering, encompassing physical, psychological, social, and spiritual aspects, prompts a crucial inquiry into the timing and extent of palliative care involvement. Current guidelines strongly advocate early integration of (specialized) palliative care. The aim of this study was to evaluate timing and depth of palliative care in German neurooncological centres.

#### Methods

A national survey was conducted at both DKG-certified and university neuro-oncological centers. Utilizing an online suvery on the Nextcloud platform, the survey link was sent to heads or coordinators of all neuro-oncological centers. A reminder email was sent at four and eight weeks, and the survey was open from November 14, 2022, to February 24, 2023.

#### Results

The questionnaire saw a robust 81% response rate from specialists in 46/57 centers, with representation from 32/36 university hospitals and 14/16 federal states. Approximately 75% of neuro-oncology centers featured specialized palliative care departments, and nearly 95% had well-functioning specialized palliative outpatient care networks. While palliative care physicians participated in tumor boards in about one-third of centers, discussions and documentation of patients' palliative care needs occurred in less than 30% of discussed cases. The distress thermometer was used in 80% of centers. Quality of life assessments, using an EORTC questionnaire, were conducted in one-fifth of the centers. Psycho-oncology services were universally available.

#### Conclusion

This survey unveils the diverse landscape of palliative care provision in German neurooncological centers, offering valuable insights for stakeholders. While efforts exist to integrate palliative care, there's variation in timing, screening methods and depth. Recommendations include reinforcing early palliative care integration and enhancing specialist participation in tumor boards. Standardizing palliative care burden, psychological, and spiritual screening tools could elevate holistic care delivery.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V092

### Vollständige Resektion bei Hirnmetastasen - wann ist das wichtig?
*Complete resection in brain metastases – When does it matter?*

T. Araceli[1], C. Doenitz[1], A. Haj[1], E. M. Stoerr[1], K. Rosengarth[1], N. O. Schmidt[1], M. Proescholdt[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland

#### Objective

Surgical resection is a critical element in the management of brain metastases (BM). Generally, the surgical goal is to achieve a gross total resection (GTR). However, radical resection may also cause additional neurological morbidity, which severely impacts quality of life and overall prognosis in BM patients. In the literature, the value of GTR in BM patients is controversial, as several studies demonstrate a significant OS benefit due to GTR, whereas others do not. We, therefore, wanted to analyze the specific circumstances under which GTR is crucial for optimal outcome in a large population of BM patients treated with surgical resection in our institution.

#### Methods

We analyzed 539 patients (247 female, 292 male) with a median age of 62.8 years (range: 23.4 – 86.2 years) who underwent surgical resection of one or several BM. Patients presented with multiple metastases in 45.5%, singular in 36.7%, and solitary in 17.8%. The majority were treated for metachronous metastases (63.8%), the median preoperative Karnofsky Index (KPI) was 80 (range: 30 – 100), the most frequent primary tumor was lung cancer (37.3%), followed by malignant melanoma (14.6%) and breast cancer (12.4%). The extent of resection (EOR) was classified as complete if there was no residual contrast-enhancing tumor detectable on the early postoperative MRI; tumor size was determined by volumetry of the contrast–enhancing areas in the presurgical MRI. OS was measured from BM diagnosis until the end of life.

#### Results

GTR was achieved in most patients (82.9%). Patients with BM in eloquent areas and with larger tumors significantly more frequently received an incomplete resection ($p = 0.037$ and 0.015, respectively). In the entire population, GTR was not associated with longer OS (HR: 0.884; $p = 0.162$). However, in patients with solitary BM, a drastic benefit of GTR was detected (HR: 0.387; $p = 0.0006$). Also, age younger than 65 years (HR: 0.701; $p = 0.047$), controlled disease status (HR: 0.682; $p = 0.033$), and postsurgical systemic treatment (HR: 0.698; $p = 0.038$) were associated with significant benefit of GTR. Interaction analysis revealed that solitary BM status and controlled disease significantly influenced the impact of GTR in our patient population ($p = 0.0001$).

#### Conclusion

Achieving GTR is highly relevant in patients with solitary BM status, controlled systemic disease, postsurgical systemic treatment options, and in the population younger than 65 years.

Abb. 1

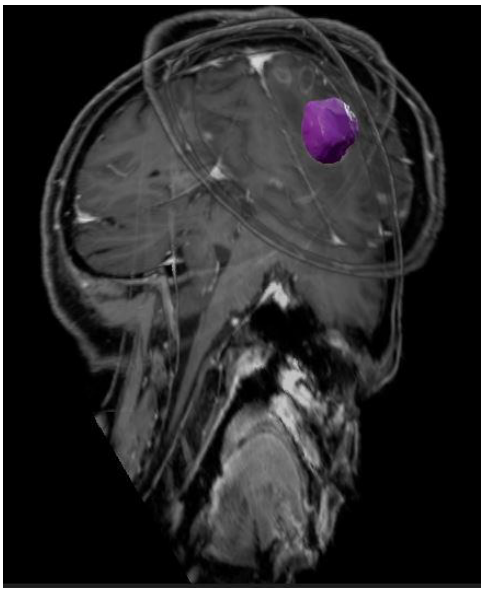


Abb. 2

| Parameter | N |
|---|---|
| Total population | 539 |
| Gender (f/m) | 247/292 (45.8%/54.2%) |
| Age (median) | 62.8 (range: 23.4–86.2) |
| Preoperative KPI (median) | 80 (range: 30–100) |
| Metastasis status | Solitary: 96(17.8%)<br>Singular: 198 (36.7%)<br>Multiple: 245 (45.5%) |
| Primary | Lung: 201 (37.3%)<br>Melanoma: 79 (14.6%)<br>Breast: 67 (12.5%)<br>Other: 192 (35,6%) |

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V093

### Entwicklung von Tumor Treating Fields (TTFields) Arrays für die Anwendung der Behandlung bei Tumoren des Kopfes im Mausmodell

***Development of Tumor Treating Fields (TTFields) arrays for application of treatment to head tumors in mice models***

S. Ehrle[1], S. Zbidat[2], R. Blat[2], M. Sellevoll[2], M. Gabay[2], I. Schlachet[2], S. Cahal[2], S. Davidi[2], I. Tzchori[2], A. Haber[2], M. Giladi[2], Y. Palti[2]

[1]Novocure GmbH, München, Deutschland
[2]NovoCure Ltd., Haifa, Israel

#### Objective

Gliomas are the most common primary malignant brain tumors in adults. Tumor Treating Fields (TTFields) therapy is an established biophysical treatment for grade 4 gliomas, delivered continuously via two pairs of arrays attached to the skin surrounding the tumor region. Currently, most glioma animal models constitute mice. Studies investigating TTFields therapy for gliomas in vivo are limited since arrays for TTFields application to the mouse head are not available yet. We strove to develop such arrays despite the challenging small dimensions and specific geometries of the mouse head.

#### Methods

Different array layouts were tested to identify one that will optimally accommodate the geometries of the mouse head while minimally restricting head movement. In addition, we analyzed different adhesive tapes for array attachment to the skin, to ensure good adherence and thus deliver treatment efficiently. Electric field measurements were performed to validate that the identified array layout delivers sufficient field intensity to the target region.

#### Results

To overcome the challenge of the small mouse head size we developed a layout in which the arrays on the head are subdivided into two smaller disks, while the respective opposing arrays are placed on the mouse torso. Further, we identified a thin, transparent adhesive tape that enables correct array positioning on the mouse head, offers appropriate tackiness, and allows for easy removal without leaving residual adhesive on the skin. The field measurements yielded an intensity ≥ 1 V/cm RMS and a current ≥ 50 mA, and the arrays were successfully applied to mice with usage ≥75%, hence they met the minimum requirements for effective tumor treatment.

#### Conclusion

Our newly developed mouse head arrays enable efficient TTFields delivery in vivo via a flexible construct that adheres strongly to the skin. By facilitating TTFields delivery to the heads of mice, we will contribute to expanding the scope and further advancing the field of brain tumor treatment research.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V094

### Brauchen Hinrtumorpatienten eine postoperative intensivmedizinische Überwachung nach elektiver Operation? Vorläufige Ergebnisse aus 3 Jahren Aufwachraum Betreuung bei supratentoriellen Eingriffen

***Do brain tumour patients need intensive care monitoring after elective craniotomy? Preliminary results from 3 years of routine postoperative recovery room surveillance in supratentorial brain tumour surgery***

F. Staub-Bartelt[1], D. M. Donaldson[2], R. Truse[2], M. Rapp[1], M. Sabel[1]

[1]Universitätsklinikum Düsseldorf, Neurochirurgie, Düsseldorf, Deutschland
[2]Universitätsklinikum Düsseldorf, Klinik für Anästhesiologie, Düsseldorf, Deutschland

#### Objective

The level of appropriate postoperative monitoring of patients after elective craniotomies for brain tumours has been intensively discussed for several years.It could be demonstrated that complications after elective craniotomies are rare and significant postoperative issues primarily arise in the first hours after the operation.The clinics of neurosurgery and anaesthesiology collaborated and changed the postoperative surveillance strategy from mandatory ICU to a more differentiated procedure involving the recovery room option.The present retrospective preliminary report analyses initial data from 437 supratentorial procedures for elective brain tumour surgery.

#### Methods

Patients were preoperatively classified into three groups according to their assumed postoperative monitoring period: 1)recovery room short = <2 hours,2) recovery room long = 3 hours and 3)ICU=intensive care unit.Patients that underwent elective supratentorial surgery with intraoperative monitoring or mapping techniques due to highly functional localization of lesions from 01/2020 to 01/2023 were enclosed in the study.Postoperative complications were categorized as revision surgery <24 h and revision surgery >24 h.In addition,clinical data and data from the recovery room and ICU protocols such as medication,vital parameters and duration of monitoring of the patients with revision surgery were considered.

#### Results

We enclosed 437 procedures in the analysis.We identified three revision surgeries (0.69%) due to rebleeding <24 hours.One patient was initially planned for ICU monitoring;two patients were planned as recovery room short.Both patients received i.v. antihypertensives,one patient received additional beta-blocker.In both cases rebleeding occurred after transfer of the patients to the normal ward.Mean duration of recovery room monitoring was 111.5.Furthermore, five procedures (1.1 %) resulted in revision surgery >24 h.

#### Conclusion

In this very special cohort of supratentorial only tumour craniotomies, we could show that monitoring is not routinely required at an ICU ward in the direct postoperative phase. If patients are carefully screened by neurosurgeons and anaesthesiologist, time and resource saving monitoring in the recovery room followed by extended surveillance on the normal ward is safely possible. However, a major limitation of the study is the much-defined cohort. Further data including posterior fossa surgery is currently being analysed.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V09

### Auswirkungen der Thromboseprophylaxe auf postoperative Komplikationen bei Glioblastom-Patienten
*Impact of thromboprophylaxis on postoperative complications in glioblastoma patients*

E. Wardenbach[1], T. Juratli[1], G. Schackert[1], I. Y. Eyüpoglu[1], W. H. Polanski[1]

[1]Uniklinikum, Neurochirurgie, Dresden, Deutschland

#### Objective

Postoperative thromboembolic events (TE) are critical side effects following glioblastoma (GBM) resection. This study assesses the impact of anticoagulant treatments—certoparin, enoxaparin, and enoxaparin combined with pneumatic stockings (PS)—alongside patient comorbidities on TE incidence after GBM surgery.

#### Methods

In this retrospective study, we analyzed patient-specific and procedure-specific risk factors for TE in 695 GBM patients. Following patient-specific risk factors were examined: epilepsy, diabetes, coronary heart disease (CHD), atrial fibrillation, hypertension, and history of TE. Procedure-specific risk factors included surgery duration (median 191min), intraoperative blood loss (median 150ml), medical thromboprophylaxis and the use of PS. This resulted in three distinct treatment groups: 1) certoparin, 2) enoxaparin, and 3) enoxaparin combined with PS.

#### Results

After GBM resection in 695 patients, 28 cases of TE occurred (4%). When considering both DVT and pulmonary embolism (PE), the incidences were 8.6% for group 2, 6.9% for group 1, and 2.6% for group 3 with a significant difference (p=.003).Longer surgery duration correlated with increased PE incidence; patients with PE had a median surgery time of 249min compared to 190min in the overall cohort (p=.002). Intraoperative blood loss was also a factor, with PE patients losing a median of 300ml, compared to 150ml in non-PE patients (p=.002). Similar trends were observed in PE/DVT patients: they had surgeries 45 minutes longer on average (p=.011) and lost in median 50ml more blood (p=.012).Older patients (>65 years) showed a higher prevalence of PE (4.3%) compared to those under 65 (1.6%) (p=.043), along with increased rates of diabetes (p=.005) and CHD (p=.037). Age, especially a median of 68 years, was linked to a higher risk of DVT/PE (p=.041), with additional risk associated with diabetes (p=.005) and hypertension (p=.048).The final multivariate logistic regression identified the prophylaxis group as an independent predictor for DVT/PE occurrence. Specifically, the risk was increased for the enoxaparin group with a hazard ratio of 0.312 (CI 0.116 - 0.842; p=.022).

#### Conclusion

GBM patients treated with enoxaparine alone have a significant higher risk for TE compared to treatment with certoparine or the combination of enoxaparine with PS. Additionally, the duration of surgery, patient age and comorbidities significantly influence the risk of postoperative TE.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## V096

### Graduelle metabolische Veränderungen beeinflussen die räumliche Architektur und Immunantwort in Glioblastomen

***Gradual metabolic alterations restructure the spatial architecture and immunity in glioblastoma***

J. Kückelhaus[1], J. Kada Benotmane[2,3,4], O. Schnell[1], J. Beck[2,3], D. H. Heiland[1,2,3,4]

[1]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Klinik für Neurochirurgie, Erlangen, Deutschland
[2]Albert-Ludwigs-Universität Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[3]CAST Center for Advanced Surgical Tissue analysis, Medical Center and Faculty of Medicine, Freiburg i. Br., Deutschland
[4]MILO Microenvironment and Immunology Research Laboratory, Medical Center and Faculty of Medicine, Freiburg i. Br., Deutschland

#### Objective

The organized layered structure of the human neocortex contrasts sharply with the chaotic architecture of malignant CNS tumors. The heterogenous nature of glioblastoma (GBM) poses significant challenges to research and treatment, given that effective strategies require consistent biological pattern. Here, we leverage the recent advances in spatial biology and integrate spatially resolved transcriptomics and metabolomics to identify drivers of GBM-specific architectural evolution.

#### Methods

We performed spatial metabolomics (MALDI) and transcriptomics (Visium n=43 and MERFISH n=25) of glioblastoma patients. Computational analysis was performed with the SPATA2 R package.

#### Results

We found that most spatial recurrent pattern in glioblastoma emerge in a gradient-like organization, particularly influenced by proximity to areas of necrosis and hypoxia. Samples without hypoxic regions demonstrated less spatial organization. Metabolomic and transcriptomic profiling revealed enhanced responses to hypoxia coupled with reduced cell proliferation and elevated expression indicative of the S-phase in cell division in near necrotic regions. The vicinity to hypoxic areas appeared to be associated with increased extracellular matrix remodeling and epithelial-to-mesenchymal transition, implying that the invasive capabilities of GBM cells originate from these hypoxic niches. By further integrating spatially resolved TCR-sequencing, we identified that hypoxic gradients drive defined T cell response with higher likelihood of T cell dysfunction within a distance of 235 µm (sd: 132µm) to hypoxia. This suggests that the presence of necrosis, hypoxia, and hypoxia associated metabolites could serve as potential predictive markers for T-cell behavior and exhaustion in glioblastoma.

#### Conclusion

Our study offers an in-depth analysis of the influence of two prevalent niches in glioblastoma: necrosis and hypoxia. We reveal that the complex architecture of glioblastoma is not solely dictated by genetic randomness and stochastic occurrences. Instead, it is significantly influenced by spatial proximity to key factors like necrosis and hypoxia. This insight contributes to an evolving model that seeks to unravel the intricate biology underpinning this formidable disease.

# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## V097

### Deep learning zur Unterscheidung von Glioblastomen und zerebralen Lymphomen
***A deep-learning based workflow for the preoperative MR-based diagnosis of primary central nervous system lymphoma***

P. Naser[1,2,3,4], M. C. Maurer[5,6], M. Fischer[2,5,7], K. Karimian-Jazi[2,8], C. Ben-Salah[2,9], A. A. Bajwa[2,10], M. Jakobs[1,2,3], C. Jungk[1,2], J. Jesser[2,8], M. Bendszus[2,8], K. Maier-Hein[5,7,11,12,4], S. Krieg[1,2], P. Neher[5,7,12], J. O. Neumann[1,2]

[1]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Medical Faculty, Heidelberg, Deutschland
[3]Heidelberg University, Division of Stereotactic Neurosurgery, Department of Neurosurgery, Heidelberg, Deutschland
[4]German Cancer Research Center (DKFZ), AI Health Innovation Cluster, Heidelberg, Deutschland
[5]German Cancer Research Center (DKFZ), Division of Medical Image Computing, Heidelberg, Deutschland
[6]University Medical Center Göttingen, Department of Medical Informatics, Göttingen, Deutschland
[7]German Cancer Consortium (DKTK), Partner site Heidelberg, Heidelberg, Deutschland
[8]Heidelberg University, Department of Neuroradiology, Heidelberg, Deutschland
[9]Heidelberg University, Department of Diagnostic and Interventional Radiology, Heidelberg, Deutschland
[10]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[11]National Center for Tumor Diseases (NCT/UCC), NCT Heidelberg, a partnership between DKFZ and the University Medical Center Heidelberg, Heidelberg, Deutschland
[12]Heidelberg University, Pattern Analysis and Learning Group, Department of Radiation Oncology, Heidelberg, Deutschland

#### Objective

MR-morphologically, primary central nervous system lymphoma (PCNSL) and high-grade gliomas like GBM share many common characteristics, such as large perifocal edemas, inhomogenous contrast enhancement, and irregular structural composition. The preoperative distinction between glioblastoma (GBM) and PCNSL can be difficult, even for experts, but is highly relevant. We aimed to develop an easy-to-use algorithm, based on a convolutional neural network (CNN) to preoperatively discern PCNSL from GBM and systematically compare its performance to experienced neurosurgeons and radiologists.

#### Methods

158 patients who underwent stereotactic biopsy (79GBM, 78 PCNSL) with 3D MRI datasets (T1-n, T1-CE, T2, FLAIR) were included in this retrospective study. Tumor volumes and demographic distribution were balanced. A CNN based on the DenseNet169 architecture was trained with the MR-imaging data of 68 PCNSL and 69 GBM patients and its performance compared on an external test set of 10 PCNSL and 10 GBM to six trained experts, who classified the lesions based on their experience. Saliency of the net was evaluated.

#### Results

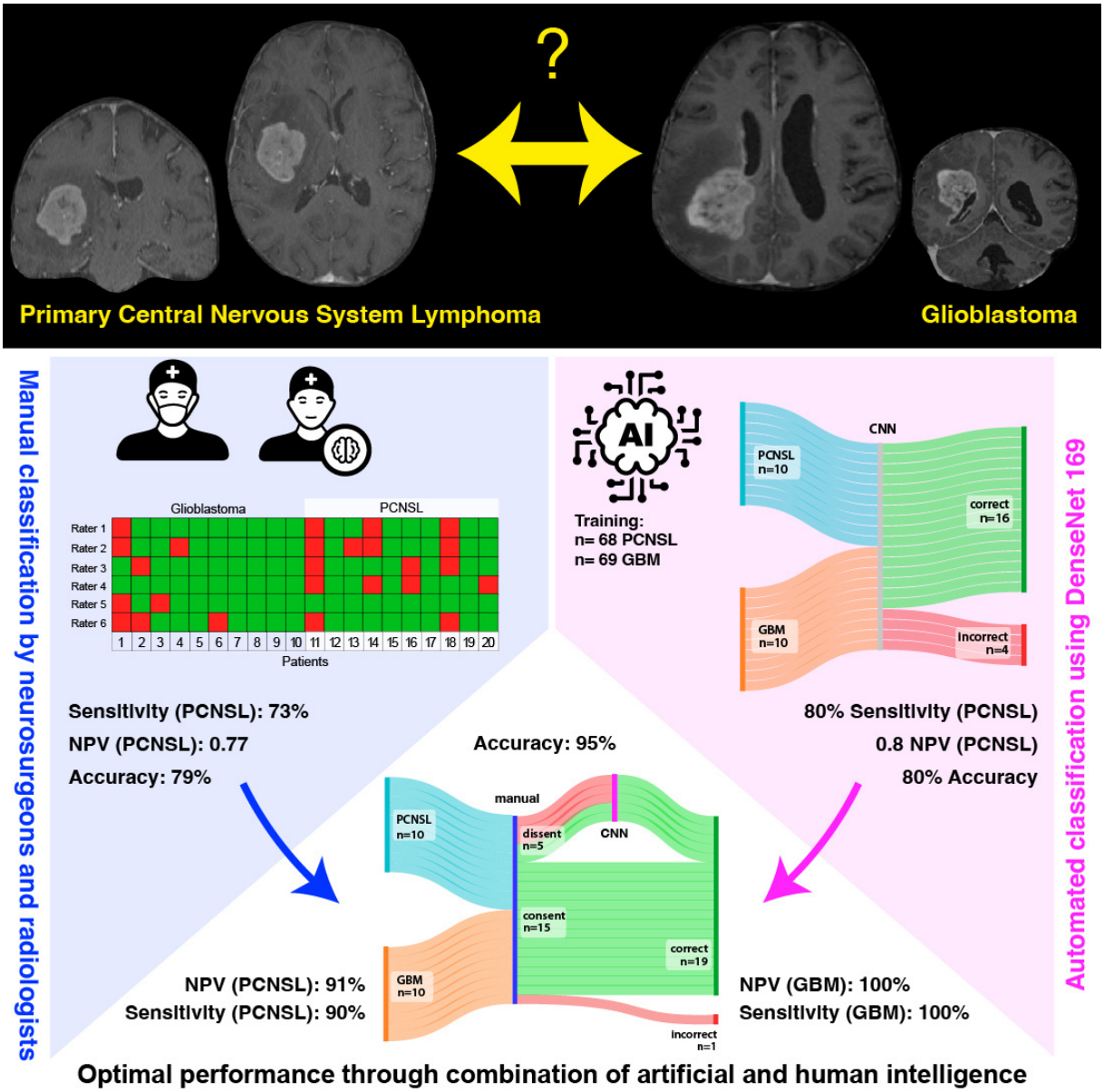
Our CNN diagnosed PCNSL with an accuracy of 80% and an NPV of 0.8. This exceeded the accuracy achieved by trained experts (73%, NPV 0.77). Neurosurgeons did not underperform the diagnostic accuracy of radiologists. While expert raters heavily relied on gadolinium-enhanced T1 images, the neural network based predictions on several modalities and showed inadequate performance when only presented with one image sequence. Interestingly, the tumors incorrectly identified differed between the CNN and the human raters. The CNN classified those tumors correctly, which human raters disagreed about. We performed a layered analysis, in which only those tumors experts dissented about were tested by the neural network. By combining manual and automated diagnosis, an accuracy of 95% was achieved.

#### Conclusion

In this pilot study, we developed a novel CNN for preoperative diagnosis of PCNSL and GBM. Our approach does not necessitate laborious preprocessing or manual annotation and can be readily used on standard MRI data.

We compared the algorithm's performance against six experienced physicians and could show non-inferiority. By integrating manual rating and this automated workflow we showed 95% preoperative accuracy when detecting GBM / PCNSL. Future studies and prospective evaluation of our methodology may lead to developing a clinically useful diagnostic tool for predicting brain-tumor entities.

Abb. 1



# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## V098

***Bewertung der navigierten 3D-Sonographie bei der Resektion intrazerebraler Tumoren. Zwischenergebnisse einer laufenden bizentrischen Studie***
***Assessment of navigated 3D ultrasound to aid brain tumor surgery. Interim results of an ongoing bicenter trial***

D. Tosin[1], D. Feucht[2], D. Aleo[3], C. R. Wirtz[4], M. Tatagiba[2], C. Roder[2], J. Coburger[1]

[1]Bezirkskliniken Schwaben, Neurochirurgie, Günzburg, Deutschland
[2]Universitätsklinikum Tübingen, Neurochirurgie, Tübingen, Deutschland
[3]Ospedale Carlo Poma, Neurochirurgia, Mantova, Italien
[4]Uniklinikum Ulm, Neurochirurgie, Ulm, Deutschland

### Objective

Intraoperative ultrasound (iUS) is a well-established tool for brain tumor surgery to localize residual tumor. The relatively recent features of 3D reconstruction of US images and its integration into neuronavigation require clinical validation. This interim analysis focuses on surgeons' perspectives regarding image quality, benefits, and accuracy of navigated 2D and 3D iUS during brain tumor resection.

### Methods

We prospectively enrolled adult patients with low- (LGG), high-grade gliomas (HGG) or cerebral metastases (cM). We performed 2D and 3D US scans right after dura opening, during tumor resection and after assumed gross total resection. Operating surgeons evaluated quality, clinical benefit and navigation accuracy of every iUS scan and its respective benefit for the whole surgery using Likert"s scales from 1 (best) to 6 (worst). We analyzed 2D and 3D iUS results employing Wilcoxon"s and Sign test.

### Results

Our study included 50 patients, 9 of whom underwent recurrent surgery. Diagnoses comprised 22 HGG, 13 LGG and 15 cM cases. While both 2D and 3D iUS image quality was rated as averagely "good" throughout the course of surgery, mean quality of 2D iUS was rated significantly better than 3D iUS scans (1,80 and 2,32 respectively; $p<0,001$). Comparison between 2D and 3D iUS showed no significant difference of benefit (mean 2,38 and 2,54 resp.; $p=0,172$) or navigation accuracy (mean 1,85 and 2,01 resp.; $p=0,051$). We observed a slight but significant decrease in both 2D and 3D iUS quality ($p=0,017$) and benefit ratings ($p=0,035$) during tumor surgery. General benefit ratings of both 2D and 3D iUS were significantly higher for LGG (mean 2,11 and 2,05 resp.) compared to HGG ($p=0,037$) and cM resection ($p<0,001$). Surgeons noted a relevant brain shift in 62% (31/50), an MRI registration error in 24% (12/50) and an insufficient iUS accuracy in 2% (1/50) of cases.

### Conclusion

Despite the challenges of 3D reconstruction in irregularly shaped resection cavities, 3D iUS showed mean rates between "very good" and "satisfying", with only slightly better ratings for 2D iUS. Both quality and benefit of 2D and 3D iUS seemed greater during early phases of tumor resection. iUS might allow for a more accurate localization of the tumor and the surrounding structures despite brain shift and MRI registration errors. LGG surgery may profit from iUS more than HGG and cM surgery.

# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## V099

### Autofluoreszenzbildgebung frischer Gehirntumorproben mit einem klinischen konfokalen Laser-Scanning-Endomikroskopiegerät

***Autofluorescence imaging of fresh brain tumor tissue samples with a medical confocal laser scanning endomicroscopy system***

M. Reichenbach[1,2], S. Richter[3,2], S. B. Sobottka[3], T. Juratli[3], D. Krex[3], D. Emmanouilidis[3], I. Y. Eyüpoglu[3], O. Uckermann[1]

[1]Technische Universität Dresden, Medizinische Fakultät, Dresden, Deutschland
[2]Technische Universität Dresden, Else Kröner Fresenius Zentrum für Digitale Gesundheit, Dresden, Deutschland
[3]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

#### Objective

Analysis of autofluorescence (AF) signals shows promise in brain tumor delineation. AF intensity is reduced in brain tumors compared to non-neoplastic tissue. AF images of various brain tumor types acquired using multiphoton microscopy (MPM) reflect tissue morphology and enable discrimination of normal and neoplastic brain tissue. Here, we performed ex vivo and in situ imaging of unlabeled tissue with a confocal laser-scanning endomicroscopy (CLE) system to assess its feasibility for in situ tissue characterization and tumor delineation in neurosurgery.

#### Methods

Ex vivo AF imaging was performed on 41 tissue samples from 29 patients (6 glioblastoma, 6 meningioma, 10 metastases, 1 hippocampal sclerosis, 6 other). Multiple images were acquired on each sample (median 183, range 54-338), using the ZEISS Convivo CLE system. Images of the same field of view were acquired with 488 nm laser excitation using band-pass (BP 518-573 nm) and long-pass (LP > 515 nm) emission filters. Mean gray values and standard deviation were measured on image background and fluorescent structures to analyze signal-to-noise ratio. Proof of concept in situ imaging was performed during surgery for glioblastoma and epilepsy. Reference histopathology and label-free MPM was performed on cryosections.

#### Results

AF signals were detected in all tissue samples as well as in situ. The images revealed different AF patterns across tumor types, including fluorescent cytoplasmic granules and elastin fibers. Distinct fibrous structures occurred in meningioma, and large cells were identified in hippocampal tissue and tumor border. Comparison of BP and LP emission filters showed a significantly higher background signal in LP images (mean gray values BP: 93 ± 9.7, LP: 126 ± 4.5, $P<0.0001$, n=16 samples, 505 image pairs), but no difference in signal-to-noise ratios. Reference imaging using MPM identified similar cellular features as seen in CLE images.

#### Conclusion

CLE of brain tumor tissue without fluorescent dyes is possible. It provides real-time information on tissue morphology comparable to AF signals obtained by MPM, which allow brain tumor recognition. This indicates that label-free CLE holds promise in intraoperative tumor classification and delineation. Identification of cellular AF sources and the combination with machine learning might foster clinical translation of this approach in the future.

# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## V100

### Veränderungen von Diffusionsparametern bei Patienten mit tumorassoziierten Krampfanfällen in einer gemischten Gliom-Kohorte

***Alterations of diffusional parameters in patients with tumor-associated seizures in a mixed glioma cohort***

D. Deuter[1], M. Mader[2,3], T. Sauvigny[2], P. Borchert[4], T. Faizy[4,5], M. Bester[4], M. Westphal[2], K. Rosengarth[1], J. Sedlacik[4,6], N. O. Schmidt[1], L. Dührsen[2]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[3]Stanford University School of Medicine, Institute for Stem Cell Biology and Regenerative Medicine, Stanford, CA, Vereinigte Staaten
[4]Universitätsklinikum Hamburg-Eppendorf, Klinik und Poliklinik für Diagnostische und Interventionelle Radiologie und Nuklearmedizin, Hamburg, Deutschland
[5]Stanford University School of Medicine, Department of Neuroimaging and Neurointervention, Stanford, CA, Vereinigte Staaten
[6]King's College London, School of Biomedical Engineering & Imaging Sciences, Centre for the Developing Brain and Biomedical Engineering Department, London, Vereinigtes Königreich

#### Objective

Epileptic seizures are a common symptom in glioma patients, heavily affecting the patients' quality of life. Nevertheless, the pathophysiological mechanisms evoking tumor-associated seizures aren't completely understood yet. The aim of this study was to investigate if an association of altered microstructural DTI parameters with tumor-associated seizures exists.

#### Methods

Two cohorts of patients with a case-mix of glial brain tumors from two tertiary centers were analyzed using two different methodological approaches to increase methodological validity (n=23 and n=46). Preoperative DTI-imaging was examined in regions-of-interest (ROI) defined relatively to the tumor. In the first cohort, these included the marginal tumor zone, peritumoral white matter (PWM) and controls; in the second cohort contrast enhancement, necrosis, non-enhancing tumor areas, marginal non-enhancing tumor zone, PWM, edema and controls. Mean fractional anisotropy (FA) and mean diffusivity (MD) were calculated for these ROIs and compared between patients with and without seizures independently for both cohorts.

#### Results

35 patients with Glioblastoma IDH-wildtype, 1 with Gliosarcoma, 11 with IDH-mutant Astrocytoma, 16 patients with Oligodendroglioma (IDH-mutant and 1p19q-codeleted), 1 with Ganglioglioma, 2 with pilocytic Astrocytoma and 3 patients with tumors formerly diagnosed as anaplastic Astrocytoma/ Oligodendroglioma WHO °III IDH-wildtype NOS were part of this study. In the primary cohort, MD was found to be significantly decreased in the marginal tumor zone in patients with tumor-associated seizures (p=0.005). In the second cohort, the result of significantly lowered MD could be retraced for non-enhancing tumor areas in non-GBM patients when normalized to control-ROIs (p=0.022).

#### Conclusion

In the marginal zone of gliomas, diffusional alterations were found, but not in other areas. These findings could represent an altered histological tumor microenvironment of the marginal tumor zone potentially being involved in seizure-evoking processes. Further studies are needed to validate the findings of this pilot study, also on a histo-biological base.

# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## V10

### Strategische Vorhersage von 18F-FET-PET-Hotspots in multimodalem MRT von niedriggradigen Gliomen durch Deep Learning-basierte Tumorsegmentierung und Extraktion radiomischer Merkmal

***Strategic 18F-FET-PET hotspot prediction in multimodal MRI from lower-grade gliomas through deep learning-based tumor segmentation and radiomics feature extraction***

Z. Özdemir[1], G. Azemi[2], A. Valls Chavarria[1], W. Roll[3], C. Thomas[4], C. Russo[2], S. Liu[2], W. Stummer[1], A. Di Ieva[2,5], E. Suero Molina[6,2]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[3]Universitätsklinikum Münster, Nuklearmedizin, Münster, Deutschland
[4]Universitätsklinikum Münster, Neuropathologie, Münster, Deutschland
[5]Macquarie University Hospital, Department of Neurosurgery, Sydney, Australien
[6]Uniklinik Münster, Neurochirurgie, Münster, Deutschland

#### Objective

Accurate identification of 18F-Fluoro-Ethyl-Tyrosine (18F-FET) positron emission tomography (PET) hotspots in lower-grade gliomas has become crucial for understanding tumor characteristics and guiding tailored surgical interventions. This study presents a novel approach employing a DL-based model for tumor segmentation and radiomics feature extraction to predict high 18F-FET-PET uptake. It uses multimodal MRI in a cohort of patients harboring histologically confirmed lower-grade gliomas and without typical MRI imaging features of high-grade tumors.

#### Methods

Our approach involves training a DL-based model to segment tumors in multimodal MRI, including T1, T1 post-gadolinium, and FLAIR-sequences. Hotspot labeling was withdrawn from the available 18F-FET-PET. The preprocessed MRIs were fed into the tumor segmentation algorithm, from which we extracted 83 radiomic features using the pyradiomics package. Utilizing the selectKBest algorithm, we identified the most effective features and utilized them in a Random Forest classifier. We allocated ~80% of the data for training purposes. To address the imbalance in the dataset, we implemented resampling techniques specifically targeting the minority class.

#### Results

We analyzed MRI scans of 225 patients harboring lower-grade gliomas. Of these, 178 had a higher uptake of 18F-FET (hotspot), while 47 did not. The best results were achieved by employing 17 top-performing radiomic features extracted from the tumor regions in the FLAIR images, resulting in an accuracy of 86% with the following associated confusion matrix:

[5 2

4 34]

#### Conclusion

In conclusion, our findings underscore the potential of combining DL-based tumor segmentation and radiomics feature extraction for predicting strategic 18F-FET-PET hotspots in lower-grade gliomas. The robust performance metrics affirm the efficacy of our approach, suggesting its utility in clinical settings for improving the precision of hotspot predictions and guiding personalized therapeutic interventions, especially in regions of the world

without access to amino acid PETs, such as 18F. This work contributes to advancing the field of non-invasive imaging for glioma characterization and treatment planning.

# Innovation und Technik – Bildgebung | Innovation and technology – Imaging

## BO-04

### *IMAGINER – Improving accuracy with augmented reality navigation system during placement of external ventricular drains: A feasibility study*

M. Vychopen[1], J. Wach[1], D. Winkler[1], F. Kropla[1], R. Grunert[1,2], E. Güresir[1]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland
[2]Fraunhofer Institut, Frauenhofer Institut für Machinebau, Zittau, Deutschland

**Objective**

Placement of a ventricular catheter (i.e. external ventricular drain, EVD) is a common and essential neurosurgical procedure. In addition, this procedure is one of the first procedures performed by young neurosurgeons. With or without surgical experience, placement of an EVD according to anatomical landmarks only can be difficult with the potential risk for inaccurate catheter placement. Repeated corrections always imply the risk of avoidable complications. Augmented reality (AR) could provide a useful guide and improve the accuracy of drain placement, especially in patients with acute pathology leading to displacement of anatomical structures. We therefore performed a feasibility study using AR in EVD placement procedures performed in a human cadaver model.

**Methods**

20 medical students performed the EVD placement procedure with a Cushing´s ventricular cannula on the right and on the left side. The cannula was placed according to landmarks on one and with the assistance of AR (Microsoft Hololens 2) on the other side. With AR a planned trajectory was displayed in the field of view which guides the placement of the cannula. Subsequently, the actual position of the cannula was assessed with the help of a CT with 1mm layer thickness. The bony structure as well as the left and right cannula positions were registered to the CT with the planned target point before the placement procedure. The software Cloudcompare was applied for the registration and the evaluation of accuracy.

**Results**

EVD placement using AR was easily performed by all medical students. The predefined target point (inside the lateral ventricle) was stuck with both techniques. However, it could be shown that the scattering radius of the target point reached with AR (12mm) could be reduced by more than 54% compared to the puncture without AR (26mm) and this represents a doubling of the puncture accuracy.

**Conclusion**

This feasibility study specifically showed that the integration and use of augmented reality helps to achieve more than double the accuracy in the placement of ventricular catheters. Due to the easy availability of these new tools and the intuitive handling, we see great potential in AR to improve the accuracy.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V102

### Supramarginale Resektion beim Glioblastom: Wie Tumorunterklassen und -zusammensetzung bestimmen, wann man die Grenzen überschreitet

***Supramarginal resection in glioblastoma: How tumor subclasses and composition dictate when to push the boundaries***

F. Ricklefs[1], R. Drexler[1], L. Dührsen[1], D. Silverbush[2], J. Gempt[1], U. Schüller[3]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[2]University of Pennsylvania, Pennsylvania, PA, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Institut für Neuropathologie, Hamburg, Deutschland

#### Objective

The prognosis of glioblastoma is poor, with limited responses to chemotherapy and radiation. Surgical tumor removal is crucial for improving survival, although the extent of resection required for a survival benefit varies across studies. Recent studies identified molecular markers for predicting the response to resection paving the way towards a tailored surgical treatment. We recently demonstrated a survival benefit after gross total resection in the *receptor tyrosine kinase* (*RTK*) *I* and *II* subclasses, which is not present in the mesenchymal (MES) subclass. In our study, we aimed to explore the benefits of supramarginal resection based on glioblastoma subclasses and underlying cell composition to guide extensive resection decisions.

#### Methods

We included 174 patients with newly diagnosed contrast-enhancing glioblastoma undergoing surgery followed by combined radio-chemotherapy. We assessed the extent of resection using 3D volumetric segmentation from magnetic resonance imaging (MRI) before and within 48 hours after surgery, according to the RANO resect group classification. We further examined DNA methylation profiles using the Illumina EPIC array and analyzed the abundance of different cell types and cell states within the tumor using a reference free deconvolution method.

#### Results

Our cohort had a mean age of 63.7 (34-84) years and 43.1% patients were female, with 52.1% having a methylated *MGMT* promoter. Supramarginal resection was achieved in 10.3%. Survival analysis demonstrated significant differences between biopsy, submaximal, and maximal resection (mOS: 10 versus 17 versus 21 months, $P < 0.0001$ but not between maximal and supramarginal resection (mOS: 21 versus 26 months, $P = 0.4478$). When dividing our cohort into *RTK* and MES tumors, we found a survival benefit after supramarginal resection for *RTK* tumors (mOS: 38 versus 21 months, $P = 0.0413$) but not MES tumors (mOS: 18 versus 18 months, $P = 0.7283$). Further analyses showed a benefit of supramarginal resection in high stem cell-like tumors (mOS: 35.5 versus 20 months, $P = 0.021$), but not in low stem cell-like tumors (mOS: 24 versus 27 months, $P = 0.8027$) or immune cell subsets.

#### Conclusion

In conclusion, we demonstrate a profound survival benefit after supramarginal CE resection in patients with *RTK* tumors with an increased stem cell-like state. Vice versa, an extensive resection in MES tumors must be critically questioned since no survival benefit was found and a greater risk of neurological deterioration exists.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V103

### Molecular glioblastomas – the same but different?
*Molekulare Glioblastome – ähnlich und doch verschieden?*

S. J. Hellwig[1], C. Thomas[2], W. Stummer[1]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Universitätsklinikum Münster, Institut für Neuropathologie, Münster, Deutschland

### Objective

The 2021 WHO-classification changed the classification of gliomas from solely histopathological criteria to molecular genetic characteristics. IDH-wildtype (wt) diffuse astrocytomas (LGG) which prior to the 2021 classification were classified as grade II, are now diagnosed as IDH-wt gliomas with molecular characteristics of glioblastomas (mGBM) when harbouring certain molecular abnormalities like chromosomal +7/-10 copy alterations, TERT promotor mutation, EGFR amplification and CDKN2A/B deletion. mGBM grade 4 are widely treated as the earlier WHO grade IV GBM with patients undergoing adjuvant radiochemotherapy. Whether early cytotoxic treatment truly improve patient"s outcome and is favourable in every case is not clear at present.

### Methods

We retrospectively analysed overall survival (OS) and tumor characteristics as well as adjuvant treatment of a total of 46 histopathological grade 2 IDH-wt LGG treated between 2012 and 2021 prior to the introduction of the 2021 WHO classification, and identified those with molecular characteristics of glioblastomas. We than searched for influencing factors on decision making for adjuvant treatment or watch-and-wait strategies using multivariant analysis. The comparison of OS between the 4 groups was performed using Kaplan-Meier estimators.

### Results

In our cohort we found that extent of resection (EOR, $p<0.001$) and age ($p=0.033$) significantly and independently influenced the decision for adjuvant therapies ($p<0.05$). Contrast enhancement on MRI was marginally significant ($p=0.086$), whereas molecularpathological diagnosis and the patient`s level of functioning (ECOG performance status) did not significantly affect this decision. When comparing OS, we found no observable difference between mGBM and IDH-wt LGG without adjuvant therapy as well as between these two entities treated with early adjuvant cytotoxic therapy. Overall, we observed a difference in OS between patients with adjuvant therapy and those without.

### Conclusion

EOR and age drove the decision for adjuvant therapy in presumed IDH wt LGG prior to the 2021 classification of brain tumors, rather than the distinction of molecular GBM. In our cohort patients with mGBM without adjuvant therapy did not do worse than other patients with histopathological IDH-wt LGG. These observation question whether adjuvant therapy should be performed in mGBM with good resection status, lack of enhancement, and younger age, with respect to possible side effects.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V104

### "Einfluss der TERT Promotormutation auf die Prognose histologisch niedriggradig erscheinender *IDH*-Wildtyp-Glioblastome"
***Impact of TERT promoter mutations on the prognosis of histologically low-grade appearing IDH wild-type glioblastoma***

A. M. Seifert[1], S. Richter[1,2], G. Schackert[1], I. Y. Eyüpoglu[1], T. Juratli[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Technische Universität Dresden, Else Kröner Fresenius Center for Digital Health, Dresden, Deutschland

#### Objective

The WHO 2021 CNS Classification allows for the identification of glioblastoma (GBM) based solely on *TERT* promoter (*TERT*p) mutations, even in tumors that are histologically low-grade, as long as they are *IDH* wild-type. This study aims to explore the outcomes of patients with astrocytoma that appear histologically low-grade but are molecularly classified as high-grade gliomas.

#### Methods

We analyzed tumor samples from 47 patients who underwent resection of IDH-wildtype (*IDH*$_{WT}$) astrocytoma (WHO grades 2-3), confirmed through molecular testing. *TERT*p status was evaluated using Sanger Sequencing (n=38) and next-generation sequencing (NGS, n=9). Data on progression-free and overall survival (PFS, OS), as well as tumor characteristics, were collected.

#### Results

Of the tumors analyzed, 68.1% (n=32) had a *TERT*p mutation (*TERT*p$_{mut}$), while 15 cases (31.9%) were *TERT*p$_{WT}$. The median age of the patients was 66 years (range 24-86 years), with a median OS of 19 months and PFS of 15 months. *TERT*p status showed no correlation with age at diagnosis (*TERT*p$_{mut}$: 66.5 years; *TERT*p$_{WT}$: 66 years). The male/female ratio was 1.13:1 (m=25, f=22) and did not associate with *TERT*p status. No significant correlation was found between other clinical features, such as tumor location, and *TERT*p status. However, *TERT*p$_{mut}$ patients had significantly shorter OS (17 months) compared to *TERT*p$_{WT}$ patients (46 months; p=0.0071). Adjuvant therapy was administered to 71.88% (n=23) of the *TERT*p$_{mut}$ group and 60% (n=9) of the *TERT*p$_{WT}$ group. Patients receiving adjuvant therapy (radiochemo- or radio/chemotherapy; n=31) had better outcomes (median OS: 28 vs. 9 months; p=0.0074).

#### Conclusion

The outcomes of histologically low-grade appearing *TERT*p-mutant gliomas in our cohort align with survival data for GBM patients. This highlights the importance of molecular profiling and indicates that *TERT*p mutation alone can justify a GBM diagnosis in the absence of characteristic histological features or an *IDH* mutation. Consequently, caution is advised when predicting survival based solely on histological appearance in low-grade glioma patients.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V105

### Präoperative Epilepsie ist ein unabhängiger prädiktiver Faktor für das Überleben von Glioblastom-Patienten – eine bizentrische Analyse von 597 Patienten

***Preoperative epilepsy is an independent predictive factor for overall survival in glioblastoma patients – A bi-center analysis of 597 patients***

L. Kotakova[1], D. Dimov[2], J. Ort[1], H. R. Clusmann[1], M. Simon[2], D. Delev[1]

[1]Universitätsklinikum RWTH Aachen, Neurochirurgie, Aachen, Deutschland
[2]Universitätsklinikum OWL Campus Bielefeld-Bethel, Neurochirurgie, Bielefeld, Deutschland

#### Objective

More than one-third of all glioblastoma patients develop epilepsy, which significantly increases the burden of an already devasting oncological disease. Since the introduction of the field of cancer neuroscience, increasing scientific evidence suggests that underlying altered neuronal activity may regulate the growth of glial malignancies through direct electrochemical synaptic communication, meaning that seizures can play a role in tumor growth. Here, we aim to determine if the occurrence of preoperative epilepsy influences patient survival, thereby offering a novel perspective in the understanding of glioblastoma patient management.

#### Methods

We conducted a retrospective analysis of a cohort comprising 597 patients diagnosed with primary IDH1-Wildtype Glioblastoma, who underwent surgical treatment in two neurosurgical centers. Relevant clinical data were extracted from the electronic medical records. The influence of epilepsy on overall survival was investigated in both univariate and multivariate analyses, incorporating prognostic factors such as MGMT status, extent of surgical resection (total resection, partial resection, and biopsy) and patient age.

#### Results

Preoperative epilepsy was observed in 190 of the patients (31.8%). The presence of MGMT promoter methylation was noted in 310 patients (53.9%). 438 patients (72.8%) received postoperative adjuvant treatment with a median overall survival of 15.6 months. The presence of preoperative epilepsy was associated with longer overall survival (p=0.012). A multivariate analysis including treatment modality, MGMT status, and neurosurgical center as covariate confirmed preoperative epilepsy as an independent predictor for longer overall survival (p=0.042). In the subgroup of patients, who underwent adjuvant treatment, preoperative epilepsy was again independent predictor for longer overall survival in both univariate (p=0.013) and multivariate (p=0.009) analyses, together with age, MGMT status, and extent of resection. No significant differences in outcomes were observed between the two treatment centers.

#### Conclusion

Our data confirm preoperative epilepsy as an independent predictor of overall survival in primary IDH1-Wildtype Glioblastoma patients. In the spotlight of cancer neuroscience, where neuronal activity and tumor behavior seem to interact, preoperative epilepsy may resemble in important clinical biomarker, potentially pointing at more personalized treatment strategies.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V106

### Evolution neurochirurgischer Ergebnisse und des Überlebens von Patienten mit neu diagnostiziertem Glioblastom in zwei Dekaden: Vergleich von zwei prospektiven, kontrollierten Studien zur Resektion von Glioblastomen mit vergleichbaren Einschlusskriterien: Die 5-ALA- und die iMRI vs. 5-ALA- Studie

***Evolution of neurosurgical results and survival of patients with newly diagnosed glioblastoma in two decades: Comparison of the results of two prospective, controlled trials on the resection of glioblastoma with comparable inclusion criteria: The 5-ALA and the iMRI vs. 5-ALA trials***

C. Roder[1], -. iMRI/ALA study group[2], -. ALA-glioma study group[3], P. Haas[1], M. Tatagiba[1], P. Martus[4], W. Stummer[5]

[1]Universitätsklinikum Tübingen, Neurochirurgie, Tübingen, Deutschland
[2]iMRI/ALA study group, Germany, Deutschland
[3]ALA-glioma study group, Germany, Deutschland
[4]IKEAB Universität Tübingen, Tübingen, Deutschland
[5]Universitätsklinikum Münster, Münster, Deutschland

#### Objective

Two prospective, controlled multicenter trials on the resection of glioblastomas are published to date spanning almost 2 decades of medical evolution. The 5-ALA (ALA) trial, published 2006, comparing the extent of resection (EOR) and overall survival (OS) of patients after 5-ALA fluorescence-guided and white-light surgery, and the iMRI vs. 5-ALA (iMRI/ALA) published 2023, comparing 5-ALA fluorescence-guided and iMRI-guided surgery. Both studies had comparable inclusion criteria, therefore this analysis aims to compare surgical and survival results of both studies.

#### Methods

We analyzed the data of both trials in terms of baseline, peri- and postoperative clinical data, as well as EOR and OS.

#### Results

Data of 243 patients of the ALA and 277 patients of the iMRI/ALA trial were analyzed. Median age and preoperative NIHSS were comparable between cohorts. Tumors were rated "eloquent" in 56% in the ALA and 51% in the iMRI/ALA trial. Total resection of contrast enhancement was achieved in 36.1% (white-light), 64.5% (ALA in ALA trial), 78% (ALA in iMRI/ALA trial) and 81% (iMRI). 19.5% (ALA trial) compared to 8% (iMRI/ALA trial) of patients deteriorated neurologically postoperatively. OS differed significantly between both studies, especially depending on the EOR: Patients with incomplete resections had a median OS of 11.8 (ALA-trial) and 19.4 (iMRI/ALA trial), in contrast to 16.9 and 25.4 months for completely resected tumors, respectively. Incomplete resections led to worse OS in both studies, regardless of residual tumor size. Patients with the prognostically "worst" tumors (MGMT non-methylated, subtotal resection) in the iMRI/ALA trial had a comparable median OS (16.1 months) to patients with the prognostically "best" tumors (total resection) have from the ALA-trial (16.9 months). First-line adjuvant treatment was radiotherapy in 92.6% of patients in the ALA trial and a combined radiochemotherapy with temozolomide in 84% of patients in the iMRI/ALA trial.

#### Conclusion

Most likely due to increasing experience with5-ALA fluorescence guidance, the numbers of complete resections using this technology increased from 64.5 to 78% within the last two decades. Further, the role of complete resections without any residual contrast enhancing tumor remains a highly significant prognostic factor. OS has significantly improved throughout the last years, most likely caused by the routine use of combined radiochemotherapy in combination with better surgical results.

# Tumor – Gliome 1 | Tumour – Gliomas 1

## V107

### Die onkologische Rolle der chirurgischen Resektion in nicht-Kontrastmittel-aufnehmenden Glioblastomen mit niedrig-gradiger Präsentation

***The oncological role of surgical resection in non-contrast-enhancing glioblastomas with low-grade appearance***

P. Karschnia[1], J. Dietrich[2], F. Bruno[3], A. Dono[4], S. T. Juenger[5], N. Teske[1], J. S. Young[6], T. Sciortino[7], L. Häni[8], M. van den Bent[9], M. Weller[10], M. A. Vogelbaum[11], R. A. Morshed[6], A. F. Haddad[6], A. M. Molinaro[6], N. Tandon[4], J. Beck[8], O. Schnell[8], L. Bello[7], S. Hervey-Jumper[6], N. Thon[1], S. J. Grau[12], Y. Esquenazi[4], R. Rudà[3], S. M. Chang[6], M. S. Berger[6], D. P. Cahill[13], J. Tonn[1]

[1]LMU University Hospital of the Ludwig-Maximilians-University Munich, Department of Neurosurgery, München, Deutschland
[2]Massachusetts General Hospital Cancer Center, Department of Neurology, Boston, MA, Vereinigte Staaten
[3]University of Turin, Department of Neuroscience, Turin, Italien
[4]McGovern Medical School at UT Health Houston, Department of Neurosurgery, Houston, TX, Vereinigte Staaten
[5]University of Cologne, Department of Neurosurgery, Köln, Deutschland
[6]University of California, Department of Neurosurgery & Division of Neuro-Oncology, San Francisco, CA, Vereinigte Staaten
[7]University of Milan, Department of Oncology and Hemato-Oncology, Milan, Italien
[8]University Medical Center Freiburg, Department of Neurosurgery, Freiburg i. Br., Deutschland
[9]Erasmus MC Cancer Institute, Department of Neurology, Rotterdam, Niederlande
[10]University Hospital and University of Zurich, Department of Neurology, Zürich, Schweiz
[11]Moffitt Cancer Center, Department of NeuroOncology, Tampa, FL, Vereinigte Staaten
[12]Klinikum Fulda, Academic Hospital of Marburg University, Department of Neurosurgery, Fulda, Deutschland
[13]Massachusetts General Hospital, Department of Neurosurgery, Boston, MA, Vereinigte Staaten

#### Objective

Surgical resection of the contrast enhancement is recommended as upfront therapy for newly diagnosed glioblastomas. However, some tumors eventually diagnosed as glioblastomas lack contrast enhancement on imaging and have therefore a '*low grade appearance*' on imaging (non-CE glioblastoma). We aimed to delineate the role of non-CE tumor resection in the absence of contrast enhancement, and to analyse outcome differences between glioblastoma patients with and without contrast enhancement.

#### Methods

A retrospective cohort of patients with newly diagnosed glioblastoma per WHO 2021 classification presenting to eight international high-volume centers was compiled. The associations between post-operative tumor volumes and outcome were volumetrically analyzed. Propensity score-matched analyses were constructed to compare glioblastomas with and without contrast enhancement by mimicking a randomized, controlled trial.

#### Results

Among 1323 newly diagnosed IDH-wildtype glioblastomas, 98 patients (7.4%) without contrast enhancement were identified. In such non-CE patients, smaller post-operative tumor volumes were associated with more favourable outcome. There was an exponential increase in risk for death with larger residual non-CE tumor on Cox regression analysis. Accordingly, more extensive resection was associated with improved survival compared to lesion biopsy. These findings were retained on a multivariable analysis adjusting for potential confounders including demographic and clinical markers. Compared to CE glioblastoma, patients with non-CE glioblastoma had more favourable clinical profile and superior overall survival. This was confirmed in a propensity score analysis by matching the patients with non-CE glioblastoma to patients with CE glioblastoma using a large set of clinical variables including postoperative tumor volumes.

#### Conclusion

The absence of contrast enhancement on initial imaging characterizes a less aggressive clinical phenotype of IDH-wildtype glioblastomas. Maximal surgical resection of non-CE tumors with minimal residual volumes has prognostic implications and translates into favourable outcome.

# Tumor – Gliome und Neurokognition | Tumour – Gliomas and neurocognition

## V108

### *Epilepsie und Neurokognition bei Patienten mit Glioblastom*
### *Epilepsy and neurocognition in patients with glioblastoma*

K. Rodrian[1,2], S. Kochs[1], M. Becker[1], R. Loução[1], C. Nettekoven[1], D. Wiewrodt[3], M. Löhr[4], C. Jungk[5], M. Kocher[1], H. R. Clusmann[2], R. Goldbrunner[1], N. 1. Studiengruppe[1,6,7,3,8,2,4,5,9,10,11,12,13,14,15], C. Weiß Lucas[1]

[1]Universitätsklinikum Köln, Zentrum für Neurochirurgie, Köln, Deutschland
[2]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[3]Uniklinik Münster, Neurochirurgische Klinik, Münster, Deutschland
[4]Universitätsklinikum Würzburg, Neurochirurgische Klinik, Würzburg, Deutschland
[5]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[6]Universität zu Köln, Department für Heilpädagogik und Rehabilitation, Köln, Deutschland
[7]Universitätsklinikum Regensburg, Neurochirurgische Klinik, Regensburg, Deutschland
[8]Universitätsklinikum Tübingen, Abteilung Neurologie mit interdisziplinärem Schwerpunkt Neuroonkologie, Tübingen, Deutschland
[9]Uniklinik Mainz, Neurochirurgische Klinik, Mainz, Deutschland
[10]Donau-Isar-Hospital, Neurochirurgische Klinik, Deggendorf, Deutschland
[11]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgische Klinik, Dresden, Deutschland
[12]Universitätsklinikum Schleswig-Holstein, Neurochirurgische Klinik, Lübeck, Deutschland
[13]Klinikum Chemnitz, Neurochirurgische Klinik, Chemnitz, Deutschland
[14]HELIOS Krankenhaus Schwerin, Neurochirurgische Klinik, Schwerin, Deutschland
[15]Universitätsklinikum Freiburg, Neurochirurgische Klinik, Freiburg i. Br., Deutschland

#### Objective

Epilepsy is a common symptom in patients with glioblastoma, often leading to first diagnosis. Many of these patients are treated with antiepileptic medication. However, especially for patients with very occasional, focal seizures the decision-making regarding anticonvulsive treatment remains a matter of discussion. Some studies suggest an impact of epilepsy and its treatment on neurocognition and mood. The aim of this study was to describe the prevalence and use of antiepileptic drugs before therapy and during the course of disease, and to analyse correlations with neurocognitive performance.

#### Methods

226 patients with untreated glioblastomas underwent neurocognitive assessment composed of 11 subtests, complemented by a standard questionnaire to assess depression (Becks Depression Index). Moreover, information on epileptic history and the use of antiepileptic drugs were collected from the attending physicians before and after first surgery, and after 3 and 6 months. Neurocognitive data were normalised to percentile ranks. Pearson"s point-biserial correlations were calculated to examine relationships between neurocognitive performance and epilepsy as well as use of antiepileptic medication. Chi-squared tests were applied to evaluate the relationship between epilepsy (treatment) and binomial factors. Correction for multiple comparisons was applied.

#### Results

Preoperatively, 22% were reported to suffer from (mostly focal) epilepsy. 28% received antiepileptic treatment (84% levetiracetam-based medication). Seizures during the acute postoperative phase occurred overall in 3.6% of the patients, largely irrespective of preoperative epilepsy (4.8% vs. 3.5%; n.s.). The prevalence of epilepsy did not significantly change over time. Patients with epilepsy showed, overall, non-inferior neurocognitive test performance. Interestingly, they even showed better performance than non-epileptic patients in visuospatial processing (p=0.05), especially when under anticonvulsive medication (p=0.003). In contrast, we found no significant association of epilepsy with depression or the IDH mutation status. Of note, tumour volumes of epilepsy patients were not different from others (p=0.899).

## Conclusion

Our data showed no negative effect of epilepsy and related medical treatment on neurocognitive functions, and even support the hypothesis that the use of levetiracetam has a positive impact on visuospatial abilities. This seems worthy of consideration for clinical decision-making.

# Tumor – Gliome und Neurokognition | Tumour – Gliomas and neurocognition

## V109

*Kognitive Reserve Index neuro-onkologischer Patienten*
*Cognitive Reserve Index in neuro-oncological patients*

D. Januzi[1], N. Dinc[1], P. Baumgarten[1], M. A. Kamp[1], C. Senft[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

### Objective

Neuro-oncological diseases often result in brain damage, leading to neurological deficits. The Cognitive Reserve Index Questionnaire (CRIq) is a validated tool that gauges cognitive reserve, reflecting the brain's resilience to neuropathological damage and its compensatory mechanisms. This study aims to conduct a comprehensive analysis of variations in CRIq scores and the underlying factors among diverse brain tumors.

### Methods

In this pilot series, all patients attending our neuro-oncology outpatient clinic over a 7-month period (October 2022 - April 2023) were requested to complete the CRIq questionnaire. Data analysis adhered to the established "Instructions for the administration of the CRIq" (Nucci et al., 2012) and was correlated with epidemiological data. Patients were categorized by age, marital and parental status, tumor malignancy, WHO Grading System, treatment modality and tumor localization. Statistical analyses were performed using Prism for Windows 10 (Version 8.4.2).

### Results

The study encompassed a cohort of 173 neuro-oncological patients. Among them, 105 individuals (60.7%) fully completed the CRIq questionnaire, allowing for CRI calculation. Of these participants, 64 were female and 41 were male, with a mean age of 52.7 ± 14.43 years. Approximately 90.5% of patients had intracranial tumors, with 58% classified as malignant. CRI scores were distributed as follows: 0.95% low, 2.85% medium-low, 67.62% medium, 19.04% medium-high, and 9.52% high (as defined by Nucci et al.). Age and parental status had a statistically significant impact on CRI, while gender did not. Interestingly, a significant increase in CRI scores was observed in highly malignant diseases such as glioblastoma (mean CRI score of 116.63 ± 13.18) compared to less malignant ones like low-grade gliomas (mean CRI score of 99.57 ± 8.18) (two-tailed p-value of 0.0063, Mann-Whitney test).

### Conclusion

The utilization of the CRIq appears promising in assessing cognitive reserve in neuro-oncological patients. Interestingly, among intracranial gliomas, a discernible pattern emerged wherein CRI scores exhibited an upward trend relative to tumor grade. Specifically, patients with glioblastomas displayed a statistically significant increase in CRI scores compared to those with low-grade gliomas. Ongoing investigations involving cognitive testing and volumetric assessments are being conducted to elucidate the mechanisms driving this phenomenon and uncover its potential implications for disease prognosis.

# Tumor – Gliome und Neurokognition | Tumour – Gliomas and neurocognition

## V110

### Überwachung der Kognition in der neurologischen Rehabilitation: Durchführbarkeit und Validität eines neuen Screening Tests (BLTT ®) in einer größeren Gruppe von Patienten mit Hirnschädigung

***Monitoring cognition in neurological rehabilitation: Feasibility and validity of a new screening test (BLTT®) in a larger group of brain damaged patients***

S. M. Gallert[1], A. L. Potthoff[1], F. von Podewils[2], L. Biermann[3], M. Göppert[4], S. Knecht[4], C. Helmstaedter[4,5], M. Schneider[1]

[1]Universitätsklinikum Bonn, Klinik mit Poliklinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Greifswald, Abteilung für Neurologie, Greifswald, Deutschland
[3]Universitätskliniken Gießen und Marburg, Abteilung für Neurologie, Gießen, Deutschland
[4]St. Mauritius Klinik, Abteilung für Neurologie, Meerbusch, Deutschland
[5]Universitätsklinikum Bonn, Klinik für Epileptologie, Bonn, Deutschland

#### Objective

To evaluate the feasibility and validity of the Brain Lesion Tracking Test (BLTT), a neuropsychological screening tool for the assessment and outcome control of older patients with acquired brain lesions undergoing neurological rehabilitation.

#### Methods

A consecutive cohort of 376 patients was screened with the BLTT at the beginning and after 4-17 weeks of rehabilitation. The test is standardized for repeated assessment and addresses episodic, semantic memory and executive functions bypassing visual or hand functions. The BLTT was complemented by a figural recognition test, the Extended Barthel Index (EBI) and the Singer scale, an ICF (International Classification of Functioning, Disability, and Health) oriented rating tool.

#### Results

Application of the BLTT was possible in majority of the patients (82%). Mild aphasia, hemineglect, hemiplegia, psychomotor slowing or visual impairments including hemianopsia did not exclude testing. With 30 minutes, testing took longer than in controls. 88% showed baseline an impaired total scale, 38% to 71% subscale deficits. Singer and EBI indicated 96% and 48% impaired. Cognitive improvement was evident in 31-37%, EBI and Singer improved in 27% and 49%. Cognitive worsening was seen in 11-17% (mostly memory), in the EBI and Singer in 2% and 0%. BLTT, figural memory, EBI and Singer correlated at baseline at best with r = 0.39, whereas pre- to post changes did not correlate. Different outcomes dependent on lesion type and side, presence of epilepsy, a previous hit, gender, education and duration of rehabilitation proved the clinical validity of the assessments.

#### Conclusion

The BLTT, a time-efficient screening tool appears suitable and valid in patients with acquired brain injury of various etiologies. In light of these findings, the test is highly appropriate for repetitive neurocognitive monitoring of neurosurgical patients in both perioperative and postoperative settings. Its application is currently underway.

# V111

## Behandlungsunterschiede bei Glioblastom-Rezidiven: Eine Umfrage unter deutschen neuroonkologischen Spezialisten

***Practice variation in the treatment of recurrent glioblastoma: A nationwide survey among German neuro-oncology specialists***

S. Brenner[1], M. Ratliff[1], G. Rinkel[1], N. Etminan[1]

[1]Universitätsmedizin Mannheim, Klinik für Neurochirurgie, Mannheim, Deutschland

### Objective

The treatment of newly diagnosed glioblastomas follows standardized recommendations based on guidelines. Despite close interdisciplinary collaboration within the neuro-oncological tumor boards, there is uncertainty regarding the optimal treatment modality in patients with a recurrent glioblastoma due to limited evidence. This study aimed to investigate practice variation between neuro-oncology specialists and to identify patient characteristics that determine specific therapies.

### Methods

We conducted an online survey using a structured questionnaire via the e-mail distribution lists of the German Society for Neurosurgery (DGNC), the Neurooncological Working Group (NOA) and the German Society for Radiooncology (DEGRO). Six recurrent glioblastoma cases with different patient characteristics were presented to neurosurgeons, neuro-oncologists, medical oncologists and radiation oncologists. In addition, we asked for practice characteristics of the participants.

### Results

The survey was filled in by 180 respondents of which 74 (41%) were neurosurgeons, 15 (8%) neuro-oncologists, 3 (2%) medical oncologists and 88 (49%) radiation oncologists. 49% of the participants were from university centres. 78% of the hospitals had participated in clinical oncology studies in the last 2 years. In the case of recurrence in young and clinical intact patients, most respondents were in favour of another tumour resection (88%) and of further adjuvant therapy (89%). There was no difference between the underlying specialties (89% of neurosurgeons, 88% of radiation oncologists, 93% of neurologists opted for another resection). However, there was substantial practice variation regarding the choice of adjuvant therapy (radiation vs. type of chemotherapy vs. experimental treatment options) between cases and specialties, but even within specialties. The clinical condition of the patient had the strongest influence on the decision to have another resection (only 53% were in favour of another resection in patients with low Karnofsky Performance Index), followed by age (only 70% were in favour with another resection in patients with higher age).

### Conclusion

Our data show that the majority of specialists opts for re-resection and adjuvant therapy in recurrent glioblastoma in young patients without neurologic deficits. However, with regard to adjuvant therapy there was a high degree of treatment heterogeneity. This underlines the need for new evidence-based treatment standards.

# Tumor – Gliome und Neurokognition | Tumour – Gliomas and neurocognition

## V112

### Stratifizierung des Rehabilitationspotentials nach Resektion diffuser Gliome durch Veränderungen der Integrität von Sprachtrakten - vorläufige Resultate

***Stratification of rehabilitation potential after resection of diffuse glioma by changes of language pathway integrity – Preliminary results***

T. Wende[1], E. Güresir[1], L. Klein[2], G. Prasse[2]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland
[2]Universitätsklinikum Leipzig, Institut für Neuroradiologie, Leipzig, Deutschland

#### Objective

Diffuse glioma is a potentially devastating disease whose prognosis is largely dependent on the extent of resection. This is only outweighed by prevention of permanent neurological deficits. However, distinction between permanent and temporary neurological deficits remains difficult, as does risk stratification before and estimation of rehabilitation potential after surgery.

#### Methods

We retrospectively analyzed 50 right-handed patients with diffuse glioma (WHO-grade 2, 3, or 4) and applied a tractography workflow before and after surgery including eddy correction, coregistration and tract segmentation within DSI Studio for the arcuate fascicle (AF), the frontal aslant tract (FAT), and the uncinate fascicle (UF).

#### Results

The patients were 34 % female and 60 ± 2 years old. Follow-up aphasia score (0–3) after three months could be recorded in 46 patients with 0.48 ± 0.13. Linear regression analysis of mean fractional anisotropy (FA) in the segmented tracts for the occurence of aphasia at follow-up revealed independent significant correlation of the preoperative left AF (0.41 ± 0.01 versus 0.34 ± 0.02). Calculation of an FA quotient postoperative / preoperative was possible in 12 patients and resulted in independent significant correlation of changed right AF FA (96 ± 4 % versus 101 ± 3 %), and changed right UF FA (107 ± 2 % versus 98 ± 1 %) with aphasia at follow-up.

#### Conclusion

These preliminary results confirm the important role of the arcuate fascicle in the dominant hemisphere. Further, in surgery of diffuse glioma, preservation and postoperative integrity of other pathways seem important for lasting speech performance, which may indicate reorganisation of the language network after glioma surgery and entails a need for further investigation.

# V113

## Prospektive longitudinale Erhebung der Gesundheits-bezogenen Lebensqualität und psychoonkologischen Belastung von Meningeom-Patienten nach einer Tumorresektion

***Prospective longitudinal assessment of health-related quality of life and psycho-oncological burden in meningioma patients after tumor resection***

C. Jungk[1], M. Rädel[1], J. Mattern-Tremper[1], S. Krieg[1], C. Herold-Mende[1], R. Warta[1], A. Unterberg[1]

[1]Ruprecht-Karls-University Heidelberg, Department of Neurosurgery, Heidelberg, Deutschland

### Objective

From the practitioners" perspective, intracranial meningioma is often considered a benign disease with long-term disease control after tumor resection. However, the patients" psycho-oncological burden and health-related quality of life (HRQOL) are still poorly defined and may be subject to changes over time due to burdensome treatment and fear of progression. Here, we prospectively assessed psycho-oncological burden and HRQOL before and after surgery.

### Methods

Since 02/2019, patients with a suspected or recurrent intracranial meningioma scheduled for resection were prospectively enrolled in this study. Psycho-oncological burden and HRQOL were assessed with standardized self-assessment questionnaires (HADS-D, EORTC-QLQ-C30, EORTC-QLQ-BN20) at four different time points: before (T1) as well as 3 (T3), 12 (T12) and 24 (T24) months after surgery. Results were compared intra-individually by pairwise t-tests and to normative data from the German general population.

### Results

Until 12/2022, 142 patients (mean age 55.7 years; 75.4% females) were enrolled with longitudinal assessment available for 115 patients at T3, 96 patients at T12 and 40 patients at T24. 94.4% underwent Simpson grade 1-3 resection and 2.8% received adjuvant radiotherapy, because of high-grade or recurrent meningioma. When compared to the general population, the frequency of patients reporting anxiety or depression was higher at all time points. At intra-individual comparison, the frequency of patients reporting anxiety remained stable over time while the number of patients reporting depression dropped from T1 to T12 ($p=0.012$). Concerning HRQOL, patients fared worse on all function and symptom scales of EORTC-QLQ-C30 than the general population. Over time, only few significant changes in HRQOL were noted: global health improved from T1 to T12 ($p=0.018$) while emotional functioning and future uncertainty improved from T1 to T3, T12 and T24 ($p<0.01$ each). Patients constantly complained of itchy skin at all time points after surgery.

### Conclusion

In this prospective analysis, psycho-oncological burden was higher and HRQOL was lower in meningioma patients at all time points before and after tumor resection than in the general population. Over time, HRQOL improved in only few (but meaningful) domains such as global health, emotional functioning, and future uncertainty. This study underlines a high need for psycho-oncological support in meningioma patients also at later stages after surgery.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V114

### Funktionelle Charakterisierung des Wachstumsfaktors Midkine in Gliomzellen
*Functional characterisation of the growth factor Midkine in glioma cells*

L. Ross[1], C. Scheller[1], C. Strauss[2], D. Gündel[3], S. Leisz[4], M. Scheer[1]

[1]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[2]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[3]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiopharmaceutical Cancer Research, Leipzig, Deutschland
[4]Universitätsklinikum Halle, Klinik mit Poliklinik für Neurochirurgie, Halle, Deutschland

#### Objective

Gliomas are the most common primary brain tumours. Subtypes can be divided into 4 different grades, classified by the World Health Organisation according to their progressiveness. Glioblastoma represents the most aggressive subtype, classified as WHO grade 4, with an average life expectancy of approximately 15 months after diagnosis. Due to its high invasiveness and heterogeneity, this tumour remains difficult to treat and new therapeutic approaches are increasingly being sought. Midkine (Mdk) is a heparin-binding growth factor known to be positively correlated with progression and invasion of several tumour types, including glioblastoma, and negatively correlated with survival. In this study, we aim to investigate the potential use of Mdk not only as a biomarker to facilitate diagnosis and monitoring during therapy, but also as a promising target to improve therapy itself.

#### Methods

So far, we have used Western blotting to determine Mdk levels in 16 different primary glioma cultures and the following glioblastoma cell lines: U87, LN229, U251, F98, A172, U343 and GL261. We also performed XTT cell viability assays with LN229 and U251 treated with 0 nM, 500 nM or 1 µM iMDK (Mdk inhibitor) for 24, 48, 72 and 96 hours. To assess the effect of Mdk expression, we developed transfectants of U87, U251 and LN229. Since LN229 and U251 showed high levels of Mdk expression, we chose these cell lines for knockout, while we chose U87 (very low levels of Mdk expression) for overexpression. The cell lines were transfected with an Mdk-pIRES Venus overexpression vector and sgRNA against Mdk cloned in a pL-CRISPR.EFS.PAC vector. Subsequently, the transfected cells were selected with Puromycin or Neomycin.

#### Results

We were able to show that the different cell lines and primary cultures differ greatly in terms of Mdk protein level. Using the viability assay, we were also able to show that iMDK reduces cell growth in cell lines with initially high Mdk expression. With iMdk treatment, we observed a reduction in cell viability of glioblastoma cells up to 62.41% compared to the untreated cells after 96 hours of growth. In addition, an altered growth behaviour of the Mdk overexpression and knockout cells was detected.

#### Conclusion

The results presented suggest that Mdk promotes cell growth in glioblastoma cells and that its inhibition could reduce further progression of the disease. Its use as an additional therapeutic approach is promising and should be further investigated.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V115

### Einfluss der Glykierung auf das Therapieansprechen von Gliomzellen auf Tumortherapiefelder (TTFields, Optune)
*Influence of glycation on the treatment response of glioma cells to tumour treating fields (TTFields, Optune)*

C. Götz[1], K. Hauschild[2], P. Schildhauer[2], C. Scheller[1], C. Strauss[2], S. Leisz[1], M. Scheer[2]

[1]Universitätsklinikum Halle, Klinik mit Poliklinik für Neurochirurgie, Halle, Deutschland
[2]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland

### Objective

Glioblastoma (GBM) is a highly aggressive and invasive brain tumour. The most malignant cells use aerobic glycolysis for energy production (Warburg effect), leading to the accumulation of highly reactive by-products such as methylglyoxal (MGO). In our own preliminary work, we have shown that MGO induces glycation of cell surface proteins in GBM cells, which was associated with a more aggressive phenotype with increased invasion.

In order to reduce the invasiveness of tumour cells, the use of alternating electric fields (Tumor Treating Fields, TTFields, Novocure) has been established in recent years in addition to the well-known therapeutic pillars of radiotherapy and chemotherapy. TTFields were able to prolong progression-free and overall survival. In this study, we aim to investigate the effect of preclinical application of TTFields (Inovitro™ system) in combination with GBM cells under the influence of MGO.

### Methods

GBM cell lines U251, LN229 and U87 were used in this study. Cells were treated with 0.1 and 0.3 mM MGO for 4 h and then exposed to the Inovitro™ system for 48 h and 72 h at the same MGO concentration. The Inovitro™ system was operated with low intensity (1-3 V/cm) and medium frequency (200 kHz) alternating electric fields, which have a selective antimitotic effect on cancer cells. To prove the efficacy of both treatments, cell death was subsequently analysed by cell counting using the Chemometec NucleoCount. In addition, the arrangement of alpha and gamma tubulin was visualised by immunofluorescence.

### Results

Application of TTFields was able to reduce the increased proliferation of cells under 0.1 mM MGO. However, treatment with 0.3 mM MGO over the entire period was associated with an increased rate of apoptosis. This effect was enhanced by additional treatment with TTFields. The combination of TTFields and MGO led to a reduction in cell diameter compared to the respective monotherapy. Immunofluorescence imaging showed a concentration of alpha- and gamma-tubulin at the cell poles after treatment with TTFields.

### Conclusion

This study shows that TTFields can attenuate the protumorigenic effects of glycation in GBM. However, higher concentrations of MGO in this setting are toxic and TTFields enhance this effect. In further studies, we would like to investigate the molecular background of these observations.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V116

### Klinische Einflussfaktoren auf den chirurgischen Behandlungsverlauf von über 70-jährigen Glioblastompatienten
*Investigating the surgical treatment course of glioblastoma patients aged 70 or older*

F. Goschütz[1], M. Neher[1], A. Liebert[1], L. Ritter[1], H. H. Steiner[1], K. M. Schebesch[1], T. Eibl[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Neurochirurgie, Nürnberg, Deutschland

#### Objective

The most beneficial neurosurgical treatment option for newly diagnosed glioblastoma is maximum safe resection. Elderly patients need to be selected well for tumor resection, and factors which are with poor surgical outcome have not been fully investigated yet. The aim of this study was to identify risk factors for unintended discontinuation of any postoperative adjuvant treatment.

#### Methods

Consecutive patients receiving either biopsy or microsurgical tumor resection for newly diagnosed glioblastoma between 2013 and June 2023 were evaluated. Inclusion criteria were patient age older than 70 years and histopathological diagnosis of glioblastoma CNS WHO grade 4. Demographic data, neuroimaging and postoperative clinical course were analyzed. Comorbidities were summarized using the Charlson Comorbidity Index and the CHA2DS2-VASc Score. Primary outcome measure was the discontinuation of tumor-specific treatment after surgery.

#### Results

148 patients were included. 62 (41.9%) were female and mean age was 76.7 ± 4.5 years. 81 patients (54.7%) received microsurgical tumor resection. A gross total resection was achieved in 33 (40.7%) cases. 28 patients (18.9%) did not receive adjuvant treatment due to poor postoperative status. Treatment discontinuation was neither associated with resection or biopsy nor with the extent of resection, preoperative motor status or speech disorders. Patients with preoperative neuropsychiatric symptoms (p=0.023), increasing age (p=0.001) and higher comorbidity scores (p=0.01 for Charlson Comorbidity Index and p=0.019 for CHA2DS2-VASc Score) were at risk for discontinuation of oncologic treatment after surgery and inferior outcome.

#### Conclusion

In our cohort of elderly patients with newly diagnosed glioblastoma resection did not result in higher surgery-associated treatment failure compared to biopsy. In this population, age, preoperative neuropsychiatric symptoms and comorbidities were relevant confounders and put patients at risk for discontinuation of adjuvant therapy. These factors should be considered for any treatment decision.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V117

### Longitudinale Analyse des Immunmikromilieus des Glioblastoms- Der Einfluss von Natural Killer Cells und TCR Clonalität auf das Gesamtüberleben

***Longitudinal analysis of the immune landscape in recurrent glioblastoma – Infiltration of natural killer cells and TCR clonality as biomarkers of overall survival***

H. Krenzlin[1], C. Sommer[2], T. Bukur[2,3], N. Keric[4], F. Ringel[4]

[1]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Institut für Neuropathologie, Mainz, Deutschland
[3]Translationale Onkologie (TRON), Mainz, Deutschland
[4]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Glioblastoma is the most common primary malignant brain tumor in adults and associated with dismal prognosis. Unchecked tumor development occurs through mechanisms of immune evasion and suppression. Tumor infiltration by T cells is paramount for effective anti-cancer immune responses. Here, the tumor immune landscape and the TCR repertoire of matched primary and recurrent glioblastoma are assessed to understand the impact of TCR diversity and clonality on survival in glioblastoma.

#### Methods

TCR beta sequencing (TCRB-seq) was used for TCR repertoire profiling in matched primary and recurrent glioblastoma. Longitudinal transcriptome changes were analyzed using RNA sequencing (RNA-seq). Inclusion criteria were histological diagnosis, gross total resection in the primary and recurrent situation.

#### Results

A total of 30 patients (median age 61 years (43-74 years; 36.7% females) were included in this study. 2 patients (6.7%) had more than one recurrence. All tumors were IDH 1/2 wildtype. The mean Karnofosky performance score (KPS) was 80 (range 50-100) at time of first resection. Longitudinal transcriptome changes occurred between primary and recurrent tumors. Multiple differentially expressed genes were statistically significant associated with progression free- (PFS) and overall survival (OS). One of those is sphingosine-1 phosphate receptor (S1PR)- a protein essential for human natural killer cell migration. ($p = 0.0018$) No longitudinal changes occurred between primary and relapse regarding the immune contexture, TCR diversity ($p = 0.69$) or clonality ($p = 0.85$). However, in univariate analyses, improved OS was associated with high densities of tumor infiltrating NK cells ($p = 0.0264$), M1 macrophages ($p = 0.029$) and TCR clonality ($p = 0.0002$). Patients age ($p = 0.33$) and preoperative KPS (p 0 0.38) were not associated with overall survival.

#### Conclusion

For the first time, longitudinal transcriptome and TCR repertoire changes were assessed in matched primary and recurrent glioblastoma samples. Transcriptome changes at the time of recurrence reflect tumor heterogeneity with significant impact on overall survival. In contrast, the immune landscape and TCR repertoire remain largely unchanged during the disease. However, sphingosine-1 phosphate receptor expression in primary- and NK infiltration and TCR clonality in recurrent glioblastoma emerge as predictors of overall survival and might guide future individualized therapy effectively using checkpoint inhibition in glioblastoma.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V118

### Serum- und Liquormetabolom bei Gliompatienten
***Metabolome profile in cerebrospinal fluid and serum of patients with diffuse glioma***

H. Hounchonou[1], N. Möhn[2], S. Nay[2], P. Schwenkenbecher[2], L. Grote-Levi[2], F. Al-Tarwani[2], M. Esmaeilzadeh[1], S. Schuchardt[3], K. Schwabe[1], H. Hildebrandt[2], H. Thiesler[2], C. Hartmann[4], T. Skripuletz[2], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Medizinische Hochschule Hannover, Hannover, Deutschland
[3]Fraunhofer-Institut für Toxikologie und Experimentelle Medizin, Hannover, Deutschland
[4]Medizinische Hochschule Hannover, Abteilung für Neuropathologie, Hannover, Deutschland

#### Objective

Diffuse glioma are among the most common brain tumors in adults and are associated with a dismal prognosis, especially in patients with glioblastoma. So far, tumor tissue acquisition is mandatory for final diagnosis and therapeutic decision making. In this study, we aimed to identify possible diagnostic and prognostic biomarkers in cerebrospinal fluid (CSF) and blood.

#### Methods

CSF and blood samples from patients undergoing surgery for glioma in our institution were collected intraoperatively. Subsequently, targeted metabolomics analysis was used to detect and quantify circulating metabolites. The metabolome profiles of glioma patients were compared to those of a control group and correlated with established diagnostic molecular markers as well as overall survival time.

#### Results

A total of 30 glioma patients were included in this study. The control group consisted of 21 patients without glioma. Serum metabolomic analysis did not show any significant differences between both groups. CSF metabolome analysis revealed increased levels for putrescine (p=0.0005), xanthine (p=0.001), betaine (p=0.0007), glutamate (p=0.002), aspartate (p=0.002) and acetyl-carnitine (p=0.002) in glioma patients. Homocysteine was identified as a possible marker for Isocitrate dehydrogenase (IDH) status (AUC=0.86). No correlation was found between the identified metabolites and the O6-methylguanine methyltransferase (MGMT) promoter methylation status within the glioma group. 1-methylhistidine showed the best correlation with the overall survival time in glioblastoma patients (AUC=0.89).

#### Conclusion

CSF but not blood metabolome profiling is a promising diagnostic tool in glioma patients. CSF metabolites can be used to predict molecular subtypes and overall survival. Lager studies are needed to establish the use of CSF metabolomics analysis in the everyday clinical practice.

# Tumor – Gliome 2 | Tumour – Gliomas 2

## V119

### MicroRNAs in nativem Tumorgewebe und primären Zellkulturen von Glioblastomen als Biomarker für ein Therapieansprechen auf Tumor Therapie Felder *in vitro*

***MicroRNAs in native tumor tissue and primary tumor cell cultures of glioblastomas as biomarkers for therapy response to tumor treating fields in vitro***

S. Hemmer[1], M. Henia[1], W. Schulz-Schaeffer[1,2], R. Ketter[1], J. Oertel[1], S. Urbschat[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Universitätsklinikum des Saarlandes, Institut für Neuropathologie, Homburg a. d. Saar, Deutschland

### Objective

Tumor treating fields (TTFields) have been implemented in the treatment of glioblastomas in addition to surgery, radiotherapy and chemotherapy. However, information about biomarkers to predict therapy response to TTFields treatment is sparse. For other treatment modalities, microRNAs represent promising biomarkers in glioblastoma therapy. This study aimed to identify potential miRNA-biomarkers for TTFields therapy response in native glioblastoma tumor tissue, plasma and primary tumor cell cultures of glioblastoma patients treated with TTFields in *vitro*.

### Methods

Primary tumor cell cultures of histologically confirmed glioblastomas were treated with tumor treating fields (Optune *inovitro* system) for 72 hours. Cell viability of the cultures was assessed before and after treatment, as well as in control cultures after 72h. Relative reduction of cell viability in the treated cell cultures compared to control cultures was calculated to measure therapy response rates. Expression of microRNAs 21, 26a, 181c, 181d and 485-5p was evaluated in corresponding native tumor tissue, plasma and primary tumor cell cultures after treatment, as well as in the corresponding control cultures. Correlation analysis of the response rates to TTFields treatment and miRNA expression in tumor tissue, plasma and cell cultures was conducted.

### Results

Twenty-one patients with histologically confirmed glioblastoma were included in this study. Interindividual therapy response rates to TTFields were recorded, with a mean therapy response rate of 48.53%. Spearman correlation revealed a positive correlation of expression of miRNA 26a in native tumor tissue ([95% CI: 0.01327-0.7976], P = 0.041), and of miRNAs 21, 26a and 181c in control cultures with treatment response to TTFields *in vitro* (P = 0.029, P=0.015, P=0.008, respectively). For miRNAs 26a and 181c in the control cultures, a linear correlation to TTFields therapy response ([95% CI: [0.001938 to 0.01725], P=0.016 and 95% CI: [0.0000003935 – 0.0001641], P=0.049, respectively) *in vitro* was demonstrated.

### Conclusion

This study reveals inter-individual response rates of primary glioblastoma cell cultures to TTFields treatment *in vitro*. A positive correlation between therapy response rates and expression of miRNA 26a in native tumor tissue and miRNAs 21, 26c and 181c in corresponding primary glioblastoma cell cultures was demonstrated. Further studies are required in order to assess the potential of these miRNAs as biomarkers for TTFields therapy response *in vivo.*

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 1 | Vascular neurosurgery – Non-ruptured aneurysms 1

## V122

### Künstliche Intelligenz zur Unterstützung der Detektion inzidenteller Aneurysmen in routine-MRT Untersuchungen

***Artificial intelligence can help detecting incidental intracranial aneurysm on routine brain MRI using TOF MRA data sets***

I. Adamchic[1], S. R. Kantelhardt[2], H. J. Wagner[1], M. Burbelko[1]

[1]Klinikum im Friedrichshain, Radiologie, Berlin, Deutschland
[2]Klinikum im Friedrichshain, Neurochirurgie, Berlin, Deutschland

#### Objective

Intracranial aneurysms pose a significant risk of rupture, leading to severe disability, and non-invasive identification can facilitate prompt treatment. This study aimed to evaluate the diagnostic efficacy of integrating commercially available AI tools with conventional radiological techniques for detecting intracranial aneurysms by an expert radiologist, and to determine whether AI assistance improves the radiologist's precision in spotting aneurysms while decreasing the time spent on image analysis.

#### Methods

A total of 500 Time-of-Flight (TOF) Magnetic Resonance Angiography (MRA) brain scans were reviewed using commercially available AI software to detect intracranial aneurysms. These findings were contrasted with a reference standard, which is a consensus review by two seasoned neuroradiologists, to assess the sensitivity and specificity of the AI system. Additionally, we analyzed the duration needed for a radiologist to evaluate the TOF MRA images, with and without the AI tool.

#### Results

Among the 500 TOF MRA brain scans examined, 106 aneurysms were identified in 85 scans. The radiologist detected 98 aneurysms, resulting in a sensitivity of 92.5%, while the AI tool found 77 aneurysms, with a sensitivity of 72.6%. The incorporation of AI into the image review process markedly decreased the average evaluation time for each TOF MRA scan, saving an average of about 19 seconds per scan.

#### Conclusion

The results suggest that AI-assisted software can aid radiologists in interpreting brain TOF MRAs. A collaborative approach, using both the AI software and expert radiologist assessments, showed greater accuracy in identifying intracranial aneurysms compared to evaluations done solely by radiologists or the software. The utilization of deep learning algorithms significantly reduced the time needed to analyze MRI data for detecting intracranial aneurysms, thereby enhancing the radiologists' efficiency in time management.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 1 | Vascular neurosurgery – Non-ruptured aneurysms 1

## V123

### Intraoperative Laser-Speckle-Kontrastbildgebung zur Beurteilung des Gefäßflusses in der Neurochirurgie: Eine Pilotstudie

***Intraoperative laser speckle contrast imaging to assess vessel flow in neurosurgery: A pilot study***

J. Goldberg[1], D. R. Miller[2], A. Dimanche[3], C. Kissling[1], T. Müller[1], M. Müller[1], M. Murek[1], D. Bervini[1], A. K. Dunn[3], A. Raabe[1]

[1]Inselspital – Universitätsspital Bern, Klinik für Neurochirurgie, Bern, Schweiz
[2]Dynamic Light Inc., Austin, TX, Vereinigte Staaten
[3]The University of Texas at Austin, Department of Biomedical Engineering, Austin, TX, Vereinigte Staaten

#### Objective

Laser speckle contrast imaging (LSCI) has emerged as a promising tool for assessment of vessel flow during neurosurgery. We aimed to investigate the feasibility of visualizing vessel flow in the macrocirculation with a new fully microscope-integrated LSCI system and assess the validity and objectivity of findings compared with fluorescence angiography (FA).

#### Methods

This is a single-center prospective observational study enrolling adult patients requiring microsurgical treatment for brain vascular pathologies or brain tumors. Three independent raters, blinded toward findings of FA, reviewed regions of interest (ROIs) placed in exposed vessels and target structures. The primary end point was the validity of LSCI for assessment of vessel flow as measured by the agreement with FA. The secondary end point was objectivity, measured as the inter-rater agreement of LSCI findings.

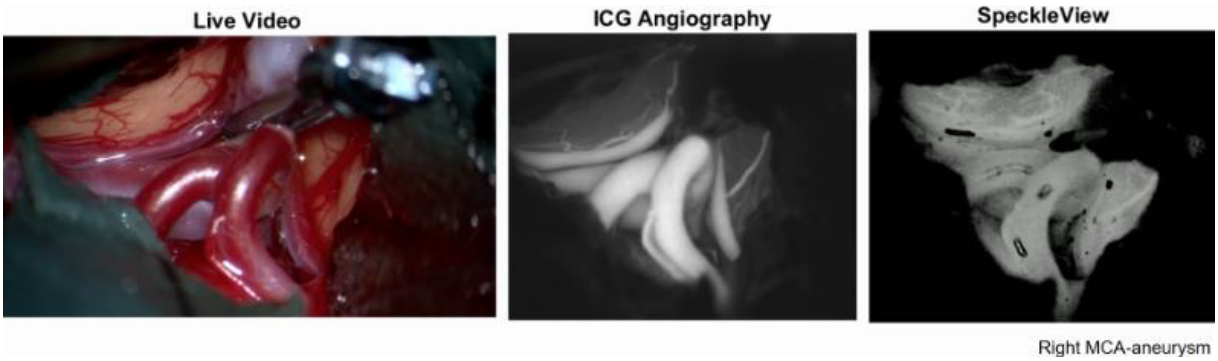
#### Results

During 18 surgical procedures, 23 observations using FA and LSCI were captured simultaneously. Using LSCI, vessel flow was assessable in 62 (86.1%) and not assessable in 10 (13.9%) ROIs. The agreement between LSCI and FA was 86.1%, with an agreement coefficient of 0.85 (95% CI: 0.75-0.94). Disagreement between LSCI and FA was observed in the 10 ROIs that were not assessable. The agreement between ROIs that were assessable using LSCI and FA was 100%. The inter-rater agreement of LSCI findings was 87.9%, with an agreement coefficient of 0.86 (95% CI: 0.79-0.94).

#### Conclusion

Fully microscope-integrated LSCI is feasible and has a high potential for clinical utility. Because of its characteristics, LSCI can be viewed as a full-field visual micro-Doppler that can be used as a complementary method to FA for assessing vessel flow during neurosurgery. Despite technical limitations related to the early development phase of the fully microscope-integrated system, we demonstrated reasonable validity and objectivity of findings compared with FA. Further research and refinement of the system may enhance its value in neurosurgical applications.

Abb. 1


Live Video
ICG Angiography
SpeckleView
Right MCA-aneurysm

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 1 | Vascular neurosurgery – Non-ruptured aneurysms 1

## V124

### Vergleich von Wirksamkeit und Sicherheit von Clipping gegenüber Coiling bei nicht gerissenen intrakraniellen Aneurysmen: Eine umfassende Meta-Analyse

***Comparative efficacy and safety of clipping versus coiling for unruptured intracranial aneurysms: A comprehensive meta-analysis***

A. Hammed[1], C. Tanislav[1], O. Alomari[2], Z. Otmani[3], K. Sarhan[4], A. M. Hamouda[5]

[1]Diakonie Hospital Jung Stilling, Department of Geriatrics and Neurology, Siegen, Deutschland
[2]University of Health Sciences, Hamidiye International School of Medicine, Istanbul, Türkei
[3]University Mouloud Mammeri, Faculty of Medicine, Tizi-ouzou, Algerien
[4]Mansoura University, Faculty of Medicine, Mansoura, Ägypten
[5]Department of neurological surgery, Rochester, NY, Vereinigte Staaten

#### Objective

Unruptured intracranial aneurysms (UIAs) are prevalent, with an estimated occurrence rate ranging from 2% to 3%. Surgical or endovascular preventive interventions can effectively eliminate the risk of aneurysmal subarachnoid hemorrhage. However, the debate over whether to opt for surgical clipping or endovascular coiling remains contentious, resulting in notable variations in treatment approaches across different medical centers.

#### Methods

A systematic review was conducted by comprehensively searching through Scopus, PubMed, Web of Science (WOS), and the Cochrane Library for relevant studies up to September 2023. Two independent reviewers meticulously screened and extracted data, with the assessment of study quality carried out using the Robin 1+2 tool. Standard mean differences, odds ratios, and risk ratios were employed to identify variations in the dataset.

#### Results

31 studies have been included in our analysis encompassing 155,728 patients. In our analysis, complete occlusion demonstrated a significantly superior outcome within the coiling group (odds ratio 0.29, p-value 0.002), even that the coiling group exhibited a higher risk of mortality (odds ratio 0.83, p-value 0.03). The need for retreatment after clipping was significantly elevated, with the risk of retreatment being 3.46 times higher in the clipping group (p-value 0.02). Post-surgery bleeding exhibited a higher prevalence in the coiling group (odds ratio 0.57, p-value 0.006), whereas there was no statistically significant difference in infarction occurrence following intervention between the two groups. Quality of life and disability did not show significant differences between the two intervention methods. Lastly, coiling showed a higher prevalence of Modified Rankin Scale (mRS) scores surpassing 2 compared to clipping.

#### Conclusion

In the absence of established criteria guiding the selection between clipping and coiling, our findings suggest that coiling exhibits superior complete occlusion, and the requirement for retreatment is less frequent compared to clipping. However, it is important to note that coiling is associated with a higher risk of bleeding and death. While coiling demonstrates favorable intervention outcomes, the presence of complications underscores the importance of individualized decision-making, considering patient-specific factors, for optimal treatment selection.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 1 | Vascular neurosurgery – Non-ruptured aneurysms 1

## V120

### Globale Ergebnisse für das mikrochirurgische Clipping nicht rupturierter intrakranieller Aneurysmen: Eine Benchmark-Analyse von 2245 Fällen

***Global outcomes for microsurgical clipping of unruptured intracranial aneurysms: A benchmark analysis of 2245 cases***

R. Drexler[1], T. Pantel[2], T. Sauvigny[2], J. Gempt[2], F. Ricklefs[2], L. Dührsen[2]

[1]Stanford University School of Medicine, Stanford, CA, Vereinigte Staaten
[2]UKE Hamburg, Neurochirurgie, Hamburg, Deutschland

#### Objective

Benchmarks represent the best possible outcome and help to improve outcomes for surgical procedures. However, global thresholds mirroring an optimal and reachable outcome for microsurgical clipping of unruptured intracranial aneurysms (UIA) are not available. This study aimed to define standardized outcome benchmarks in patients who underwent clipping of UIA.

#### Methods

A total of 2245 microsurgically treated UIA from 15 centers were analyzed. Patients were categorized into low- ("benchmark") and high-risk ("nonbenchmark") patients based on known factors affecting outcome. The benchmark was defined as the 75th percentile of all centers' median scores for a given outcome. Benchmark outcomes included intraoperative (eg, duration of surgery, blood transfusion), postoperative (eg, reoperation, neurological status), and aneurysm-related factors (eg, aneurysm occlusion). Benchmark cutoffs for aneurysms of the anterior communicating/anterior cerebral artery, middle cerebral artery, and posterior communicating artery were determined separately.

#### Results

Of the 2245 cases, 852 (37.9%) patients formed the benchmark cohort. Most operations were performed for middle cerebral artery aneurysms (53.6%), followed by anterior communicating and anterior cerebral artery aneurysms (25.2%). Based on the results of the benchmark cohort, the following benchmark cutoffs were established: favorable neurological outcome (modified Rankin scale ≤2) ≥95.9%, postoperative complication rate ≤20.7%, length of postoperative stay ≤7.7 days, asymptomatic stroke ≤3.6%, surgical site infection ≤2.7%, cerebral vasospasm ≤2.5%, new motor deficit ≤5.9%, aneurysm closure rate ≥97.1%, and at 1-year follow-up: aneurysm closure rate ≥98.0%. At 24 months, benchmark patients had a better score on the modified Rankin scale than nonbenchmark patients.

#### Conclusion

This study presents internationally applicable benchmarks for clinically relevant outcomes after microsurgical clipping of UIA. These benchmark cutoffs can serve as reference values for other centers, patient registries, and for comparing the benefit of other interventions or novel surgical techniques.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 1 | Vascular neurosurgery – Non-ruptured aneurysms 1

## V125

### Evaluierung der Leistungsfähigkeit eines neuartigen mikrochirurgischen Trainings-Simulators in der neurochirurgischen Bildung.

***How good is simulation? Unveiling the efficacy of a novel microsurgical training simulator in neurosurgical education***

J. Reiser[1], A. Amini[1], V. M. Swiatek[1], F. Taskaya[1], K. P. Stein[1], A. Rashidi[1], I. E. Sandalcioglu[1], B. Neyazi[1]

[1]Otto-von-Guericke-Universität Magdeburg, Universitätsklinik für Neurochirurgie, Magdeburg, Deutschland

#### Objective

Recent years in neurosurgical education have seen a proliferation of simulation methods, aimed at tackling the critical challenge posed by a decreasing number of real-case experiences. This situation necessitates an accelerated learning curve for neurosurgical trainees. While the introduction of simulators has been well-received, there remains a significant gap in their systematic evaluation. This study aims to fill this void by conducting a thorough evaluation of the Microsurgical Aneurysm Training Simulator (MATS), a model previously introduced. The primary objective of this study is to systematically evaluate MATS, confirming its validity as a tool in neurosurgical education. By doing so, we aim to provide a benchmark for the effectiveness of simulation-based training in neurosurgery.

#### Methods

MATS was evaluated by two groups. Group A consisted out of 6 medical students with neurosurgical basic knowledge which were selected from a neurosurgical elective. Group B consisted out of 4 residents and 2 attendings with experience in vascular neurosurgery. Three attempts have been undertaken by each participant (S1-3) over a period of one week (Fig. 1). Evaluation of content and face validity was assessed by questionnaires, the objective assessment was performed by OSAACS.

#### Results

The results demonstrated a high level of face and content validity for MATS. Participants, irrespective of their experience level, showed significant improvement in their microsurgical skills post-training measured by OSAACS (Fig. 2+3). Furthermore, group B rated the face validity 4.3 on the Likert scale and the content validity was rated 4.

#### Conclusion

The study validates MATS as an effective neurosurgical training tool, emphasizing the need for systematic evaluation of such simulators. However, it acknowledges the limitation of its sample size and calls for further research. Additionally, the study highlights the broader implications for medical simulation, advocating for continuous improvement in simulation-based training to meet the evolving needs of neurosurgical education.

Abb. 1

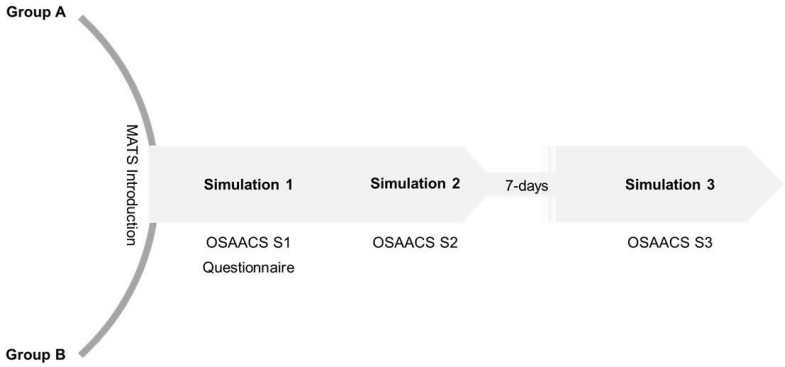



Figure 1: Evaluation process of MATS

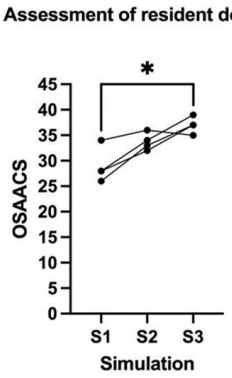



Figure 2

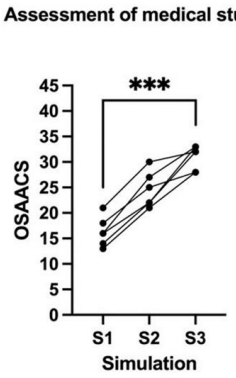



Figure 3

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V126

### Vergleich von Traktografie-Algorithmen bei Gliompatienten
***Comparison of tractography algorithms in glioma patients***

S. Vellmer[1], S. Caliri[1], P. Vajkoczy[1], T. Picht[1], L. Fekonja[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

#### Objective

Tractography enables us to reconstruct white matter (wm) fibre bundles from MRI, providing crucial insights into anatomical structures. It has become essential for planning and risk stratification in neurosurgery. Peritumoral tractography is challenging due to arising edema, demyelination and infiltration, yet vital in patients with gliomas in the left perisylvian area, possibly causing aphasia. Several deterministic and probabilistic algorithms have been developed, that model wm based on tensors (DTI) or spherical harmonic functions (CSD). Here we compared tractograms derived by common algorithms, examining how they differ in patients with perisylvian gliomas.

#### Methods

We included n=62 presurgical patients with left perisylvian gliomas (24 females, 38 males, average age=53,5±15.4, age range 21–83). All were right-handed and had an initial diagnosis of supratentorial, unilateral WHO grade II (6), III (20), or IV (36) glioma. We derived the language relevant tractograms, AF, IFOF, ILF and UF, on both hemispheres employing DTI- (tensor_det, tensor_prob) and CSD-based (SD_stream, iFOD2) algorithms via TractSeg. We compared the results by streamline length, volume and dice scores.

#### Results

DTI- and CSD-algorithms failed in 16% and 13% peritumorally, respectively, and in 2% and 0% on the healthy hemisphere. Streamlines in the pathologic side were significantly 3% shorter and tract volumes 10% smaller than on the healthy one for all algorithms. Tract volumes vary a lot for different algorithms, but their ratios are similar in both healthy and pathologic hemisphere. Using the largest volumes generated by iFOD2 as reference, we find the ratios 0.47, 0.33 and 0.28 for SD_stream, tensor_prob and tensor_det, respectively. The dice scores for the pathological side revealed that DTI tractograms are more similar (0.85±0.10) than CSD-based ones (0.51±0.10). iFOD2 tracts differ substantially from tensor_det tracts (0.38±0.10).

#### Conclusion

Tractograms generated by different algorithms vary in size and shape. These variations are similar in healthy and pathological hemispheres. CSD-based algorithms are less likely to fail and, thus, are useful in neurosurgical practice. Since DTI-based algorithms tend to underestimate and iFOD2 to overestimate tracts, integrating both in clinical practice may offer more precise results, finding a middle ground.

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V127

### Autofluoreszenzbasierte Erkennung von Hirntumoren mit einem neuronalen Netzwerk
***Autofluorescence based recognition of brain tumors with a convolutional neural network***

S. Richter[1,2], J. Dremel[3], T. Wang[3], I. Y. Eyüpoglu[2], J. Czarske[3], K. Kirsche[2], R. Kuschmierz[3], W. H. Polanski[2], O. Uckermann[2]

[1]Technische Universität Dresden, Else Kröner Fresenius Center for Digital Health, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[3]Technische Universität Dresden, Institut für Mess- und Sensortechnik, Dresden, Deutschland

#### Objective

The delineation of malignant brain tumors from surrounding tissue is crucial for maximal safe resection. Existing tools for intraoperative tumor visualization lack the possibility of real-time tissue classification. We therefore built a coherent fiber bundle (CFB) endoscope for autofluorescence imaging and trained a convolutional neural network (CNN) to distinguish tumor tissue (T) and non-tumor tissue (nT) in an *ex vivo* proof of concept study.

#### Methods

The T-cohort included frozen tissue sections of 35 glioblastoma and 30 brain metastasis patients (10 breast cancer, 10 melanoma, 10 lung cancer). The nT-cohort comprised frozen tissue sections of hippocampi and temporal lobes from 23 patients undergoing surgery for epilepsy treatment. For image acquisition, a laser with excitation wavelength of 473 nm was coupled into a CFB and tissue autofluorescence between 500-550 nm was collected using a bandpass filter. The acquisition time of the camera was set to 700 ms. A CNN (VGG-19) was trained to differentiate the labels T from nT wherein the ground truth was defined by histopathological diagnosis. Training, validation and test sets were randomly generated across all patients in 66.6% / 16.6% / 16.6% proportion. Set generation was repeated 5 times and reported results for the independent test sets are mean values of all iterations.

#### Results

In total, 3259 CFB images were acquired (T:2408, nT:851), with usually 40 CFB images per sample. Removal of CFB background was not improving classification accuracy and thus, was not performed. The classification accuracy of the CNN with a threshold probability of 0.5 for T-label assignment was 0.986 (sensitivity: 0.988, specificity: 0.982) for analysis of images and 0.98 (sensitivity: 0.971, specificity: 1) when calculating the result for each patient. To simulate clinical application where correct identification of healthy tissue is crucial, we created a specificity-tuned CNN with adjusted threshold probability of 0.9 for T-label assignment. This led to a decreased accuracy of 0.945 but increased specificity on the image evaluation approach to 1 (sensitivity: 0.92).

#### Conclusion

Autofluorescence imaging through a CFB is capable of *ex vivo* recognition of brain tumor tissue with a CNN. The simplicity of the setupallows for intraoperative implementation and potentially enables real-time *in vivo* brain tumor delineation. To realize intraoperative transition, analysis of *ex vivo* bulk tissue will be upcoming to capture the signal complexity caused by tissue depth.

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V128

### Netzwerkanalyse bei perisylvischen Gliompatienten
*Network analysis of perisylvian glioma patients*

B. Shams[1,2], P. Vajkoczy[1], T. Picht[1,2], L. Fekonja[1,2]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Humboldt-Universität zu Berlin, Cluster of Excellence Matters of Activity, Image Space Material, Berlin, Deutschland

#### Objective

Gliomas can impair the white matter (WM) network, potentially resulting in dysfunction. We analysed the gliomas" effects on structural connectivity in relation to aphasia. We used the patients" connectomes to identify network impairments related to aphasia and network topology using network theory.

#### Methods

We studied 47 patients with left-perisylvian gliomas (WHO grade II (6), III (15), IV (26), 32; females; mean age=53, SD=14; age-range=28-78) for aphasia assessment using the Aachen aphasia test (AAT). AAT subtests included a token test, naming, repetition, and speech comprehension. 15 patients presented with aphasia. We constructed whole brain tractograms with constrained spherical deconvolution (CSD), performed anatomically constrained tractography and CSD-informed filtering of tractograms using MRtrix3. The resulting connectomes were based on the Desikan-Killiany-Tourville atlas and FreeSurfer. We calculated graph-based measures, such as assortativity, local & global efficiency, and node measures like node strength, betweenness centrality, and clustering coefficients, comparing these between hemispheres and correlating with AAT results.

#### Results

We found significant differences between the two hemispheres in assortativity (p=3.8e-5) and global efficiency (p=3.6e-3). Strong correlations emerged between global efficiency and token test (rs(46)=.52, p=1.2e-3). Node measures correlated significantly with AAT subtests, especially in the left hemisphere. The left precentral gyrus showed the strongest negative correlation between node strength and naming (rs(46)=-.51, p=1.5e-4), and betweenness centrality and token test (rs(46)=-.41, p=1.3e-2). The left superior frontal gyrus correlated most strongly with token test and betweenness centrality (rs(46)=.47, p=4.5e-3) and the left superior parietal gyrus correlated with token test and node strength (rs(46)=-.54, p=7.4e-4). Further, the left paracentral region correlated most strongly with naming and betweenness centrality (rs(46)=-.55, p=4.09e-4), speech comprehension and betweenness centrality (rs(46)=-.46, p=5.3e-3), and token test and betweenness centrality (rs(46)=-.67, p=1.1e-5).

#### Conclusion

Network theory enables the mapping of impaired WM structure caused by tumors. Our analyses shed light on how a tumor affects a brain"s structural network and impairs the networks" integrity, leading to functional defects. Here, we identified significant sub-networks in relation to the gliomas" impact on the language network.

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V129

### Automatisierte vs. nTMS-basierte Analyse zur Identifizierung des motorischen Kortex und des kortikospinalen Trakts bei motorisch eloquenten Hirntumoren

***Automated vs. nTMS-based analysis identification of the motor cortex and the corticospinal tract in motor eloquent brain tumors***

E. Coban[1], B. Shams[1,2], P. Vajkoczy[1], T. Picht[1,2], T. Rosenstock[1,3]

[1]Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[2]Humboldt University, Cluster of Excellence Matters of Activity, Image Space Material, Berlin, Deutschland
[3]BIH – Berlin Institute of Health, Berlin, Deutschland

#### Objective

nTMS is a reliable tool for accurate identification of the motor cortex (M1) and corticospinal tract (CST) and allows prediction of individual risk for new/progressive postoperative paresis in motor-associated brain tumors. However, it requires appropriate technical and personnel resources. In this study, we assessed the feasibility of identifying M1 and CST based on an anatomical mapping-based algorithm of a navigation planning software in comparison to the clinically established and validated nTMS motor mapping.

#### Methods

A retrospective analysis of a consecutive, prospective cohort of patients with brain tumors in motor eloquent areas who underwent preoperative nTMS motor mapping was performed. For both methods, the infiltration of M1 and CST, the tumor tract distance (TTD) and the fractional anisotropy (FA) were assessed. The agreement is measured with dice score and the overlap coefficient using the nTMS motor map as ground truth.

#### Results

101 patients (46 females) with a mean age of 51 years (range: 20-86 years) were included. All patients suffered from brain tumors (74 contrast-enhancing tumors, 29 tumor recurrences), of whom edema was present in M1 in 50 cases. The automated algorithm visualized the precentral gyrus in all but in one subject (99%) and the corticospinal tract in all subjects (100%). However, limited results with clearly implausible components (e.g. extended segmentations beyond M1 / restricted segmentations with only a few parts of M1 / tracts that clearly do not correspond to the course of the CST) were observed in 60 cases for M1 (59.4%) and 56 cases for CST (55.4%). Significant differences were found in TTD between the two models (mean+-SD: 4+-6 mm, p=.0001). On average, the overlap for M1 segmentation was 40% (range: 0-86%), and the dice score of the CST tractography was 35% (range: 6-78%).

#### Conclusion

Automated anatomical-based segmentation of M1 and tractography of CST was feasible in almost all cases. However, nTMS is necessary for proper surgical planning, especially in cases where the tumor and perifocal edema interfere with the results of automated anatomical-based algorithm, highlighting the importance of individual functional mapping. Big data analysis and neural networks may help to improve the accuracy and efficiency of automated algorithms.

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V130

### Parameter der Graphentheorie weisen auf eine für das Gesamtüberleben relevante hohe funktionelle peritumorale Netzwerkeffizienz bei therapienaîven Glioblastomen hin.

***Graph network theory parameters reveal a high functional peritumoral network efficiency relevant for overall survival in treatment-naîve glioblastoma***

K. Jütten[1], A. Meyer-Baese[2], U. Meyer-Baese[2], J. M. Kernbach[3], J. Ort[1,4], K. Hakvoort[1,4], H. R. Clusmann[5,1], D. Delev[5,6,1,4]

[1]RWTH Aachen University, Department of Neurosurgery, Aachen, Deutschland
[2]Florida State University, Department of Scientific Computing, Tallahassee, FL, Vereinigte Staaten
[3]Heidelberg University, Departement for Neuroradiology, Heidelberg, Deutschland
[4]RWTH Aachen University, Neurosurgical Artificial Intelligence Laboratory, Aachen, Deutschland
[5]Center for Integrated Oncology, Aachen Bonn Cologne Duesseldorf (CIO ABCD), Deutschland
[6]University Hospital Erlangen, Friedrich-Alexander-University, Department of Neurosurgery, Erlangen, Deutschland

#### Objective

When investigating tumor-related changes in the brain's functional connectome, graph network theory analyses allow promising insights into the dynamic functional interaction between a tumor and its peritumoral microenvironment. Regarding the peritumoral surrounding as a network, important information about its efficiency and its connectedness can be gained, allowing to estimate the tumor's impact on its immediate surrounding. We investigated whether network properties might be suitable candidates for the identification of peritumoral network efficiency and its relevance for overall survival (OS), considering surgical resection and adjuvant treatment.

#### Methods

50 treatment-naîve glioblastoma patients (age: 65±9 years) were included and underwent resting-state fMRI. Tumor lesions were segmented and a 40mm tumor-surrounding peritumoral network was created. This peritumoral network was mirrored to the contralesional hemisphere, and lesional and contralesional peritumoral networks were analyzed by applying graph network theory techniques. Lesional and contralesional mean degree centrality (MDC) were compared, and the relevance for OS was analyzed. In a preliminary analysis, treatment-related changes in MDC differences were investigated in five patients with follow-up data.

#### Results

MDC was significantly higher in the lesional than in the contralesional peritumoral network (MDClesional=163, MDCcontra=137, $p$=.028), indicating a tumor-induced effect on its local surrounding, reflecting a high peritumoral network efficiency. Results further indicated a higher difference between lesional and contralesional MDC to be associated with shorter survival times (MDChigh=304 days, MDClow=581 days, $p$=.013). Treatment reduced the difference between lesional and contralesional MDC, an effect that was especially prominent in four patients with tumor resection and adjuvant therapy (MDCinitial=64, MDCfollow-up=16).

#### Conclusion

A high difference between lesional and contralesional MDC suggested a high peritumoral network efficiency and reduced OS in treatment-naîve glioblastoma. This efficiency tended to decrease after tumor resection and adjuvant treatment, emphasizing the importance of surgery for the interruption of the functional communication between the tumor and its peritumoral surrounding. Investigating peritumoral network dynamics can aid in identifying network efficiency hubs, which can be addressed by individualized surgical treatment, thus improving oncological outcome.

# Tumor – Funktionelle Diagnostik | Tumour – Functional diagnostics

## V131

### Neuroplastische Veränderungen im visuellen System bei Patienten mit Hirntumor in der radiatio optica
*Neuroplastic changes in the visual system and network connectivity in brain tumor patients with lesions in the optical radiation*

K. Hense[1], D. Deuter[1], C. Doenitz[1], N. O. Schmidt[1], K. Rosengarth[1]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland

#### Objective

The influence of brain tumors along important structures of the visual pathway on the overall organization of the visual system is not yet well understood. To address this, the influence of a brain tumor in the area of the optic radiation on the functional connectivity of the visual network was investigated in this study.

#### Methods

fMRI data of 145 patients (76 male, 69 female, mean age 54.15 years) with brain tumors (96 left hemisphere, 49 right hemisphere) were included in this study. Based on the tumor location, patients were either assigned to a group with tumors in the area of the optic radiation (69 patients) or to a group that did not involve this structure (76 patients). A word generation task was chosen as fMRI paradigm, as this reliably addresses the visual system through the visual presentation of stimuli in written form. Based on these data, seed-to-voxel functional connectivity was calculated using the CONN toolbox. Here, four different Regions of Interest (ROIs) of the visual network were used as seed regions. These ROIs were located in the calcarine cortex of both hemispheres (CC), occipital poles of both hemispheres (OP), and lateral occipital cortex of each the left (LOCL) and right (LOCR) hemisphere.

#### Results

The results showed that patients with tumors distant from the optic radiation had higher connectivity regarding all four ROIs compared to patients with tumors located in the projection area of the optic radiation. Significant connectivity clusters included parts of the left planum temporale, Heschl"s gyrus, parietal operulum, and central opercular cortex for the CC ($p = .013$), OP ($p < .001$), and LOCR ($p < .001$) seed ROIs. Also, the left lateral occipital cortex was included in the significant connectivity clusters of the OP and LOCR seeds, while the same area of the right hemisphere was significant for the LOCL ROI ($p = .045$). To evaluate hemispheric effects, the patients were additionally subdivided according to the tumor-affected hemisphere. The results yieled similar significant connectivity profiles as the entire patient sample, except that the cluster sizes of the single significant connectivity clusters were reduced.

#### Conclusion

This study showed differences between the two patient groups in functional connectivity within the visual network. The results suggest that not only primary visual areas but also higher visual areas appear to be affected, as significant voxels were not only found in the occipital lobe, but also in the parietal and temporal lobes.

# Funktionelle Neurochirurgie – Epilepsie | Functional Neurosurgery – Epilepsy

## V132

### Interictale Spikes im Hippocampus als Biomarker für Gedächtnisstörungen für Epilepsie und Alzheimer Demenz
***Interictal epileptiform discharges in the hippocampus are biomarkers of memory dysfunction in epilepsy and Alzheimer's disease***

A. Maslarova[1], J. Shin[2], H. Hamer[3], A. Dörfler[4], A. Liu[2], G. Buzsáki[1]

[1]New York University Grossman School of Medicine, Neuroscience Institute, New York, NY, Vereinigte Staaten
[2]New York University Langone Health, Department of Neurology, New York, NY, Vereinigte Staaten
[3]Universitätsklinikum Erlangen, Epilepsiezentrum, Erlangen, Deutschland
[4]Universitätsklinikum Erlangen, Neuroradiologisches Institut, Erlangen, Deutschland

#### Objective

Cognitive impairment is common in patients with epilepsy (PWE) and can severely affect the quality of life. Interictal epileptiform discharges (IEDs) are transient abnormal electrophysiological events happening between seizures associated with transient cognitive impairment in PWE and observed in patients and rodents with Alzheimer"s disease (AD). IEDs interfere with physiologic oscillations during sleep that are necessary for memory consolidation, specifically hippocampal sharp-wave ripples (SPW-Rs) and cortical spindles. Recently we demonstrated a negative effect of IEDs on memory consolidation and hippocampal SWRs in the hippocampal CA1 region in an AD mouse model. Here we aim to characterize the negative impact of IEDs in other hippocampal subfields as well as their clinical relevance.

#### Methods

We compared the spread of IEDs their impact on neuronal firing in the hippocampus in two distinct settings. First, we investigated hippocampal and parahippocampal IEDs in epilepsy patients implanted with combined micro/macrowire intracranial EEG electrodes for surgical resection planning, including patients with temporal (n=8) and extratemporal (n=7) epilepsy focus. Next, we obtained high-density recordings from the entire dorsal hippocampus (1024 Channel, SiNAPS Probes, Neuronexus) from adult AD transgenic mice (APP/S1, n=5).

#### Results

We observed IEDs in the hippocampus of epilepsy patients with temporal and frontal lobe foci and in AD mice, independent of seizure generation or seizure onset zone. SWRs were only detected on electrodes in the CA1 and CA2 regions in all rodents and only in a subset of patients, possibly because of location of the recording electrode outside the CA1/CA2 region. By contrast IEDs were easily detected in the human microwire recordings. IEDs showed similar local field potential features and waveforms in both subject groups, and quickly generalized across channels, leading to global supression of neuronal firing rates, that could be associated with interruption of physiologic signaling. The high-density rodent recordings demonstrated that the IED spread respected anatomical pathways.

#### Conclusion

We propose that IEDs may be a suitable biomarker for treatment of memory disorders in epilepsy and Alzheimer's Disease by targeted closed-loop stimulation, because of their impact on neuronal firing and easy detection.

# V134

## Durch virtuelle Realität verstärkte funktionelle Neuronavigation für pediatrische Epilepsiechirurgie: Erleichtert es die Resektion, reduziert es Komplikationen oder verbessert es die Anfallsfreiheit?

***Virtual reality (VR) augmented functional neuronavigation in pediatric epilepsy surgery: Does it facilitate resection, reduce complications, or improve seizure outcome?***

J. Shawarba[1], M. Tomschik[1], F. Winter[1], J. Wais[1], V. Zeiser[1], F. Mayer[1], M. Feucht[1], C. Dorfer[1], K. Rössler[1]

[1]Medizinische Universität Wien, Neurochirurgie, Wien, Österreich

### Objective

Virtual reality (VR) is increasingly being used to improve surgical planning and assist in real time surgical procedures. A retrospective investigation was conducted to investigate its role in pediatric epilepsy surgery at our institution.

### Methods

Functional neuronavigation using multimodal imaging data (fMRI, DTI-tractography, PET, SPECT, sEEG) were used to augment the surgical navigation by transferring 3D imaging reconstructions as VR maps into the surgical microscope during surgery. Additionally, a navigated suction tool used for surgery was displayed in the virtual reality display and used for orientation during surgery. Real time augmentation of the surgery was performed using this dynamic VR information.

### Results

Altogether, 43 patients (17 female, 0-18 yrs, mean 9 yrs) were operated between 10/2020 and 10/2023 and fulfilled all inclusion criteria. 26 patients (60.5%) had an extra-temporal and 17 (39.5%) a temporal seizure origin. Preoperative MRI studies were negative in 11 patients (25.6%), which necessitated implantation of depth electrodes before resection. Advantages of VR augmentation comprised: 1. on-line targeting of the lesions, 2. avoiding injury of eloquent structures, 3. contour-guided resection of lesions even in cases with unclear visual delineation, and 4. estimation of the resection amount at the end of surgery.

Altogether, of 25 patients with a follow up of over one year, 83% displayed a favorable seizure outcome with ILAE 1 (75% ILAE 1a). One patient was found to have postoperative hemianopia, but no complications leading to surgical revision were encountered.

### Conclusion

VR augmented microscope resection facilitated targeting and removal of lesional as well as non-lesional (sEEG guided) epileptogenic zones in pediatric epilepsy surgery with low morbidity and a remarkably good seizure outcome.

# Funktionelle Neurochirurgie – Epilepsie | Functional Neurosurgery – Epilepsy

## V135

### Jenseits der Läsion: Stereoelektroenzephalographie (SEEG)-Evaluation und Prädiktoren für das postoperative Anfallsoutcome nach resektiver Epilepsiechirurgie

***Beyond the lesion: stereoelectroencephalography (SEEG) evaluation and predictors for post-operative seizure outcome in resective epilepsy surgery***

E. Shabo[1], V. Gnatkovsky[2], A. L. Potthoff[1], I. Ilic[1], A. Racz[2], T. Baumgartner[2], T. Rüber[2], M. Schneider[1], F. Mormann[2], R. Surges[2], H. Vatter[1], V. Borger[1]

[1]Universitätsklinikum Bonn, Klinik mit Poliklinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Klinik und Poliklinik für Epileptologie, Bonn, Deutschland

#### Objective

It is often assumed that patients with refractory epilepsy requiring invasive pre-surgical evaluation using stereoelectroencephalography (SEEG) prior to epilepsy surgery have a lower chance of achieving seizure freedom postoperatively. However, some predictors have been proposed, and their impact on postoperative seizure freedom is controversially discussed. The aim of this study is to identify factors in patients undergoing invasive pre-surgical evaluation that influence postoperative seizure outcomes following resective epilepsy surgery.

#### Methods

In this retrospective single-center study, we included all patients with pharmacoresistant epilepsy who underwent resective epilepsy surgery following invasive pre-surgical evaluation using SEEG between 2012 and 2022. Seizure outcome was determined according to the ILAE classification with a follow-up of at least one year after the epilepsy surgery. Patients were divided into two groups according to their postoperative seizure outcomes: seizure-free (SF) and not seizure-free (non-SF). Both groups were analyzed and compared regarding factors determining seizure outcome.

#### Results

83(72.8%) of a total of 114 patients were seizure-free (SF) and 31(27.2%) were not seizure-free (non-SF) after epilepsy surgery. The comparison of both groups shows that patient characteristics such as age at surgery, sex, BMI, and ASA-score statistically had no impact on post-operative seizure outcome. Univariate analysis revealed that non-lesional MRI scan prior to evaluation (p=0.002), detected peri-operative complications according to MRI scan after completing the SEEG monitorung (p=0.006) and selective amygdalo-hippocampectomy as chosen resective approach (p=0.010) was significantly more often associated with a non-seizure-free outcome. Multivariate analysis revealed the non-lesional MRI scan (p=0.008, OR 6.4, CI 95% 1.6-25.4) and post-operative complications depicted on MRI scan during the SEEG evaluation (p=0.024, OR 8.2, CI 95% 1.0-8.5) as independent risk factors for the non-seizure-free outcome.

#### Conclusion

In this study, we demonstrate that patients with a non-lesional MRI, who were pre-surgically evaluated using SEEG and had an identified epileptogenic focus, showed a significantly higher risk of not achieving seizure freedom following resective epilepsy surgery. Furthermore, the detection of peri-operative complications in the MRI scan following the completion of the SEEG evaluation was a statistically significant predictor of non-seizure-free outcome.

# V136

## Langzeitauswirkungen der Stimulation des Hypoglossusnervs auf Lebensqualität und Stimmungslage bei obstruktiver SchlafapnoeLong

***Long-Term impact of hypoglossal nerve stimulation on quality of life and mood in obstructive sleep apnea***

F. Corr[1], V. Krüger[2], D. Soydaş[1], F. Kilinç[1], J. Oros[1], L. E. Qasem[1], A. Al-Hilou[1], L. Stange[1], D. Jussen[1], M. Czabanka[1], J. Quick-Weller[1]

[1]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[2]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Frankfurt a. M., Deutschland

### Objective

Obstructive sleep apnea is associated with significant morbidity and mortality. Poor sleep quality has a significant impact on the patient's quality of life and mental health. Hypoglossal nerve stimulation (HNS) represents a neurosurgical option for individuals who exhibit inadequate responses to standard treatment. Although the positive effects of nerve stimulation on objective measures such as the apnea-hypopnea index (AHI) have been observed, the long-term effects on quality of life and mood have not yet been investigated.

### Methods

A single-center prospective analysis including twelve patients undergoing unilateral HNS (Inspire Medical Systems, Inc, Maple Grove, Minnesota) was performed between 2020 and 2024. All participants were assessed using the Becks Depression Inventory score (BDI-II) for mood evaluation, and the Quality-of-Life Scale questionnaire (QoL) at baseline, six months, and more than two years after stimulator activation. Patients were dichotomously stratified based on the degree of treatment success, defined as achieving a postoperative AHI of ≤ 20 events/h, with a reduction of at least 50% compared to baseline.

### Results

All participants completed the six-month follow-up, while three patients were lost to follow-up at over 2 years. The average follow-up time was 30.8 months. Five out of twelve patients were classified as non-responders. Mean BDS-II scores were 0.77, 0.49, and 0.42 ($p < 0.05$), and mean QoL scores were 4.93, 4.84, and 5.2 at the respective time points. Noteworthy differences in the QoL domain were seen in autonomy, family relationships, and close friends. In the BDS-II domain, significant improvements were noted in change in sleep habits, irritability, and suicidal thoughts, among others. Non-responders exhibited elevated BDI-II scores in 18/21, 20/21, and 17/21 categories, and demonstrated higher dissatisfaction rates in 13/16, 8/16, and 11/16 cases at the respective follow-up points.

### Conclusion

Apart from measurable parameters such as AHI, there is a positive influence of HNS on the quality of life, particularly with more positive outcomes observed over a two-year period. As a subgroup, responders consistently exhibited higher satisfaction levels and lower BDI-II scores at all follow-up points. A slower or poorer response in satisfaction and mood should not be prematurely interpreted as treatment failure. Instead, the enhancement and restoration of quality of life seem to unfold gradually in the long-term trajectory.

# V137

## Hypoglossus nerv Stimulation als Alternative in der Therapie der Obstructiven Schlafapnoe
*Hypoglossal nerve stimulation as an alternative in the therapy of obstructive sleep apnea*

K. D. Martin[1], S. Romualdo[1], I. Y. Eyüpoglu[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik für Neurochirurgie, Dresden, Deutschland

### Objective

Due to the very poor therapy acceptance and the side effects of CPAP therapy in obstructive sleep apnea, there is a great need for alternatives. Hypoglossal stimulation represents a new therapy option that has been available since 2016. In this study, we would like to present our initial results from 53 patients with implanted hypoglossal stimulators.

### Methods

In the period from August 2016 to December 2023, we were able to evaluate the data from 52 patients with respiratory sensor-triggered hypoglossal stimulators that were implanted by us. The pre- and postoperative AHI was determined using polygraphy and polysomnography, the pre- and postoperative daytime sleepiness using the Epworth Sleepiness Scale (ESS) and patient satisfaction were determined.

### Results

In 48 out of 52 patients (92.3%), we observed a reduction in AHI under stimulation by over 60%. Four patients did not tolerate this therapy or did not use it regularly. Twenty-six patients (47.3%) achieved a reduction in AHI of over 80% from the baseline value. Regarding daytime sleepiness, there was an average reduction in the ESS score from 10 to 6.5. The subjectively reported satisfaction with sleep improved by 66.3% in 43 evaluable patients.

### Conclusion

Stimulating the hypoglossal nerve for the treatment of OSA (obstructive sleep apnea) provides a viable alternative to CPAP/PAP therapy. With strict indications, an acceptable reduction in AHI (apnea-hypopnea index) can be achieved. Daytime sleepiness is effectively treated, and the subjectively perceived sleep quality improves. This is a new and emerging technology with the potential to replace PAP therapy in the coming years.

# Tumor – Verschiedenes 2 | Tumour – Various 2

## V138

### Prädiktivität von Läsionslokalisationen bei Patient*innen mit Benennstörung bekannter Personen und Orte und linksseitigen Hirntumoren

***Predictability of lesion locations in left-sided brain tumor patients with impaired proper name retrieval***

P. Felgenhauer[1], M. G. Prem[1], C. Buszello[1], G. Reiß[1], J. Linn[1], I. Y. Eyüpoglu[1], S. B. Sobottka[1], N. Knobloch[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland

#### Objective

Proper name retrieval is often not a primary focus for neurosurgeons. However, the ability to name familiar people and places plays a vital role in social interactions. This study examines the incidence of this issue in patients with left-sided brain tumors.

#### Methods

We assessed the incidence of impaired proper name retrieval in 55 patients with left-sided brain tumors. They underwent 107 perioperative examinations using the Anatomical Functional Aphasia Screening (AFAS). The proper name retrieval deficits were correlated with cortical and subcortical lesion locations identified by MRI/DTI tractography. A combined functional severity score (CFS) was calculated as the relative number of correctly named people and places. The CFS was compared with the overall AFAS score, which describes the general AFAS language ability (GLA).

#### Results

30 of 55 patients showed an impairment of proper name retrieval perioperatively (13/55 pre- and 17/55 postoperatively) with 3 patients showing an impairment in naming familiar people, 6 in naming familiar places, and 21 with a combined deficit. Primary lesion locations were temporal (disruption of UF, ILF, and MdLF; n=10; mean CFS 43.9%; mean GLA 73.7%), temporoparietooccipital (TPO) junction (IFOF, ILF, MdLF, AF; n=9; mean CFS 34.8%; mean GLA 78.6%), frontal (FAT, AF, SLF; n=5; mean CFS 64.8%; mean GLA 85%), and insular (IFOF, UF; n=7; mean CFS 26.4%; mean GLA 72%). Among the 7 patients who underwent a 3-month follow-up only 2 showed a considerable improvement of CFS (patient 1, frontal, 56% to 100%; patient 2, insular, 33.5% to 78%). No improvement was observed in the remaining 5 patients (temporal n=3; TPO n=1; insular n=1).

#### Conclusion

Given its frequent occurrence, the poor recovery rate, and significant impact on daily life, proper name retrieval should be tested perioperatively in patients with relevant lesion locations. In addition, awake surgery with an intraoperative testing should be considered.

(UF: uncinate fascicle; FAT: frontal aslant tract; AF: arcuate fascicle; IFOF: inf. frontooccipital fascicle; ILF/MdLF: inf./mid. longitudinal fascicles)

# Tumor – Verschiedenes 2 | Tumour – Various 2

## V139

### Prozessoptimierte intraoperative Gewebeanalyse von stereotaktischen Biopsien: Detektion, Klassifikation und molekulare Subtypisierung von Hirntumoren mit stimulierter Raman-Histologie und Deep Learning

***Streamlined intraoperative Stereotactic-guided biopsy analysis: Brain tumor detection, classification and molecular subtyping with stimulated raman histology and deep learning***

D. Reinecke[1], D. Rueß[1], A. K. Meissner[2], G. Fürtjes[2], N. von Spreckelsen[2], N. Müller[2], A. Ion-Margineanu[3], F. Khalid[3], T. Blau[4], A. Al-Shugri[5], T. Stehle[5], R. Goldbrunner[2], M. I. Ruge[1], V. Neuschmelting[2]

[1]Universitätsklinikum Köln, Klinik für Stereotaxie und funktionelle Neurochirurgie, Köln, Deutschland
[2]Universitätsklinikum Köln, Klinik für Allgemeine Neurochirurgie, Köln, Deutschland
[3]Invenio Imaging Inc., Santa Clara, CA, Vereinigte Staaten
[4]Universitätsklinikum Essen, Institut für Neuropathologie, Essen, Deutschland
[5]Universitätsklinikum Köln, Institut für Neuropathologie, Köln, Deutschland

#### Objective

Deep-learning-based algorithms leveraged intraoperative decision-making via stimulated Raman histology (SRH) during microsurgical resection. This study evaluates this technique for fast diagnosis during stereotactic-guided brain biopsies and defines a minimum tissue sample size, ensuring diagnostic accuracy.

#### Methods

A prospective single-center study evaluated 121 SRH images from 84 patients with suspected intracranial lesions undergoing stereotactic-guided biopsy. Fresh, label-free tissue samples were squeezed on a slide and imaged with a portable fiber-laser Raman scattering microscope. Deep-learning-based models were tested to (1) identify tumorous/non-tumorous tissue for qualitative biopsy control, then (2) classify it into malignant glioma, diffuse low-grade glioma, metastases, lymphoma, or gliosis, and then (3) molecularly subtype the IDH- and 1p/19q-status of adult-type diffuse gliomas. Model predictions were compared to frozen section analyses and final neuropathological diagnoses.

#### Results

The first model identified tumorous/non-tumorous tissue with 91.5% accuracy. Tissue sample size influenced brain tumor subclassification accuracy (81.6%, $\kappa$=0.72 frozen section; 73.9%, $\kappa$=0.61 second model). SRH slide images >140 high-quality patches with a mean squeezed sample of 5.26mm2 yielded 89.5% accuracy in brain tumor subclassification comparable to conventional frozen section diagnostics and 93.9% accuracy in molecular subtyping of adult-type diffuse gliomas outperforming the limits of conventional rapid section histopathological review. Of note, the tissue sample size subject to SRH was still significantly smaller (4.1±2.5mm2) than H&E frozen sections (16.7±8.2mm2, $p<0.001$).

#### Conclusion

AI-based image analysis is non-inferior to frozen section analysis in detecting and classifying brain tumors during small stereotactic-guided biopsies once a critically squeezed sample size is reached. It also allows for valid molecular glioma subtyping, potentially leading to faster treatment decisions in the future. Further refinement is needed for long-term clinical routine use.

# Tumor – Verschiedenes 2 | Tumour – Various 2

## V140

### Veränderungen der strukturellen Konnektivität bei Patienten mit Tumoren in der supplementär-motorischen Area (SMA)

***Structural connectivity alterations in patients with tumor lesions in the supplementary motor area (SMA)***

C. H. Na[1,2], O. Poznansky[3], R. Sijben[3], H. R. Clusmann[1,2], M. Wiesmann[4], D. Delev[2,5,6], R. Rodriguez-Raecke[3]

[1]Rheinisch-Westfälische Technische Hochschule Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[2]Center for Integrated Oncology, Aachen Bonn Cologne Düsseldorf (CIO ABCD), Aachen, Deutschland
[3]Universitätsklinikum RWTH Aachen, Brain Imaging Facility, Interdisciplinary Center for Clinical Research (IZKF), Aachen, Deutschland
[4]Rheinisch-Westfälische Technische Hochschule Aachen, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Aachen, Deutschland
[5]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[6]University Hospital Erlangen, Friedrich-Alexander-University, Department of Neur, Erlangen, Deutschland

#### Objective

SMA tumor patients typically develop postoperatively a contralateral akinesia with or without speech deficit ("SMA syndrome"), which often regresses within the first three months. The time to recovery however varies, and has previously been related to structural integrity of transcallosal connectivity of the SMA and of the Frontal Aslant Tract (FAT). Whether SMA tumor patients differ in structural connectivity (SC) already prior to surgical intervention is however unclear. We investigated diffusion-MRI based SC in SMA tumor patients preoperatively compared to healthy controls.

#### Methods

13 SMA tumor patients (10 gliomas/2 metastases/1 meningioma; 5 right-hemispheric; mean age 49±21 yrs), and 13 matched healthy controls (49±16 yrs) underwent diffusion-MRI preoperatively. Applying deterministic diffusion tractography, SC of the FAT, and of transcallosal SMA connectivity to the contralateral SMA (SMA-SMA), and to the contralateral primary motor cortex (SMA-M1) was analyzed. Normalized parameters evaluated for each tract were tract volume, number of fibers, tract length, as well as mean fractional anisotropy (FA), and mean-, radial-, and axial-diffusivity (MD, RD, AD), which were compared between patients and controls.

#### Results

For FAT connectivity, patients showed a trend towards smaller tract volumes, with MD ($p<.012$) and AD ($p<.010$) being ipsilesionally increased only in patients. Transcallosal SMA-SMA connectivity did not significantly differ between groups, although the mean number of fibers appeared to be increased in some of the patients ($Mean_{patients}=0.81+/-0.47$; $Mean_{controls}=0.56+/-0.34$), which however did not reach significance due to the high variance. For SMA-M1 connectivity, tract volumes were reduced ($p<.005$), and fiber length of contralesional compared to ipsilesional SMA-M1 connections ($p<.026$), as well as AD ($p<.019$) were increased in patients.

#### Conclusion

Patients showed tumor-associated signs of ipsilesional and transcallosal microstructural white matter disintegration, but with a high variance in homologue transcallosal SMA connectivity. Variability in transcallosal connectivity might relate to differing abilities for bihemispheric or contralateral information processing. Longitudinal studies should evaluate, whether tumor-associated alterations of transcallosal connectivity impact on the postoperative functional outcome in SMA tumor patients

# Tumor – Verschiedenes 2 | Tumour – Various 2

## V141

### Optimierte Sprachtestung bei Wach-Operationen von infiltrierenden Hirntumoren
***Preservation of language during awake craniotomy for infiltrating brain tumors – A new diagnostic tool improves functional resolution***

M. Rapp[1], M. Bartnitzky[1], A. Haida[1], M. Sabel[1], Y. Grodzynski[1,2]

[1]Universitätsklinikum Düsseldorf, Neurochirurgie, Düsseldorf, Deutschland
[2]Hebrew University, Jerusalem, Israel

#### Objective

The preservation of language functions despite the goal of supramaximal resection for infiltrating brain tumors, necessitates the intraoperative identification of language-associated areas. The current standard of language assessment addresses word-level articulation (e.g., counting or word repetition), word retrieval (picture naming-PN) or identification and semantic-relatedness (pyramid-palm tree test-PPTP). These tests are all at the word level. As such, they probe language functions very partially. We humans communicate via sentence and stories, not just word. To move to this level, we adopted a linguistic approach, and constructed a test battery comprising of a relatively rich variety of sentence types whose comprehension we tested. We then evaluated the feasibility and sensitivity of newly developed linguistic tests in awake surgery for infiltrating brain tumor.

#### Methods

In this prospective study, patients planned for awake craniotomy performed (peri- and intra-operatively) an app-based linguistic language test (sentence comprehension of different syntactic and semantic types) in addition to the standard test (counting, PN, PPTP). We applied these tests peri- and intra-operatively. This enabled a comparison between patients" performance on the new linguistic tests and the standard tests.

#### Results

Thus far, we have tested 140 patients peri-operatively, of which about 25 were also tested intra-operatively. While the analysis is still in progress, we can report three important results: a. the test is highly feasible: most patients can carry out the test at all stages. b. while patients" performance standard word-level tests tends to be at ceiling (at least pre-operatively), thereby failing to differentiate between different functional deficits, the new sentence-level tests rarely record performance at ceiling (although healthy controls are always at ceiling). c. the new tests evince much higher individual variability.

#### Conclusion

Our preliminary results demonstrate (i) the feasibility of the linguistic test application at all stages; (ii) the resolution of the new test is higher: it uncovers language impairments not revealed by standard testing. This suggests that the current standard of care can be improved with the new tool.

# BO-05

## Entwicklung und Validierung eines deep learning basierten Modells zur präoperativen Unterscheidung von Glioblastomen und zerebralen Lymphomen vor stereotaktischer Biopsie

P. Naser[1], M. Maurer[2], K. Karimian-Jazi[3], C. Ben-Salah[4], A. A. Bajwa[1], M. Jakobs[1], J. Jesser[3], K. Maier-Hein[2], A. W. Unterberg[1], J.-O. Neumann[1]

[1]Neurochirurgische Universitätsklinik Heidelberg, , Heidelberg, Deutschland
[2]Deutsches Krebsforschungszentrum (DKFZ) Heidelberg, Abteilung Medizinische Bildverarbeitung, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Neuroradiologie, Heidelberg, Deutschland
[4]Universitätsklinikum Heidelberg, Diag. und interventionelle Radiologie, Heidelberg, Deutschland

### Fragest.

Viele Tumorentitäten können auf Basis der präoperativen (MRT) Bildgebung eindeutig unterschieden werden. Glioblastome (GBM) und Lymphome (PCNSL) sind derart ähnlich, dass eine Einschätzung anhand des Bildmaterials präoperativ oft fehlschlägt. Die Behandlungspfade dieser Tumorarten unterscheiden sich grundsätzlich, eine bioptische Diagnosesicherung vor Therapieeinleitung ist daher unbedingt notwendig. Insbesondere die präoperative Verabreichung von Steroiden führt im Falle des Lymphoms zum Untergang der Lymphomzellen, was die pathologische Diagnose erschwert. In dieser Studie entwickelten wir einen deep-learning Algorithmus, welcher präoperativ eine Vorhersage zum Vorliegen eines Lymphoms treffen soll und evaluierten diesen im Vergleich mit radiologisch erfahrenen Ärzten.

### Meth.

158 stereotaktisch biopsierte Pat. (80GBM, 78 PCNSL) mit 3D MRT Datensätzen (T1-nativ, T1-KM, T2, FLAIR) wurden in diese retrospektive Studie eingeschlossen. Auf Basis der densenet169 Architektur entwickelten wir ein neurales Netzwerk, welches auf den Bilddaten von 138 Patienten (70GBM, 68 PCNSL) trainiert, und anhand von 20, dem Netz unbekannten Patienten (10GBM/ 10PCNSL) validiert wurde. Zudem wurden die Testpat. von 6 neuroradiologisch erfahrenen, verblindeten Ärzten (drei Neurochirurgen, drei Radiologen) bewertet und die gestellten Diagnosen verglichen.

### Ergeb.

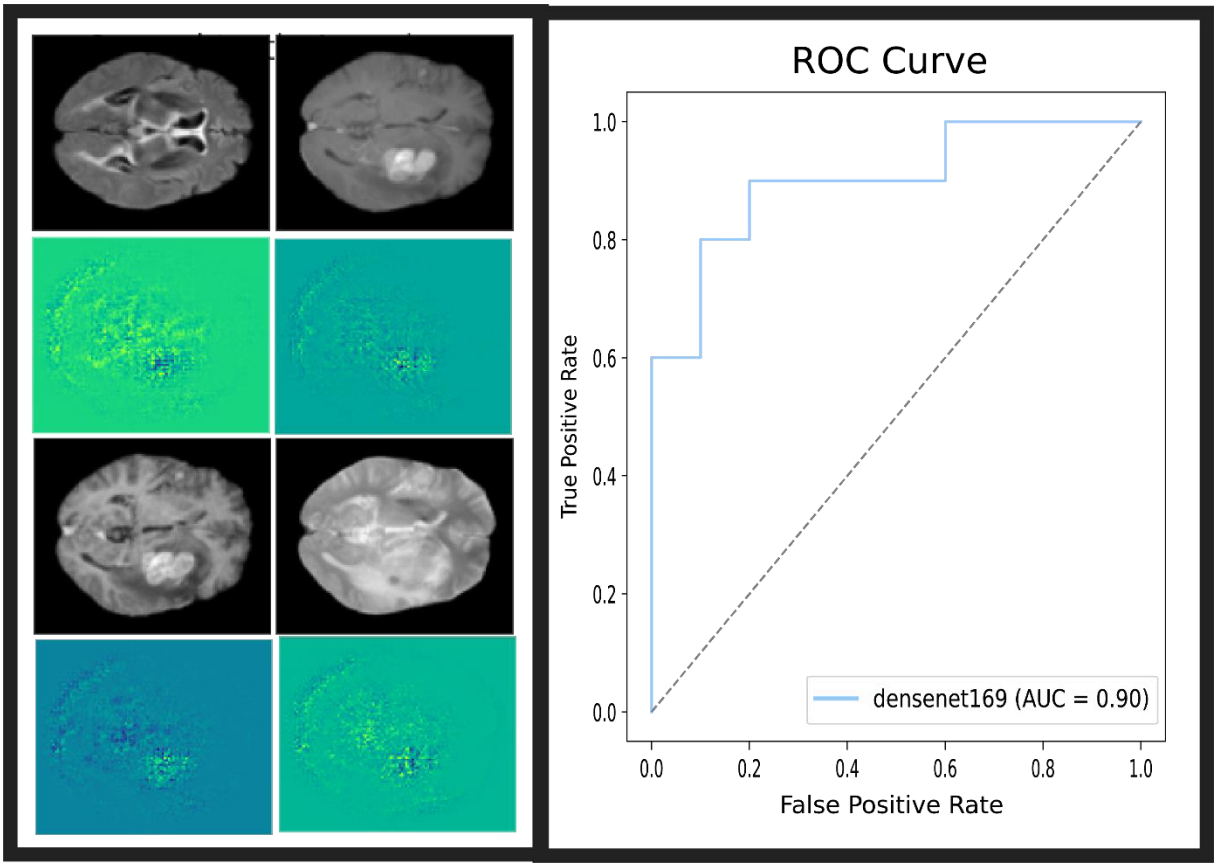
Bezüglich Tumorgröße, Alter und Geschlecht lagen keine signifikanten Unterschiede zwischen GBM und PCNLS vor. Das neurale Netzwerk konnte mit hoher Wahrscheinlichkeit das Vorliegen eines PCNSL ausschließen (NPV 0.8). Die Vorhersagegenauigkeit (ACC) betrug 0.8, die ROC-AUC 0.9 (Abb.1). Im Vergleich dazu erreichte der "beste" Radiologe einen NPV von 1 (ACC 0.8), wobei im Mittel eine ACC von 0.792 und ein NPV von 0.8 bei einer Sensitivität von 0.786 und Spezifität von 0.927 erreicht wurde. T1-KM wurde durch die Befragten als die wichtigste Modalität befunden, wobei für die Entscheidung des neuralen Netzwerkes die T2 Sequenz entscheidend war. Die manuelle Diagnosestellung dauerte im Mittel 105 ± 55 s (automatisiert 0,04 ± 0,0002s), wobei sich keine signifikanten Unterschiede zwischen GBM und PCNSL oder zwischen korrekter und inkorrekter Diagnose fanden.

### Schlussfolgerungen

Einige Ansätze der maschinellen Diagnose cerebraler Pathologien wurden bereits entwickelt. Bisher fußen diese jedoch auf einer sehr intensiven Bildvorbereitung bzw. wurden lediglich auf vordefinierten Bildausschnitten erprobt. Wir konnten in dieser Pilotstudie erstmals einen Algorithmus entwickeln, welcher nativ auf 3D MRT Datensätzen reliable, mit den erfahrener Ärzte vergleichbare Vorhersagen zum Nichtvorliegen eines PCNSL liefert. Interessant ist zudem, dass der Algorithmus im Gegensatz zum Menschen andere Charakteristika zur Entscheidung heranzieht.

*Abb.1: li: Saliency maps visualisieren die für das neuronale Netzwerk wichtigen Bildareale. Rechts: Receiver Operating Characteristic-Kurve für automatisierte Diagnosestellung PCNSL*

**Abb. 1**



V143

## 5807 Patienten mit einem leichten Schädelhirntrauma in einer neurochirurgischen Notambulanz - Optimierung der Effizienz und Effektivität bei der Behandlung

***5807 mild TBI patients presenting to a neurosurgical emergency department – Optimizing care paths and increasing efficiency and efficacy***

T. Schink[1], S. Bahtijari[1], L. Kromer[1], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Mild traumatic brain injuries (mTBI) have become the predominant neurotrauma, with recent studies highlighting their potential for significant morbidity and intensive diagnostic requirements. Given their socioeconomic impact, accurately determining the need for neuroimaging, monitoring, and interventions is essential. This study aims to elucidate the clinical management of mTBI patients in a neurosurgical emergency department.

### Methods

All TBI patients admitted to the emergency department of a single neurosurgical institution were analyzed between December 2017 and January 2024. Demographic and clinical variables were collected and possible predictors for posttraumatic intracranial pathologies and neurosurgical interventions were assessed using multiple logistic regression.

### Results

Over a period of over six years, 5807 mild TBI patients were included (50% male; mean age 52 ± 25 years). The most common cause of injury was an incidental fall (n=3339; 57.5%). Antithrombotic medication was used by 26.5% of patients (n=1540). Only 10% (n=595) showed neurological deficits but 1019 patients (17.5%) suffered from amnesia and 740 (12.7%) had experienced vomiting. Cranial imaging by computer tomography (CT) was performed in 68% of cases (n=3960), revealing posttraumatic pathologies in 938 patients (23.7%). Medical or surgical interventions were performed in 2960 patients (51%), including, inter alia, i.v.-analgesia (n=1071; 36%) and neurosurgery (n=241; 8%) and 20% (n=1181) were admitted to either the normal ward or ICU. In statistical analysis, neurological deficits were significantly associated with a pathological CT scan ($p<0.01$), admission to the ward ($p=0.049$) and requiring neurosurgery after mTBI ($p<0.05$). Neither the GCS upon admission, nor usage of antithrombotic medication showed similar associations with posttraumatic intracranial pathologies or the need for neurosurgery. When evaluating the clinical examination as a diagnostic test to predict intracranial pathologies, the absence of neurological deficits exhibited a negative predictive value of 85% and a specificity of 91% with an accuracy of 80%.

### Conclusion

Even "mild" traumatic brain injuries can lead to intracranial pathologies requiring neurosurgical attention. Since neurological deficits seem to be reliably associated with relevant radiological findings, emphasizing the clinical presentation of mTBI patients could increase efficiency in their acute management.

# Trauma und Neurointensiv – Verschiedenes 2 | Trauma – Various 2

## V144

### Autologe Kranioplastiken nach dekompressiven Kraniektomien – Immer noch zeitgemäß?
***Autologous cranioplasty following decompressive craniectomy – Still up to date?***

L. Ritter[1], K. Strohhäcker[1], K. M. Schebesch[1], T. Eibl[1], J. Höhne[1], A. Liebert[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Klinik für Neurochirurgie, Nürnberg, Deutschland

#### Objective

The usage of autologous bone crafts for cranioplasties after decompressive craniectomies (DC) is still up for debate. The objective of this study was to analyze the complication rate for autologous cranioplasties in our department and to compare them with the current literature. Also, we aimed to identify predictors for complications after autologous cranioplasty.

#### Methods

A retrospective single-center review was conducted for adult patients who underwent autologous cranioplasty after DC. The primary outcome was defined as infection resulting in surgical removal of the bone craft. Secondary outcomes included osteolysis, cerebro-spinal fluid (CSF) fistula, re-bleeding and wound healing disorders. Demographic data, medical records, surgical reports and imaging studies were collected and a bivariate analysis was performed to identify predictors for complications.

#### Results

177 consecutive patients met the inclusion criteria. The mean interval between DC and cranioplasty was 87 ± 41 days (Range 5 to 325 days). The mean age was 50.5 ± 12.9 years and 41.6 percent were female. 33 patients (18.6%) had revision surgery after cranioplasty. Surgical site infections occurred in 14 cases (7.9%) with Staphylococcus aureus in 42.8%. Complications were as follows: N=14 re-bleedings (7.9%), n=9 dislocation of material (5.1%), n=7 osteolysis (4%), n=7 wound dehiscences (4%), and n=4 CSF fistulas (2.3%). Bivariate analysis revealed the omission of preoperative prophylactic antibiotics ($p<0.001$), dural sutures ($p=0.02$) and surgery time ($p=0.03$) as significant risk factors for surgical site infections.

#### Conclusion

The complication rate after autologous cranioplasty was comparable to previously reported data as well as alternative techniques, such as titanium cranioplasties. Accordingly, preservation of the bone flap after DC is a valid and economic alternative for artificial implants.

# V145

## Klinisches Management von jungen Patienten (15-25 Jahre) mit leichtem Schädelhirntrauma: eine retrospektive Analyse von 594 Fällen

***Clinical management of mild traumatic brain injuries in young patients (15-25 Years): A retrospective analysis of 594 cases***

T. Schink[1], L. Kromer[1], S. Bahtijari[1], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Traumatic brain injuries (TBI) continue to be causative factors for mortality and long-term morbidity in adolescents and young adults. This population faces a high risk of long-term damage, even in cases of "mild" traumatic brain injuries (mTBI). We therefore analyzed young mTBI patients with a focus on clinical management and clinical outcomes.

### Methods

All young patients (15-25 years old) diagnosed with a mTBI (GCS 13-15) who were treated at a single-center neurosurgical emergency department from 2018 to 2020 were assessed in this retrospective study. Leveraging the clinical database, descriptive analysis and statistical comparisons were conducted to pinpoint risk factors associated with more complicated brain injuries in the younger population.

### Results

During 36 months, 594 mTBI patients aged 15 to 25 years were included (50% male, mean age 21 ± 2.7 years). Most common injury causes were falls (25%, n=129), violence (21%, n=125), accidents related to alcohol intoxication (15%, n=89) and bicycle or car accidents (16%, n=97). Mild TBI manifested with symptoms such as headaches (80%, n=479), vomiting (25%, n=148), amnesia (20%, n=119) and unconsciousness (17%, n=102). Focal neurological deficits were observed in 12% (n=71). As for imaging, computed tomography of the head (CCT) was used in 30% (n=179) of cases, out of which 89%(n=159) showed no pathological findings. Presence of symptoms such as vomiting (OR=3.1561; $p<0.05$), amnesia (OR= 3.407; $p<0.05$) unconsciousness (OR=4.42; $p<0.05$), and neurological deficits (OR=2.604: $p=0.05$) had an association with receiving CCT. Neither neurological deficits, nor vomiting had significant associations with pathological CT findings, while posttraumatic unconsciousness seemed to be a more relevant predictor for a more complicated mTBI with a pathological CT (OR=2.7; $p=0.09$). Therapeutic interventions were carried out in 40%(n=237) of cases, out of which only 1.2% were neurosurgical operations (n=3). Notably, 12% (n= 74) of patients were discharged against medical advice, whereas 16%(n=96) were admitted to the hospital, usually solely for an observational period for one day.

### Conclusion

These findings underscore the importance of tailored diagnostics for comprehensive healthcare strategies in younger patients with a mTBI as most do not show relevant pathologies. However, more complicated injuries can occur and prospective analyses are needed to analyze outcome of this mTBI cohort.

# Trauma und Neurointensiv – Verschiedenes 2 | Trauma – Various 2

## V146

### Förderung der neuronalen Regeneration nach Schädel-Hirn-Trauma durch Ascl1-vermittelte Umprogrammierung von Astrozyten zu Neuronen

***Enhancing neuronal regeneration in traumatic brain injury via Ascl1-Mediated astrocyte-to-neuron reprogramming***

J. Tödt[1], X. Zhou[2], G. Zheng[1], A. Schnaubelt[1], M. Hatami[2], T. Skutella[2], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Ruprecht-Karls-Universität Heidelberg, Institut für Anatomie und Zellbiologie, Heidelberg, Deutschland

#### Objective

Traumatic brain injury (TBI) results in neuron loss, astrogliosis, and glial scar formation, hindering the central nervous system's regenerative capacity. This study investigates the conversion of reactive astrocytes into functional neurons to counter astrogliosis and promote neuronal regeneration in a rat TBI model.

#### Methods

Primary rat cortical astrocytes were cultured and transduced with lentiviral vectors to overexpress the Ascl1 transcription factor. Lineage tracing used GFAP-driven Cre recombinase and Synapsin1-driven mScarlet expression. Cell phenotypes were evaluated at 7 and 14 days via immunocytochemistry (ICC). For in vivo application, adeno-associated viral (AAV) vectors were developed, purified, and quantified. A controlled cortical impact (CCI) or sham surgery was induced in 36 male Wistar rats and vectors, or placebo were injected into the perilesional area 7 days later. Functional outcomes were assessed over 38 days using Rotarod, Open Field, and CatWalk gait analyses, complemented by lineage tracing and immunohistochemistry (IHC).

#### Results

Astrocyte-to-neuron (AtN) reprogramming was evidenced 7- and 14-days post-transduction in vitro, characterized by 60% vs. 5% mScarlet positive cells in the Ascl1 vs. the control group (p= 0,03) and an increased expression of neuronal markers in the Ascl1 group (e.g., 70% more Synapsin1 and 75% more beta-Tubulin 3 positive cells than the control group, p=0,04 and p= 0,01, respectively). After stereotactic injection of the astrocyte-specific, Ascl1-overexpressing AAVs in the injured brain in vivo, rats exhibited enhanced functional outcomes compared to non-Ascl1-overexpressing AAVs or placebo treated rats (e.g., 33s longer run duration in the Rotarod test or 0,5 cm2 wider print width in the CatWalk gait analysis). Lineage tracing confirmed successful AtN reprogramming in the perilesional area, which was further confirmed by co-staining with additional neuronal markers. IHC also revealed decreased neuroinflammation after AtN.

#### Conclusion

An in vitro lentiviral approach for astrocyte-to-neuron conversion was successfully established and translated into an in vivo AAV-based rat TBI model. The strategy showed effective astrocyte to neuron reprogramming as well as promising functional improvements, suggesting its therapeutic potential in TBI treatment.

# V147

## Stereotaktische Transplantation von neuroD1/Prox1 Gyrus Dentatus Vorläuferzellen zur Behandlung der Hippocampusschädigung nach Schädel-Hirntrauma im Rattenmodell

***Stereotactic transplantation of neuroD1/Prox1 gyrus dentate precursor cells for the treatment of hippocampal damage after traumatic brain injury in a rat model***

M. Grutza[1], M. Milivojevic[1], K. Große[2], T. Skutella[2], M. Hatami[2], S. Krieg[1], A. Unterberg[2], A. Younsi[2]

[1]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Traumatic Brain Injury (TBI) is frequently associated with the impairment of cognitive function, potentially related to damage of the hippocampus. However, data on neurocognitive and histopathological changes after hippocampal injury remain scarce and no regenerative treatment for hippocampal damage currently exists. Here, we investigate potential neuroregenerative effects of hippocampal transplantation of neuroD1/Prox1 gyrus dentate precursor cells after experimental TBI in a rat model.

### Methods

We allocated 22 male Wistar rats to either right parietal Controlled Cortical Impact (CCI) with a depth of 3 mm, a contact time of 150 ms and an impact speed of 6 m/sec, to specifically induce hippocampal damage, or sham surgery. At 7 days post injury (dpi), stereotactic transplantation of 6 x 105 gyrus dentate precursor cells expressing neuroD1 and Prox1 or a placebo (PBS) to three distinct areas in the hippocampus were performed. Motor function and behavioral changes were examined via the Rotarod (RR) and Open-Field test (OF) after 1, 3, 7 dpi and weekly thereafter. Learning and memory function were tested via the Sacktor"s Active Avoidance test (AAT). At the end of the experiment 35 dpi, hippocampal injury and neuroregeneration on the histological level were examined via immunohistochemistry (IHC).

### Results

In the AAT, significant worsening of spatial learning and memory was observed 4 dpi in injured CCI animals compared to sham animals. With the stem cell treatment, only a slight improvement of cognitive function could be detected compared to the placebo group12 dpi. Similarly, a slight improvement of motor deficits was observed via the RR 14 and 21 dpi only in the stem cell group. A significant decrease of anxiety-like and an increase of exploratory behavior was seen via the OF 14 and 28 dpi with the stem cell compared to the placebo treatment. On the histological level, hippocampal damage with loss of brain tissue overall and specifically neurons, astrogliosis, and inflammation was noticeable after CCI 35 dpi. Of note, cell transplantation led to a substantial increase of histological neuroregeneration compared to the placebo treatment.

### Conclusion

Our study provides a better understanding of histopathological and neurobehavioral changes in the hippocampus after experimental TBI. Stereotactic transplantation of neuroD1/Prox1 expressing gyrus dentate precursor cells might be a potential therapeutic approach to improve such sequalae of TBI.

# V148

## Der Effekt einer Interleukin-4 Therapie auf die subakute und chronische systemische Entzündungsreaktion nach experimentellem Schädel-Hirn-Trauma im Mausmodell

***The effect of Interleukin-4 treatment on the subacute and chronic systemic inflammatory response after experimental traumatic brain injury in mice***

J. Walter[1], N. Kruck[1], A. Balandina[1], O. Alhalabi[1], S. Krieg[1], A. Unterberg[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Recently, the therapeutic administration of the anti-inflammatory cytokine Interleukine-4 (IL-4) has been shown to reduce contusion volume and ameliorate the local inflammatory response in the brain after experimental traumatic brain injury (TBI) in mice. However, its effect on the systemic inflammatory response, which is an important determinant of functional outcome after TBI, remains unknown. Therefore, we assessed the systemic inflammatory response in the subacute and phase after experimental TBI and initiation of systemic IL-4 therapy.

### Methods

A total of 50 C57Bl/6 wildtype mice were randomly assigned to receive either IL-4 at a dose of 5mg/kg (IL-4 group) or phosphate buffered saline (control group) subcutaneously once daily for seven days starting 15 minutes after controlled cortical impact (CCI, tip diameter 2mm, impact depth 1mm, velocity 8m/s, contact time 150ms). On days seven and 28 post CCI (7dpi and 28dpi, respectively), the animals were sacrificed, and blood was drawn for further analysis. Blood serum concentrations of 13 pro-inflammatory cytokines such as, e.g., Interleukin-1, Interleukin-6 or TNFα, were analyzed utilizing a flow cytometry based LEGENDplex™ immunoassay (BioLegend®, San Diego, USA).

### Results

At the first timepoint in the subacute phase 7dpi, only two cytokines showed significantly different blood serum concentrations between the IL-4 and the control group (IL-1α: 108.4 ± 24.5 pg/ml vs. 25.0 ± 6.1 pg/ml, p=0.04 for IL-4 and control, respectively; IL-10: 171.1 ± 55.1 pg/ml vs. 27.3 ± 10.7 pg/ml, p=0.01 for IL-4 and control, respectively). However, at the later timepoint in the chronic phase 28 dpi, the concentrations of IL-1β, IL-10, IL-12, Interferon-γ, MCP-1 and GM-CSF were significantly elevated in IL-4 treated animals compared to control animals (e.g., IL-12: 7.0 ± 1.5 pg/ml vs. 2.3 ± 0.7 pg/ml, p=0.002 for IL-4 and control, respectively; Interferon-γ: 11.9 ± 2.3 pg/ml vs. 5.5 ± 1.5 pg/ml, p=0.03 for IL-4 and control, respectively).

### Conclusion

The repetitive administration of IL-4 does not seem to ameliorate the systemic inflammatory response in the subacute and chronic phase after CCI; however, additional studies need to assess potential early systemic anti-inflammatory effects within the first week after trauma induction.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V149

### Autologes plättchenreiches Fibrin: Ein neuartiges zweischichtiges Abdichtungsverfahren für Liquorlecks nach Wirbelsäulenoperationen

***Autologous Platelet Rich Fibrin: A novel two-layer sealing technique for Cerebrospinal fluid leak after spinal surgery***

I. Vasilikos[1], K. Argiti[1], A. Stathi[1], K. Joseph[1], V. Ravi[1], R. Rölz[1], J. Beck[1], U. Hubbe[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Persistent cerebrospinal fluid (CSF) leakage is a common complication following spine surgery. When conservative strategies fail, operative revision aims to locate the dura defect and augment its closure with sutures and autologous or commercial sealants. Platelet-rich fibrin (PRF) is an autologous biomaterial that is easily prepared in the operating room from the patients blood and consists of a fibrin matrix with high concentrations of growth factors. It can be prepared after a single cycle of angled centrifugation in two forms, the solid membranous form (s-PRF) and the injectable form (i-PRF). Its regenerative and adhesive properties have been previously demonstrated in other disciplines such as maxillofacial, plastic and orthopedic surgery. This is a technical note and case series on its novel application for the treatment of persistent cerebrospinal fluid leaks following spinal surgery.

#### Methods

21 patients with persistent CSF leak after lumbar spine surgery were referred to our medical center for treatment. MRI scans showed the level of the leak. All patients had symptoms of intracranial hypotension. Revision surgery was indicated in all cases. During surgery, the dural defects responsible for the CSF leak were identified and sutured in a first step with 5-0 running simple closure suture. In a second step, the sutured defect was covered with a flattened s-PRF membrane. A further layer of sealing was achieved by covering with i-PRF, which gradually polymerized to form a gelatinous onlay. Watertightness was assessed intraoperatively by two cycles of short Valsalva maneuvers.

#### Results

In all patients, CSF leak was successfully treated with the PRF approach. The postoperative course was uneventful, and no recurrence of CSF leak or adverse effects were observed during a 12-month follow-up period.

#### Conclusion

The novel autologous PRF multilayer augmentation of dural lacerations is a safe and effective strategy for treating persistent CSF-leaks after spinal surgery.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V150

### Mikrochirurgische Versorgung von ventralen Duralecks bei spontaner intrakranieller Hypotension: Nähen vs. Kleben

***Comparison of microsurgical suturing vs. patching of ventral dural leaks in spontaneous intracranial hypotension***

T. Petutschnigg[1,2], R. Schär[1,2], L. Häni[1,2], T. Dobrocky[3,2], E. Piechowiak[3,2], A. Raabe[1,2], C. M. Jesse[1,2]

[1]Inselspital – Universitätsspital Bern, Neurochirurgie, Bern, Schweiz
[2]Universität Bern, Bern, Schweiz
[3]Inselspital, Diagnostische und interventionelle Neuroradiologie, Bern, Schweiz

#### Objective

Over the years, the understanding of the pathophysiology of spontaneous intracranial hypotension (SIH) has increased. Meanwhile there is growing evidence for the necessity of microsurgical repair in Type 1 leaks in SIH patients, when conservative measures fail. Studies have demonstrated significantly improved neurological outcome, patient symptom relief and resolution of spinal longitudinal extradural CSF collection (SLEC) after microsurgical closure of the underlying spinal CSF leak. To date, however, there is lacking consensus on the optimal surgical technique to achieve permanent closure of a ventral CSF leak.

#### Methods

We performed a retrospective analysis of all SIH patients with Type 1 leaks who were microsurgically treated at our institution between 2013 and 2023. Patients were divided into two groups depending on the surgical technique used for ventral dural closure: transdural 1) microsurgical closing suture or 2) extra- and intradural patching, using standard hemostatic patches (sandwich-technique). Primary endpoints were changes in SIH Score (Bern Score) on brain MRI and resolution of SLEC on postoperative MRI at two months follow-up. As secondary endpoint, we compared operation duration.

#### Results

In total, 85 (66% female) consecutive SIH patients with a mean age of 47 years (±11) underwent transdural surgical repair of a Type 1 leak. Most (92%) of the leaks presented at the level of the thoracic spine. The leak was sutured in 53 patients and patched in 32 patients. We found no significant difference in the rates of postoperative residual SLEC between the suture and patching groups (16.6% vs. 25.8% p = .38) and Bern Score (mean 1.4 (±2) vs. 1.7 (±2) p = .51). Operation time was significantly shorter in the patching group (mean 169 ± 51 minutes vs. mean 139 ± 48 minutes p = .03).

#### Conclusion

We found no significant difference in radiological outcomes between the two techniques. The sandwich-technique is feasible, equally effective and requires less operation time for microsurgical closure of ventral dura leaks. Therefore, in most cases, there is no need for intradural suturing of ventral CSF leaks.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V152

### Die minimalinvasive *keyhole fenestration* als ausreichender und sicherer Zugang zu allen spontanen Liquorlecks an der thorakalen Wirbelsäule
### *The keyhole fenestration as a safe minimally invasive approach for all CSF-leaks in the thoracic spine*

F. Volz[1], A. El Rahal[1], K. Wolf[1], R. Doria-Medina[1], C. Fung[2], U. Hubbe[1], J. H. Klingler[1], J. Beck[1]

[1]Klinik für Neurochirurgie, Uniklinik Freiburg, Freiburg i. Br., Deutschland
[2]Lindenhofspital, Neurochirurgie, Bern, Schweiz

#### Objective

For all spinal pathologies in the thoracic spine, but especially anterior to the spinal cord in the midline, a safe working trajectory is mandatory. Multiple approaches are described, some of them very invasive and involving weight-bearing structures like pedicles and facet joints. We developed a minimally invasive unilateral "keyhole fenestration" for thoracic cerebrospinal fluid (CSF) leaks. This study quantitatively investigates the necessary bone removal with special regard to weight-bearing structures for different leak types.

#### Methods

The axial and sagittal diameter of the hemilamina defects and the volume of necessary bone resection after sealing of a thoracic CSF leak via keyhole fenestration was quantified by two independent raters. The involvement of pedicles and facet joints was qualitatively rated. Demographic (age, sex, BMI, leak type) and surgical data (blood loss, surgery time, discharge after surgery) and complications were analyzed.

#### Results

Between January 2022 and June 2023, 33 patients with 34 approaches were included. 17/34 surgeries were performed for ventral leaks (Type 1), 10/34 for lateral leaks (Type 2), and 7/34 for CSF-venous fistulas (Type 3). The median diameter of the hemilamina defect was 17.8 mm in the sagittal and 15.1 mm in the axial plane, the median volume of resected bone was 1.5 cm3. Pedicles remained completely intact in 71% and were only minimally involved in 29%. Facet joints were completely uninvolved in 24%, and partly resected in 74%, one facet joint was resected completely. Median surgery time was 93 minutes, blood loss 45 ml, and discharge was 4 days after surgery. Three patients needed revision surgery: One because of an epidural hematoseroma, one because of insufficient closure of the initial ventral leak and one because of an insufficient closure of a CSF-venous fistula. No relevant and persisting morbidity occurred. Within the 10-months follow-up, no additional stabilizing surgery was necessary.

#### Conclusion

The keyhole fenestration leaves pedicles and facet joints intact in the majority of cases. The very limited, Penny-sized bone resection offers a sufficient exposure from the anterior midline to the ganglion that allows to safely reach and close all thoracic CSF leaks. However, a high level of experience in minimally invasive spine surgery and ideally spinal cord surgery is recommended.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V151

### Eine kürzere Symptomdauer hat einen positiven Einfluss auf das Outcome nach Verschluss spinaler Liquorlecks bei spontaner intrakranieller Hypotension

***Early treatment for a better outcome – The influence of timing in Spontaneous Intracranial Hypotension (SIH)***

F. Volz[1], A. El Rahal[1], K. Wolf[1], C. Fung[2], M. Shah[1], J. Beck[1]

[1]Klinik für Neurochirurgie, Uniklinik Freiburg, Freiburg i. Br., Deutschland
[2]Lindenhofspital, Neurochirurgie, Bern, Schweiz

#### Objective

In spontaneous intracranial hypotension (SIH), there is usually an acute and well-remembered onset of symptoms, with orthostatic headache often the most prominent clinical complaint. Microsurgical sealing of the responsible spinal CSF leak is an established treatment option. Several factors may have an influence the postoperative outcome, with symptom duration before adequate treatment probably the most modifiable variable.

#### Methods

In this single-center study, patients with microsurgical closure of spinal CSF leaks between September 2020 and March 2023 and a follow-up period of six months were included. Patient-reported outcome measures (PROMs) for the impact of headaches (via HIT-6) and quality of life (QoL, via EQ-5D-5L) were systematically collected preoperatively and six months after surgery. The influence of symptom duration and several non- modifiable patient characteristics (comorbidity, sex, age, Body Mass Index, type of spinal CSF leak) on these outcome measures was analyzed via multiple regression modelling and subgroup analyses for a symptom duration of below or above 90 days.

#### Results

One hundred patients (61% female, median age 43.5 years) were included. The median symptom duration before surgery was 173 days (IQR 80 -482), ranging from 9 days to 13 years. 74% had a symptom duration above 90 days. Six months after surgery, there was significant improvement of headaches (HIT-6: 66 (IQR 62-69) to 52 (IQR 40-61, $p<0.001$) and QoL (EQ-5D-5L VAS: 40 (IQR 30-60) to 79 (IQR 60-90); EQ-5D-5L Index: 0.67 (IQR 0.35-0.8) to 0.91 (IQR 0.8-0.94, $p<0.001$, respectively). Subgroup analysis for a symptom duration <90 and ≥90 days and multiple regression analysis revealed a moderate trend in favor of earlier treatment. Comparably, lower comorbidity was moderately associated with better outcome. However, even after a prolonged symptom duration and with higher comorbidity, the improvement was highly significant and clinically relevant.

#### Conclusion

The symptom duration from the onset of clinical symptoms until the correct diagnosis and adequate treatment is -up to now- the only modifiable variable in patients with SIH causes by a spinal CSF leak. As patients with shorter symptom duration show a trend for a better outcome, our results promote the rather timely diagnosis and treatment of these patients. However, a significant postoperative improvement can still be expected even after a prolonged symptom duration.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V153

### Ergebnisse einer deutschen nationalen Umfrage zur Evaluation von Frühmobilisierung gegenüber Bettruhe in der postoperativen Versorgung von inzidentiellen Durotomien während der Lumbalchirurgie.

***Results of a German national survey to assess early mobilization vs. bet rest in the postoperative management of incidental durotomy during lumbar surgery***

T. Abboud[1], P. Evangelou[1], B. Younes[1], D. Mielke[1], V. Rohde[1]

[1]Universitätsmedizin Göttingen, Nerochirurgie, Göttingen, Deutschland

#### Objective

Incidental durotomy is a prevalent and challenging complication during degenerative lumbar spinal surgeries. Despite its frequency, a standardized approach to postoperative management, specifically concerning early mobilization versus bed rest, is lacking due to the absence of robust evidence. This variability in practice underscores the necessity of evaluating current strategies. This survey aims to delineate the prevailing practices in Germany regarding the postoperative management of incidental durotomy during lumbar surgery to gauge the need for a comprehensive randomized clinical trial.

#### Methods

We conducted a digital survey titled "Postoperative Management of Accidental Durotomy in Lumbar Spine Surgery" across 119 neurosurgical departments in Germany. The survey included questions on the application of bed rest following surgery, the timing of postoperative mobilization, the factors influencing the duration of bed rest (including the complexity of surgery and the quality of dural tear repair), the role of lumbar drains in management, and the department's willingness to participate in a multicenter study on this topic.

#### Results

Out of the surveyed departments, 89 (75%) responded. The majority, 78.6%, implement bed rest in managing incidental durotomy. The decision to use bed rest varies according to the surgical complexity and the quality of dural repair, with 58.4% reporting dependency on these factors and 20.2% applying it uniformly. The duration of bed rest predominantly is 24 hours (48% of departments), followed by 72 hours (31%), and 48 hours (21%). Lumbar drains are utilized by 34% for persistent postoperative cerebrospinal fluid leaks and 36% for secondary surgical revisions, while 30% do not use them at all. Finally, 62% of departments expressed a willingness to engage in a multicenter randomized trial to explore the efficacy of bed rest in postoperative management.

#### Conclusion

The management of incidental durotomy in lumbar surgeries across German neurosurgical departments is heterogeneous, with bed rest being a common but variably applied strategy. The results highlight a significant interest in a multicenter randomized trial to clarify the benefits of bed rest, indicating a pressing need for evidence-based guidelines in this aspect of postoperative care.

# Spinal – Verschiedenes 3 | Spinal – Various 3

## V154

### Radiologische Progression und Wirbelsäulendeformität bei konservativ behandelter pyogener Spondylodiszitis: Eine monozentrische, retrospektive Analyse von MRT-Daten von 59 Patienten

***Radiographic progression and spinal deformity in conservatively treated pyogenic spondylodiscitis: A monocentric, retrospective analysis of MRI Data from 59 patients***

A. Kramer[1], J. Neuhoff[2], S. G. Thavarajasingam[1], B. Davies[3], E. Shiban[4], A. Demetriades[5], F. Ringel[1]

[1]Universitätsmedizin Mainz, Klinik mit Poliklinik für Neurochirurgie, Mainz, Deutschland
[2]Berufsgenossenschaftliche Unfallklinik Frankfurt am Main, Wirbelsäulenchirurgie und Neurotraumatologie, Frankfurt a. M., Deutschland
[3]Cambridge University Hospital, Department of Academic Neurosurgery, Cambridge, Vereinigtes Königreich
[4]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland
[5]Edinburgh University Hospitals, Department of Neurosurgery, Edinburgh, Vereinigtes Königreich

#### Objective

Pyogenic spondylodiscitis (SD) presents diverse management challenges, especially regarding the development of spinal deformity during conservative treatment. This study aims to explore the radiographic progression in conservatively treated SD, focusing on specific patterns of spinal deformities and their relationship with initial clinical and radiological factors.

#### Methods

This retrospective study analysed MRI data from 59 conservatively treated SD patients. Progression was categorised into four types based on distinct radiological features. The analysis included evaluating spinal measures like progressive deformity, translation, fractures, and fusion, and their correlation with initial radiological characteristics.

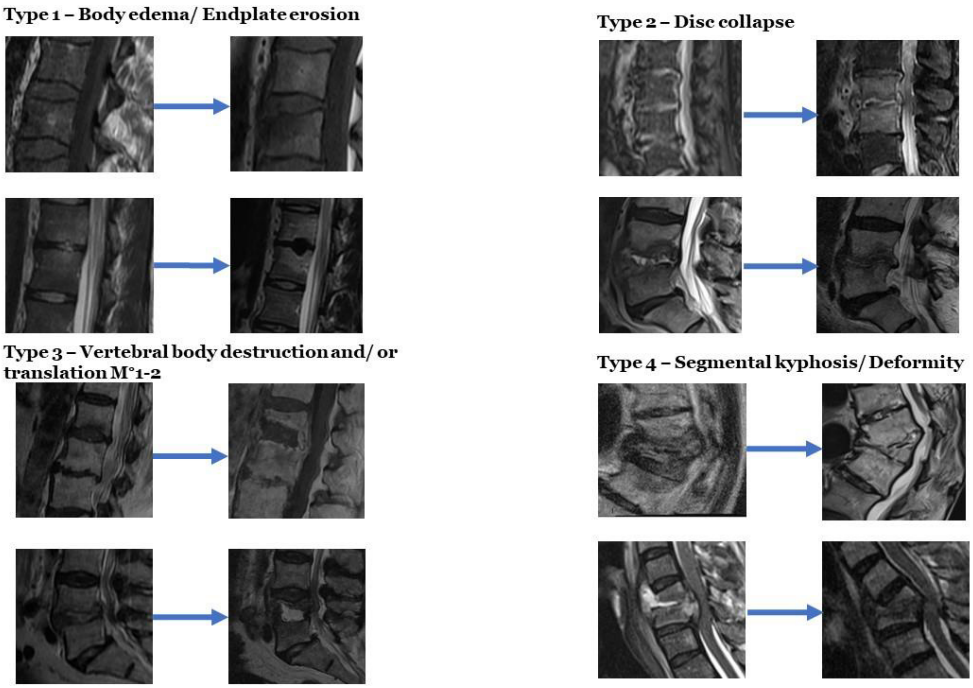
#### Results

Progressive deformity was seen in 66% of patients. Segmental kyphosis increased from 12 to 23 cases, representing a 92% increase. Segmental translation cases rose by 167%, from 3 to 8 cases. The distribution of progression types was as follows: No progression in 20 cases (34%), Type 1 (progressive vertebral body edema and/or endplate erosion) in two cases (3%), Type 2 (addition of disc collapse at follow-up) in seven cases (12%), Type 3 (vertebral body destruction and/or mild translation) in 13 cases (22%), and Type 4 (significant segmental kyphosis or severe translation) in 17 cases (29%). Lumbar region involvement was significantly associated with a reduced likelihood of spinal fusion at follow-up ($p=0.01997$). The presence of a paravertebral abscess was significantly associated with an increased risk of fractures at follow-up ($p=0.0401$).

#### Conclusion

The observed high rate of spinal deformity in conservatively treated SD, especially segmental kyphosis and significant translation, highlights the need to reconsider conservative management strategies and suggests the potential benefits of early surgical intervention in preventing these progressive deformities. Further research is needed to correlate these radiological outcomes with patient-centric measures such as pain and functional impairment, to fully understand their clinical implications and inform treatment decisions.

Abb. 1


Type 1 – Body edema/ Endplate erosion
Type 2 – Disc collapse
Type 3 – Vertebral body destruction and/ or translation M°1-2
Type 4 – Segmental kyphosis/ Deformity

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V155

### Kollagenabbauprodukte als Biomarker für die Wirksamkeit einer Behandlung mit Acetylsalicylsäure bei Patient:innen mit unrupturierten intrakraniellen Aneurysmen

***Collagen breakdown products as a biomarker for efficacy of acetylsalicylic acid treatment in patients with unruptured intracranial aneurysms***

K. Hackenberg[1], J. Dremel[1], O. Akanji[1], A. Abdulazim[1], G. Rinkel[1], N. Etminan[1]

[1]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland

#### Objective

There is an unmet need for biomarkers that permit the estimation of the structural stability (=growth or change in configuration) of unruptured intracranial aneurysms (IA). The main molecular constituent of the IA wall is type I collagen, which undergoes permanent turnover. Our previous cross-sectional study indicated that collagen breakdown products were elevated in patients with IA compared to healthy controls and also in patients with unstable IA compared to stable IA. Previous studies highlighted that acetylsalicylic acid (ASA) had a protective effect on the stability of unruptured IA. We studied if collagen breakdown products could serve as biomarkers for the efficacy of ASA treatment and IA stability in IA patients.

#### Methods

This ongoing prospective, longitudinal study included patients with unruptured IA. We determined C-telopeptide (CTx) and c-terminal telopeptide (ICTP) as breakdown products of type I collagen in venous blood at baseline, at 3, 6, 12 and 24 months. Exclusion criteria were pre-existing conditions that were associated with more collagen turnover (e.g., osteoporosis, bone metastases). T-test and ANOVA analyses were performed.

#### Results

Since 04/2022, we included 53 patients with unruptured IA. Mean age was 57.2±11.3 years, 37 (70%) were female, 20 (38%) were currently smoking, 33 (62%) had arterial hypertension. Mean IA size was 3.6±1.4mm, 51 (96%) were located in the anterior circulation, 11 (21%) were irregular in shape. Twenty-seven (51%) patients were under ASA treatment at baseline. Regarding CTx/ICTP 44/53 (83/100%) samples were analyzed at baseline, 35/48 (66/91%) at 3 and 34/46 (64/87%) at 6 months.

Mean CTx and ICTP levels according to ASA treatment are shown in Figure 1. Mean CTx levels were lower in female patients with ASA intake compared to no intake at any time point (Figure 2). There were no differences regarding ICTP levels.

#### Conclusion

Our preliminary data indicate that venous CTx levels were lower in female patients with unruptured IA and ASA intake. This finding provides molecular evidence that risk factor modification might result in stabilization of unruptured IA and that CTx may serve as a biomarker for efficacy of risk factor treatment in such patients. However, larger sample sizes and longer follow-up in relation with radiological data on IA (un)stability are needed to validate our findings.

Fig. 1: CTx (a) and ICTP (b) levels according to ASS treatment

Fig. 2: CTx levels in female (a) and male (b) patients according to ASS treatment

Abb. 1

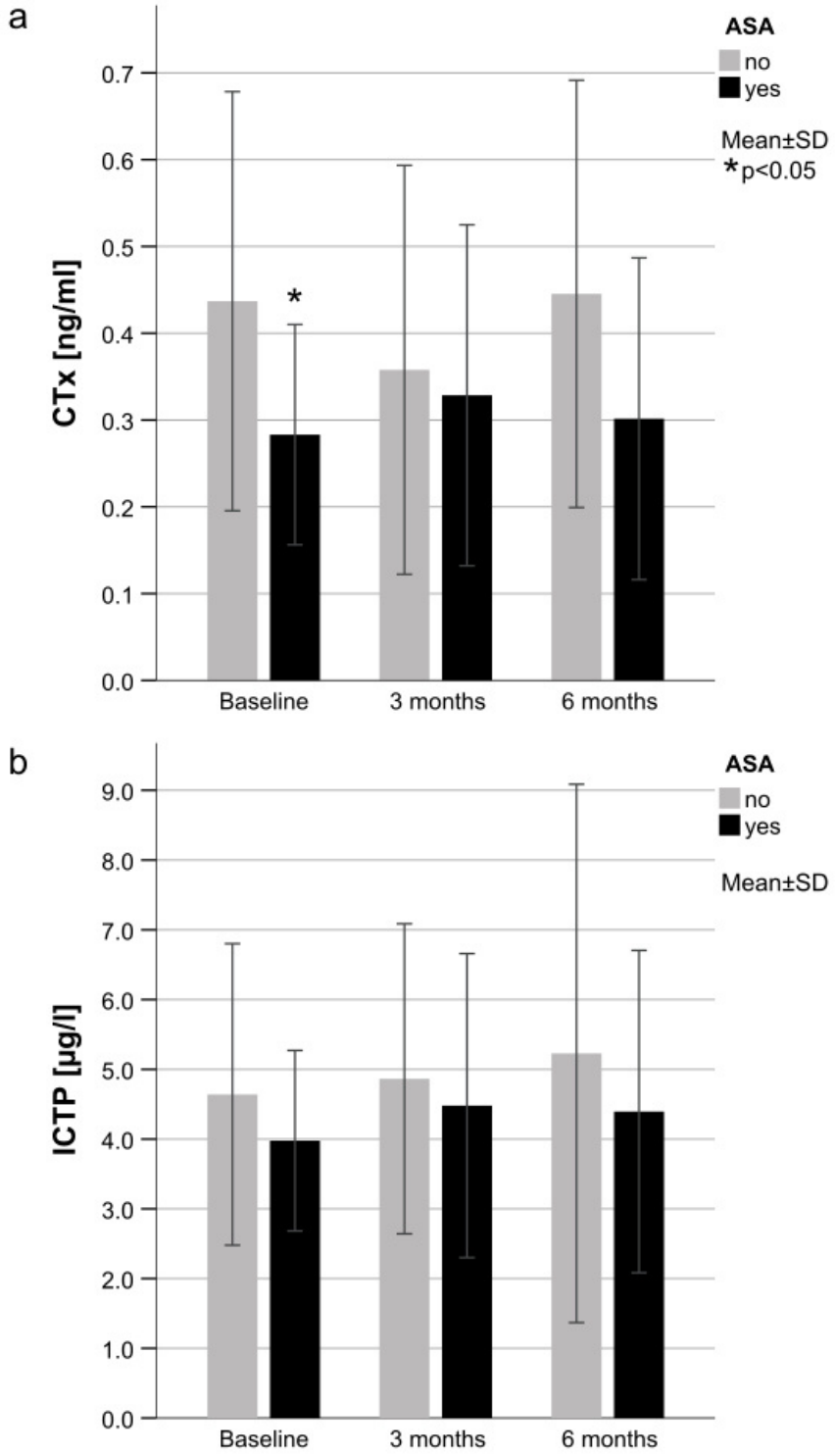
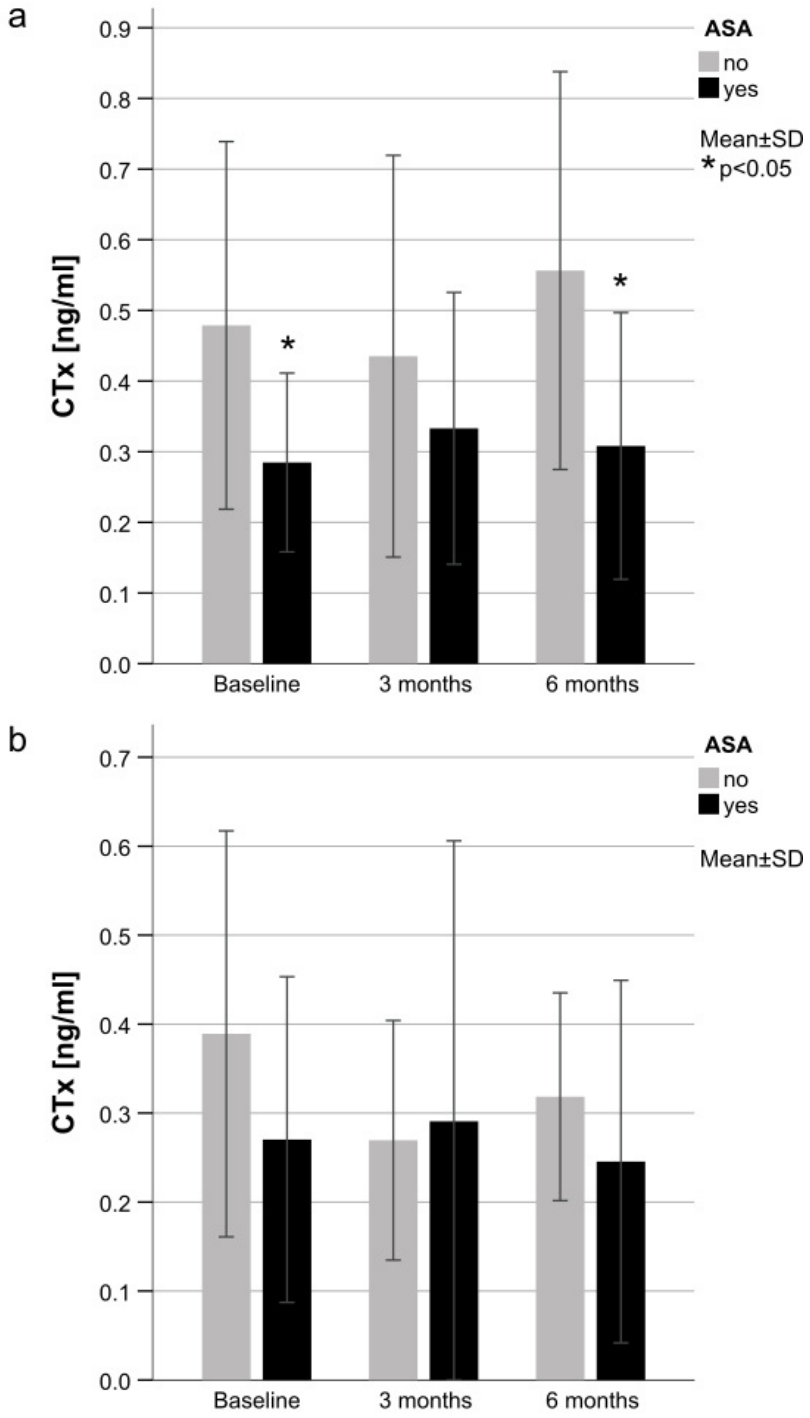


Abb. 2


a
ASA
no
yes
Mean±SD
*p<0.05
CTx [ng/ml]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
*
*
Baseline
3 months
6 months
b
ASA
no
yes
Mean±SD
CTx [ng/ml]
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Baseline
3 months
6 months

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V156

### Der natürliche Verlauf unrupturierter intrakranieller Riesenaneurysmen in Abhängigkeit von der Lokalisation des Aneurysmas - 3 Jahre Follow-up des prospektiven internationalen Giant intracranial aneurysm Registers.

***The natural course of unruptured giant intracranial aneurysms depending on aneurysm localization – 3 years follow-up of the prospective international Giant intracranial aneurysm Register***

L. Wessels[1], K. Ferdowssian[1], J. Dengler[2], S. Marbacher[3], E. Güresir[4], S. Rath[5], D. Hänggi[6], U. Sure[7], J. Beck[8], J. Hämmerli[9], P. Bijlenga[9], V. Rohde[10], L. Dührsen[11], J. Hernesniemi[12], G. Dabus[13], I. Linfante[13], M. Cenzato[14], E. Boccardi[14], M. Wostrack[15], B. Meyer[15], N. O. Schmidt[16], A. Raco[17], C. Cognard[18], M. Sames[19], A. van der Zwaan[20], W. T. Wang[21], L. Regli[22], D. Rüfenacht[23], P. Vajkoczy[24]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]HELIOS Hospital Bad Saarow, Department of Neurosurgery, Bad Sarow, Deutschland
[3]Kantonsspital Aarau, Klinik für Neurochirurgie, Aarau, Schweiz
[4]Universitätsklinikum Leipzig, Klinik für Neurochirurgie, Leipzig, Deutschland
[5]Donau Isar Kliniken Deggendorf, Klinik für Neurochirurgie, Deggendorf, Deutschland
[6]Universitätsklinikum Düsseldorf, Klinik für Neurochirurgie, Düsseldorf, Deutschland
[7]Universitätsklinikum Essen, Klinik für Neurochirurgie, Essen, Deutschland
[8]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[9]Geneva University Hospitals, Department of Neurosurgery, Geneva, Schweiz
[10]Universitätsklinikum Göttingen, Klinik für Neurochirurgie, Göttingen, Deutschland
[11]Universitätsklinkum Hamburg-Eppendorf, Klinik für Neurochirurgie, Hamburg, Deutschland
[12]University Hospital of Helsinki, Department of Neurosurgery, Helsinki, Finnland
[13]Baptist Health Medical Group, Department of Neurosurgery, Miami, FL, Vereinigte Staaten
[14]Niguarda Hospital, Department of Neurosurgery, Milano, Italien
[15]Klinikum rechts der Isar, Technische Universität München, Klinik für Neurochirurgie, München, Deutschland
[16]Universitätsklinikum Regensburg, Klinik für Neurochirurgie, Regensburg, Deutschland
[17]Universitaria Sant'Andrea, Department of Neurosurgery, Rome, Italien
[18]University of Toulouse, Department of Diagnostic and Therapeutic Neuroradiology, Toulouse, Frankreich
[19]Masaryk Hopsital, Department of Neurosurgery, Usti nad Labem, Tschechien
[20]University Medical Center Utrecht, Department of Neurosurgery, Utrecht, Niederlande
[21]Universitätsklinikum Wien, Klinik für Neurochirurgie, Wien, Österreich
[22]Universitätsklinikum Zürich, Klinik für Neurochirurgie, Zürich, Schweiz
[23]Klinkum Hirslanden, Neuroradiologie, Zürich, Schweiz
[24]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland

#### Objective

Giant intracranial aneurysms (GIA) are exceptionally rare occurrences, constituting a small fraction of intracranial aneurysms. Their infrequency poses a significant challenge to obtaining substantial empirical evidence for guiding clinical management decisions, necessitating reliance on expert opinions. This study seeks to comprehensively evaluate the clinical outcomes associated with the natural progression of GIA in various anatomical localizations.

#### Methods

In this prospective part of an international observational registry study, we investigated the natural cause of untreated patients with an unruptured GIA depending on the localization of the aneurysm.

#### Results

Between 2008 and 2018, a cohort of 79 conservatively managed patients with non-ruptured GIA were enrolled in the prospective phase of the study. An analysis of localization revealed that 17% of the aneurysms were situated in the middle cerebral artery (MCA), 46% in the internal carotid artery (ICA), 1% in the anterior cerebral

artery (ACA), and 36% in the posterior circulation. The average age of the patients was 66.6±13.5 years, with an average aneurysm size of 32.8±7.7 cm. The overall survival probability for patients with GIA three years after the index hospitalization was determined to be 62% in the cohort. Outcomes were categorized as favorable (mRS 0-2) and unfavorable (mRS 3-6). At the time of discharge from the index hospitalization, 84% of patients in the GIA cohort exhibited a favorable outcome; however, this proportion declined to 52% after three years. Notably, the three-year mortality rate was most pronounced in patients with aneurysms located in the posterior circulation and MCA regions, reaching 54%. In contrast, patients with ICA aneurysms experienced a comparatively less severe clinical course, yet they still exhibited a notable 20% mortality rate after three years.

## Conclusion

The findings of this study underscore the grave clinical trajectory experienced by patients with untreated GIA, particularly those harboring aneurysms in the posterior circulation and MCA, so treatment of GIA aneurysms should be considered in every localization.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V157

### Geschlechtsabhängige Unterschiede der Charakteristika und des Outcomes nach mikrochirurgischem Clipping von nichtrupturierten intrakraniellen Aneurysmen: Eine globale multizentrische Propensity-Score-Matched-Analyse

***Sex-dependent disparities in characteristics and outcomes following microsurgical clipping of unruptured intracranial aneurysms: A global multicenter propensity score-matched analysis***

R. Drexler[1], J. Sauvigny[1], T. Pantel[1], F. Ricklefs[1], J. Catapano[2], J. Wanebo[2], M. Lawton[2], A. Sanchin[3], N. Hecht[3], P. Vajkoczy[3], K. Raygor[4], D. Tonetti[4], A. Abla[4], K. El Naamani[5], S. Tjoumakaris[5], P. Jabbour[5], B. Jankowitz[6], M. Salem[6], J. K. Burkhardt[6], A. Wagner[7], M. Wostrack[7], J. Gempt[1], B. Meyer[7], M. Gaub[8], J. Mascitelli[8], P. Dodier[9], G. Bavinzski[9], K. Roessler[9], N. Stroh[10], M. Gmeiner[10], A. Gruber[10], E. Figueiredo[11], A. da Silva Coelho[11], A. Bervitskiy[12], E. Anisimov[12], J. Rzaev[12], H. Krenzlin[13], N. Keric[13], F. Ringel[13], D. Park[14], M. C. Kim[14], E. Marcati[15], M. Cenzato[15], M. Westphal[1], T. Sauvigny[1], L. Dührsen[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[2]St. Joseph's Hospital and Medical Center, Barrow Neurological Institute, Phoenix, AZ, Vereinigte Staaten
[3]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland
[4]University of California, Department of Neurological Surgery, San Francisco, CA, Vereinigte Staaten
[5]Thomas Jefferson University Hospital, Department of Neurological Surgery, Philadelphia, PA, Vereinigte Staaten
[6]Hospital of the University of Pennsylvania, Department of Neurosurgery, Philadelphia, PA, Vereinigte Staaten
[7]Klinikum rechts der Isar, Technical University of Munich, Department of Neurosurgery, München, Deutschland
[8]University of Texas Health Science Center, Department of Neurosurgery, San Antonio, TX, Vereinigte Staaten
[9]Medical University of Vienna, Department of Neurosurgery, Wien, Österreich
[10]Kepler University Hospital, Johannes Kepler University, Department of Neurosurgery, Linz, Österreich
[11]Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, Division of Neurological Surgery, São Paulo, Brasilien
[12]Federal Center of Neurosurgery, Novosibirsk, Russische Föderation
[13]University Hospital Mainz, Department of Neurosurgery, Mainz, Deutschland
[14]Pohang Stroke and Spine Hospital, Department of Neurosurgery, Pohang, Südkorea
[15]Grande Ospedale Metropolitano Niguarda, Department of Neurosurgery, Milan, Italien

#### Objective

Epidemiology and growth rates of aneurysms differ between the sexes; however, little is known about sex-dependent outcomes after microsurgical clipping of unruptured intracranial aneurysms (UIA). The aim of this study was to examine sex differences in characteristics and outcomes after microsurgical clipping of UIA and to perform a propensity score-matched analysis using an international, multicenter cohort.

#### Methods

Fifteen centers from four continents participated in this retrospective cohort study. Consecutive adult patients who underwent microsurgical clipping of UIA between January 2016 and December 2020 were included. Patients were stratified according to their sex and analyzed for differences in morbidities and aneurysm characteristics. Based on this, female patients were matched to male patients in a 1:1 ratio with a caliper of 0.1 using propensity score matching. Endpoints included postoperative complications, neurological performance and aneurysm occlusion at the time of discharge and 24 months after surgery.

#### Results

A total of 2245 patients with a mean age (range) of 57.3 (20-87) years were included. Female patients (n=1675; 74.6%) were significantly older (mean: 57.6 versus 56.4 years, $P = 0.03$) but had fewer comorbidities ($P = 0.003$). After propensity score matching, female patients had fewer pulmonary complications (1.4% vs. 4.2%, $P = 0.01$). However, general morbidity (24.5% versus 23.4%, $P = 0.72$) and mortality (0.5% versus 1.1%, $P = 0.34$), as well as

neurological performance ($P$ = 0.58), were comparable at the discharge of both sexes. Lastly, rates of aneurysm occlusion at the time of discharge (95.5% versus 94.9%, $P$ = 0.71) and 24 months after surgery (93.8% versus 96.1%, $P$ = 0.22) did not significantly differ between male and female patients.

## Conclusion

This international, multicenter study highlights sex-dependent differences in aneurysm characteristics in UIA patients and reports comparable outcomes after microsurgical clipping between both sexes.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V158

### Identifikation von Risikofaktoren für die Größe von unrupturierten und rupturierten intrakraniellen Aneurysmen - Ein Weg die Aneurysmagröße als Risikofaktor besser einzuordnen?

***Identification of size risk factors of unruptured and ruptured intracranial aneurysms – A way to contextualize the importance of IA size?***

T. F. Dinger[1], M. Chihi[1], M. Darkwah Oppong[1], M. Gümüs[1], C. Rieß[1], A. N. Santos[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

The size of unruptured intracranial aneurysms (UIA) remains the most crucial risk factor for treatment decisions in clinical practice. This firm reliance on size in treatment decisions ignores contradicting observations, such as the fact that there is a non-negligible proportion of unstable small UIA (risk of undertreatment) and stable large UIA (risk of overtreatment). This study aimed to identify IA-size risk factors to individually spare UIA patients from treatment risks and aneurysmal subarachnoid hemorrhage (SAH).

#### Methods

A total of 2,152 patients (=IA), with 1,002 being hospitalized for an acute aneurysmal SAH, met the inclusion criteria for this study and were therefore extracted from our institutional IA database. Different demographic, clinical, laboratory and radiographic characteristics of patients and IA were collected. In the case of multiple IA, only the largest UIA or the ruptured IA (RIA) were selected for further univariate and multivariable linear regression analysis of putative IA size risk factors. The RIA and UIA subgroup were analyzed separately, with size being a continuous variable.

#### Results

In the UIA subpopulation, the mean IA size was 8.3 mm, and in RIA 7.3 mm. Higher age ($p=0.003$) and urea level ($p<0.001$) were independently associated with increasing UIA size, whereas location at the posterior circulation ($p<0.001$), familiar intracranial aneurysms ($p<0.001$), serum potassium ($p=0.006$), and total serum protein ($p=0.019$) were related to smaller UIA size in the multivariate analysis. For RIA, a statistically significant and independent association was detected for location ($p=0.019$), gastrointestinal diseases ($p=0.042$), and levothyroxine intake ($p=0.002$).

#### Conclusion

By identifying known and new factors concerning IA size, a further step has been taken towards a more differentiated view of IA size as a basis for therapeutic decision-making. Depending on the IA's location and the patient's age and general medical condition, treatment options for IA of the same size could differ. More research is needed to verify the identified risk factors. Still, our results might help to potentially use the modifiable factors and serum markers as therapeutic and diagnostical options in the future.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V159

### Effektivität und Sicherheit von intraarteriellen Rescue Therapien in der Behandlung von refraktären verzögerten zerebralen Ischämien nach aneurysmatischer Subarachnoidalblutung

***The efficacy and safety of intraarterial rescue therapies for the management of refractory delayed cerebral ischemia after aneurysmal subarachnoid hemorrhage***

A. Abdulazim[1], N. Riemann[1], H. Roth[1], M. Heilig[1], F. Wenz[1], K. Hackenberg[1], E. Neumaier-Probst[2], C. Groden[2], M. Vergouwen[3], G. Rinkel[1,3], N. Etminan[1]

[1]Universitätsmedizin Mannheim, Klinik für Neurochirurgie, Mannheim, Deutschland
[2]Universitätsmedizin Mannheim, Abteilung für Neuroradiologie, Mannheim, Deutschland
[3]UMC Utrecht Brain Center, University Medical Center Utrecht, Department of Neurology and Neurosurgery, Utrecht, Niederlande

#### Objective

The risk benefit ratio of intraarterial rescue therapy strategies for intractable delayed cerebral ischemia (DCI) after aneurysmal subarachnoid haemorrhage (SAH) remains uncertain. We analysed the safety and efficacy of intraarterial rescue therapies.

#### Methods

A prospective cohort of 379 consecutive SAH patients admitted to our department between January 2016 and December 2022 was treated using a standardized, escalating treatment protocol in case of persistent clinical or radiological (CT perfusion impairment and/or severe angiographic vasospasm) features of DCI: 1) induced hypertension >180mmHg systolic, 2) twice solitary intraarterial nimodipine bolus applications during catheter angiography, 3) angiographic application of an intraarterial catheter for continuous nimodipine administration over 48 hours with CT Perfusion imaging in between each escalating step. Efficacy was evaluated by means of clinical (recovery of a neurological deficit) and/or radiological (resolution of a CT perfusion deficit) improvement after treatment. Safety was evaluated by means of treatment associated complications.

#### Results

Of the 379 SAH patients, 126 received at least one intraarterial nimodipine bolus application and were included in this analysis. Clinical improvement occurred in 33 (26.2%) and radiological improvement in 42 (33.3%) patients. A second intraarterial nimodipine bolus was performed in 64 (51%) patients. Of those, 15 (23%) had clinical and 30 (47%) radiological improvement after the treatment. An intraarterial catheter for continuous nimodipine administration was used in 16 (25%) among those patients. Overall, a total of 43 patients received an intraarterial catheter for continuous nimodipine administration. Clinical and/or radiological improvement was notable in 25 (58%) patients whereas in 15 (34.9%) additional intraarterial treatments were given. The rate of unfavourable outcome in patients treated by means of an intraarterial catheter was 65.1%. The overall catheter-associated complication rate was 27.9%, mainly comprising of catheter dysfunction (33.3%), catheter-associated haemorrhages (16.7%), and catheter-associated infarctions (16.7%).

#### Conclusion

Intraarterial rescue therapy for intractable DCI is associated with clinical or radiological improvement in one out of 2 to 4 patients. This beneficial effect may be offset by treatment associated complications. Matched-pair analyses are warranted to further elucidate to what degree unfavourable outcome rates are affected.

# Vaskuläre Neurochirurgie – Nicht-rupturierte Aneurysmen 2 | Vascular neurosurgery – Non-ruptured aneurysms 2

## V160

### ENTWICKLUNG EINES INTERDISZIPLINÄREN ENDOVASKULÄREN NEUROCHIRURGISCHEN AUSBILDUNGSPROGRAMMS
*Developing of an interdisciplinary endovascular neurosurgical curriculum*

A. Minasyan[1], R. Steinmeier[1], S. Brandt[2], D. Fedders[2], M. Kirsch[1]

[1]Klinikum Chemnitz, Klinik für Neurochirurgie, Chemnitz, Deutschland
[2]Klinikum Chemnitz, Institut für Radiologie und Neuroradiologie, Chemnitz, Deutschland

#### Objective

The multidisciplinary management of the neurovascular disease represents the standard of care for neurovascular pathologies. At the interface between these disciplines a new type of neurosurgeon emerges and the concept of a hybrid or endovascular neurosurgeon evolves. Currently, there is no established German-wide curriculum for training such specialists. Here, we aim to demonstrate the development of a combined neurovascular surgical and endovascular program in a German hospital.

#### Methods

We have started the endovascular training of a board-certified neurosurgeon as a cooperation between the neurosurgical and neuroradiological departments in a non-university 1700 bed hospital. Both neurosurgery and neuroradiology have a strict interdisciplinary concept for treating neurovascular diseases including a neurovascular board as well as emergency consultations of all involved departments. The departments agreed to introduce a fellowship to educate a vascular neurosurgeon in endovascular techniques. A curriculum based on the Regulation of Continued Medical Education for neuroradiologists (minimum 100 diagnostic angiograms and minimum 100 interventions) and an on-call program was designed.

#### Results

The duration of training compiled 24 months. Parallel to neurosurgical activities, the fellow was involved in most of the neuroendovascular supraaortic procedures, accounting: 400 diagnostic angiographies, 160 carotid stentings, 250 thrombectomies,. 150 interdisciplinary aneurysm, AVM, dAVF treatments and 100 middle meningeal artery embolisations.

After accomplishing of around 50% of total cases needed for neuroradiological certification the fellow was involved in on-call shifts. At the end of his fellowship, endovascular procedures were performed alone or under the mentoring of a endovascular neuroradiologist. Currently, the fellow covers the operative vascular and endovascular procedures in both Departments. Meanwhile, the next fellow has been identified and will be supported by the interdisciplinary team.

#### Conclusion

The development of an interdisciplinary endovascular neurosurgical curriculum is possible and is viable within a highly supportive interdisciplinary neurovascular team.

# Tumor – Vestibularisschwannome 2 | Tumour – Vestibular schwannomas 2

# V162

## Die Expression von MSR1 ist mit der Infiltration durch M2-Makrophagenin in Vestibularisschwannomen assoziiert sowie mit stärkerer Proliferation.

***Expression of MSR1 identifies M2 macrophages in vestibular schwannomas and is associated with higher proliferation***

L. Dörner[1], E. M. Suhm[1], V. Ries[1], V. Goncalves[2], J. Schittenhelm[3], M. Tatagiba[1], F. Behling[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]University of Porto, Faculty of Medicine, Porto, Portugal
[3]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland

### Objective

The concept of tumor associated macrophages has been applied to vestibular schwannomas, based on increasing evidence of the impact of inflammatory regulations during tumor progression. The macrophage scavenging receptor 1 (MSR1) has been linked to several pathological processes including an unfavorable prognosis in different cancers. It has become established as a tissue marker for tumor associated macrophages. While inflammation has gained increasing interest in vestibular schwannomas, the expression and distribution of MSR1 has not yet been described in vestibular schwannomas.

### Methods

We analyzed the immunohistochemical expression of MSR1 in 1272 vestibular schwannoma tissue samples. The distribution and correlation with clinical factors such as age, gender, tumor size, NF2, prior radiation, recurrent tumor status, the proliferation marker MIB1 and volumetric tumor growth. MSR1 expression was assessed using a semiquantitative score. CD163 was applied for the detection of M2 macrophages and samples were semiquantitatively scored. MIB1 expression was measured with the help of a digital quantification plugin.

### Results

MSR1 expression showed marked differences among vestibular schwannoma samples and a higher expression was significantly associated with a more extensive infiltration with M2 macrophages ($p<0.0001$). There was no difference of MSR1 expression regarding age, gender, prior radiotherapy or recurrent tumor status. NF2 associated tumors showed a lower MSR1 expression ($p=0.0005$). No association of MSR1 expression with volumetric tumor growth was observed, but with MIB1 expression ($p<0.0001$).

### Conclusion

MSR1 expression identifies M2 macrophages in vestibular schwannomas and is associated with increased proliferation expressed by MIB1.

# Tumor – Vestibularisschwannome 2 | Tumour – Vestibular schwannomas 2

## V163

### Genetischer Einfluss, individuelles genetisches Profil und zielgerichtete Behandlung bei Patienten mit NF2-assoziierten Vestibularisschwannomen

***Genetic influence, individual genetic profiling and targetable treatment in patients with NF2-associated vestibular schwannomas***

I. Gugel[1,2], R. Beschorner[3], C. Schroeder[4], M. U. Schuhmann[1,2,5], M. Tatagiba[1,2]

[1]Universitätsklinikum Tübingen, Zentrum für Neurofibromatosen, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Klinik für Neurochirurgie, Tübingen, Deutschland
[3]Universitätsklinikum Tübingen, Abteilung für Neuropathologie, Tübingen, Deutschland
[4]Universitätsklinikum Tübingen, Institut für Medizinische Genetik und Angewandte Genomik, Tübingen, Deutschland
[5]Universitätsklinikum Tübingen, Sektion Pädiatrische Neurochirurgie, Tübingen, Deutschland

#### Objective

To investigate the relationship between genetic alterations (*NF2* mutation type, VEGF expression, etc.) and clinical parameters (growth rate, hearing status, tumor load) in primary operated vestibular schwannomas (VS) in patients with neurofibromatosis Type 2 (NF2) related schwannomatosis. The response of the therapy (surgery, bevacizumab) as well as possible novel genes and pathways that can be individually targeted will also be investigated.

#### Methods

16 operated tumors in 8 NF2 patients with detailed long-term follow-up data (3D-volumes, pure-tone, and speech audiometry, auditory evoked potentials) and clinical parameters (e. g. tumor load) as well as their *NF2* mutation type were included. 3D volumetric data sets were used, and the growth rate was calculated by a linear regression model. After DNA isolation of paraffin-embedded samples, whole-exome sequencing (WES) was performed for all tumors. Signaling pathway analysis was completed to assess response to treatment and to identify potential targeted genes and/or pathways.

#### Results

The mean age at the time of diagnosis was 11± 5 (range 1-16) years and at the time of first surgery was 17± 4 (range 11-23) years. All tumors received (externally) off-label bevacizumab treatment before or after surgery with an initial dose of 5 mg/kg body weight every 2 weeks and adaptive dose reduction if radiological and clinical response was positive. Three tumors were operated on multiple times at different treatment intervals (with and without bevacizumab). A total of approximately 400 datasets of 3D volumetry and hearing parameters were collected and included. Patients with concomitant spinal ependymomas showed faster VS growth rates compared to patients with associated peripheral nerve schwannomas with lower VS growth rates. Six patients had truncating mutations (frameshift or nonsense) and two patients exhibited deletions of the *NF2 gene*.

#### Conclusion

The response of neoadjuvant or adjuvant bevacizumab treatment for the treatment of NF2-associated VS is heterogeneous, worse in surgically reduced (small) tumors, and in young patients. Spinal tumor load appears to have a stronger negative influence on VS growth rate than the protective positive influence of peripheral tumor load. WES analysis in primary operated tumors seems to be an opportunity for individualized targeted treatment, which can be validated and simulated in vitro models.

# Tumor – Vestibularisschwannome 2 | Tumour – Vestibular schwannomas 2

## V164

### Hohe prognostische Bedeutung der präoperativen FDG-PET-Aufnahme und des MIB-1-Index bei MPNST-Tumoren mit und ohne Assoziation zur NF1-Erkrankung.

***High prognostic impact of preoperative FDG PET uptake and MIB-1 index in MPNST tumors with and without association to NF1 disease***

I. Gugel[1,2], J. Tellermann[2,3], H. Dittmann[4], K. Nikolaou[5], J. F. Schäfer[5], M. Tatagiba[1,2], M. U. Schuhmann[1,2,3], J. Zipfel[1,2,3,6]

[1]Universitätsklinikum Tübingen, Zentrum für Neurofibromatosen, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Klinik für Neurochirurgie, Tübingen, Deutschland
[3]Universitätsklinikum Tübingen, Sektion Pädiatrische Neurochirurgie, Tübingen, Deutschland
[4]Universitätsklinikum Tübingen, Nuklearmedizin und Klinische Molekulare Bildgebung, Tübingen, Deutschland
[5]Universitätsklinikum Tübingen, Abteilung für Diagnostische und Interventionelle Radiologie, Tübingen, Deutschland
[6]BC Children's Hospital, University of British Columbia, Division of Pediatric Neurosurgery, Vancouver, Kanada

#### Objective

This retrospective observational study aimed to investigate the perioperative outcome in Malignant Peripheral Nerve Sheath Tumors (MPNST) with and without relation to Neurofibromatosis Type 1 (NF1) and to detect possible prognostic factors.

#### Methods

We retrospectively reviewed 37 operated MPNST in 33 patients. Patient, tumor, and treatment characteristics were evaluated to identify prognostic variables.

#### Results

Patients with NF1 were younger at the time of surgery (mean age: 29±13, 8-54 years) compared to sporadic cases (mean age: 45±13, 24-67 years) and exhibited larger tumor volumes (mean 299 vs. 18cm3). Most tumors were located in the facial/cervical/neck area (34%, n=12), followed by the trunk (31%, n=11), lower extremity (17%, n=6), upper extremity (14%, n=5) and intraspinal (3%, n=1). NF1-associated MPNST appeared predominantly on the trunk (39%) and sporadic in the facial/cervical/neck area (50%). R0 resection was possible in 66% and improvement or stability of function was achieved in most cases (motor 69%, sensory 74%) as well as a decrease in pain intensity (63%). In 12 cases with available 18F-fluorodeoxyglucose (FDG) PET, the mean preoperative standardized uptake value (SUV) (9.8±7.2) positively correlated with the mean maximum MIB-1 index (34±26%, *p=.005*), and the mean preoperative tumor volume (474.7±686.3cm3, *p=.047*). High-grade tumors exhibited more severe pain scores (median VRS scale 2, *p=.002*) and larger preoperative tumor volumes (mean 20.36cm3) compared to low-grade tumors (median VRS scale 0.5, mean vol 8cm3). Sporadic MPNST located at the head/facial/brachial plexus and upper extremities exhibited better preoperative functions compared to those on the lower extremities.

#### Conclusion

Early inclusion of PET diagnostics in clinical routine, especially for patients with NF1, is prognostically relevant. Surgery can improve symptoms, particularly medication-resistant pain, and should also be considered in advanced disease for symptom control/improvement.

# Tumor – Vestibularisschwannome 2 | Tumour – Vestibular schwannomas 2

## V166

### Die Aufweitung des inneren Gehörgangs bei Vestibularisschwannomen ist mit einem schlechten präoperativen Hörvermögen verbunden, unabhängig von der präoeprativen Tumorgröße.

***Widening of the internal acoustic meatus is a factor for poor preoperative hearing in vestibular schwannoma independent of preaoperative tumor size***

L. Dörner[1], J. Schittenhelm[2], V. Goncalves[3], E. M. Suhm[1], V. Ries[1], M. Tatagiba[1], F. Behling[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland
[3]University of Porto, Faculty of Medicine, Porto, Portugal

#### Objective

Preoperative hearing function shows wide variations among patients diagnosed with vestibular schwannoma. Although tumor size seems to be of importance other factors influencing hearing function are frequently discussed.

#### Methods

We analyzed clinical factors, imaging data and the expression of the proliferation marker MIB1 as potential influencing fators on the preoperative hearing function in a retrospective cohort of 523 primary sporadic vestibular schwannomas. Audiomoetry results were quantified applying the Gardner-Robertson Score. Uni- and multivariate analyses were performed.

#### Results

A Gardner-Robertson Score of 1 or 2 was documented in 391 cases (74.8%). Factors associated with a poor preoperative hearing function were patient age over 55.5 years ($p<0.0001$), a preoperative tumor volume larger than 6.57 cm3 ($p=0.0005$), widening of the internal acoustic meatus by over 1.2 mm compared to the healthy side ($p=0.0072$). In the multivariate analysis increased age ($p<0.0001$), larger tumor volume ($p=0.0001$) and widening of the internal acoustic meatus ($p=0.0111$) were independent factors associated with poor preoperative hearing. MIB1 expression was not significant in the univariate or multivariate analysis.

#### Conclusion

Poor preoperative hearing function in patients diagnsoed with vestibular schwannoma is associated with widening of the internal acoustic meatus independent of age and tumor size.

# Periphere Nerven | Peripheral Nerves

## V167

### Vorstellung der aktualisierten S3-Leitlinie "Behandlung von peripheren Nervenverletzungen
*Presentation of the updated S3 guideline 'Treatment of peripheral nerve injuries'*

N. Dengler[1], M. T. Pedro[2], C. Heinen[3], T. Kretschmer[4], J. Frank[5], C. Dumont[6], P. Pöschl[7], A. Grimm[8], D. Schwarz[9], S. Tafelski[10], J. Kolbenschlag[11], R. Ahmadi[12], K. Schwerdtfeger[13], L. Harhaus[14]

[1]Brandenburg Medical School Theodor Fontane, Faculty of Health Sciences Brandenburg, Bad Saarow, Deutschland
[2]BKH Günzburg at Ulm University, Peripheral Nerve Unit, Department of Neurosurgery, Günzburg, Deutschland
[3]Christian Hospital Quakenbrück GmbH, Periphere Nerven Unit Nord, Osnabrück, Deutschland
[4]Klagenfurt Hospital KABEG, Department of Neurosurgery & Neurorestoration, Klagenfurt, Österreich
[5]University Hospital Frankfurt a.M., Department of trauma-, hand- and reconstructive surgery, Frankfurt a. M., Deutschland
[6]Kassel Hospital, Department of trauma and orthopedic surgery, Kassel, Deutschland
[7]Practice of Neurology Sinzing, Sinzing b. Regensburg, Deutschland
[8]University Hospital Tübingen, Department of Neurology, Tübingen, Deutschland
[9]Heidelberg University, Department of Neuroradiology, Heidelberg, Deutschland
[10]Charité – Universitätsmedizin Berlin, Department of Anesthesiology and Intensive Care Medicine, Berlin, Deutschland
[11]BG Clinic Tübingen, Tübingen University, Department of hand, plastic, reconstructive, and burn surgery, Tübingen, Deutschland
[12]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[13]University of Saarlandes, Department of Neurosurgery, Homburg a. d. Saar, Deutschland
[14]BG Clinic Ludwigshafen and Heidelberg University, Department of hand & peripheral nerve surgery & rehabilitation, Ludwigshafen, Deutschland

#### Objective

Uncertainty about adequate diagnosis and treatment leads to a wide variation in the quality of care for patients with peripheral nerve injuries. The aim of the AWMF S3 guideline 'Treatment of peripheral nerve injuries' (first published June 20, 2013) is to provide reliable and generally accepted definitions of what is necessary and appropriate in prevention, diagnosis and treatment. The current update of the S3 guideline 'Treatment of peripheral nerve injuries' is being led by 5 specialist medical societies (DGNC, DGPRÄC, DGN, DGKOU and DGH) and coordinated by DGPRÄC and DGNC.

#### Methods

By systematic literature review and consensus in an interdisciplinary panel of experts, seven PICO questions as well as statements and recommendations with explanatory background texts were developed.

#### Results

Six out of the seven PICO questions were addressed using quantitative systematic literature research. The working group agreed on six statements and 59 recommendations as part of the nominal group process and justified them on the basis of current studies. Significant innovations were implemented in the chapters on epidemiology in the area of war injuries, iatrogenic nerve damage and nerve injuries in children. Diagnostically, the relevance of MR neurography has been taken into account and in the area of therapy, reference has been made to the increasing availability of positive studies on the use of nerve transfers. The existing chapter on pain treatment has been expanded, particularly in the areas of 'neuromas' and "neuromodulation", based on current studies.

#### Conclusion

The updated version was agreed by the working group, approved by the medical societies and submitted to the AWMF on time. To reduce uncertainties in the diagnosis and treatment of nerve injuries and improve the quality of treatment the guideline will be made publically available on the AWMF website.

# Periphere Nerven | Peripheral Nerves

## V168

### Die Bedeutung der Gebrechlichkeit bei neurochirurgisch behandelbaren Erkrankungen der peripheren Nerven: eine landesweite Beobachtungsstudie aus einem großen Krankenhausverbund

***The relevance of frailty in neurosurgically treatable diseases of peripheral nerves: A nationwide observational study from a large hospital network***

H. Gheewala[1,2], G. Rico-Gonzalez[1,2], H. von Riegen[1,2], R. Kuhlen[3], J. Dengler[1,2], S. Hohenstein[4], A. Bollmann[5], N. Dengler[1,2]

[1]Medical School Theodor Fontane, Faculty of Health Sciences Brandenburg, Bad Saarow, Deutschland
[2]HELIOS Hospital Bad Saarow, Department of Neurosurgery, Bad Saarow, Deutschland
[3]HELIOS Health GmbH, Berlin, Deutschland
[4]Real World Evidence & Health Technology Assessment, Helios Health Institute, Berlin, Deutschland
[5]University of Leipzig, Heart Centre Leipzig, Department of Electrophysiology, Leipzig, Deutschland

#### Objective

In many neurosurgically treatable diseases, frailty is associated with pronounced disease progression and poorer treatment outcomes. The COVID-19 pandemic led to an increase in frailty among the general population. The impact of frailty on neurosurgically treatable diseases of peripheral nerves (PN) has never been studied before. Our study presents the first German-wide analysis of the impact of frailty on patients with four diseases of PN: Meralgia paresthetica (MP), benign nerve tumors (BNT), lesions of the brachial plexus (BP), and ulnar neuropathy (UN).

#### Methods

Administrative Data from a German-wide network of 76 hospitals was retrospectively analyzed comparing the prepandemic (January 1, 2016 – December 31, 2019) vs. the pandemic phase (January 1, 2020 – December 31, 2022). Patients hospitalized for MP (G57.1), BNT (D36.1), lesions of BP (G54.0), and UN (G66.2) were included. Frailty was categorized according to the Hospital Frailty Risk Score (HFRS), as follows: low (HFRS <5 points), medium (5-15 points), and high (>15 points). Ethical approval was granted by the local ethics comittee (490/20-ek).

#### Results

A total of 8,992 patients were included in the study (prepandemic n=5,918, pandemic n=3,074). Daily admission rates decreased during the pandemic among all of the four entities: MP (0.6 to 0.3 [p<0.01], BNT (0.8 to 0.7, [p=0.05]), lesion of BP (0.9 to 0.7 [p<0.01]), and UN (1.9 to 1.2 [p<0.01], respectively. For MP, the rate of patients with medium frailty increased from 16.5 to 26.7% (p<0.01) during the pandemic phase compared with the prepandemic phase. Concordantly, the rates of patients with low frailty decreased from 82.2 to 71.0% (p=0.3). For BNT, lesion of BP, and UN, the overall rate of frail patients were lower and no change of HFRS between the pre- and pandemic phase were observed. Type of surgery did not change comparing the two phases. A reduction in length of hospital stay between pre- and pandemic phase was observed for BNT (4.6 ±4.7 vs. 3.7 ±3.4 days [p<0.01]), for lesions of BP (4.5 ±4.3 vs. 5.1 ±4.0 days [p>0.01], and for UN (2.4 ±2.3 vs. 1.9 ±3.4 days [p<0.01]).

#### Conclusion

Daily admission rates of patients with PN diseases decreased during the COVID-19 pandemic in Germany. Among these, MP patients had the highest frailty scores with an increase during the pandemic phase. In all entities but MP, the pandemic led to a reduction in lenght of hospital stay. Our data shows for the first time, that frailty has an impact on patients treated for MP.

# Periphere Nerven | Peripheral Nerves

## V169

### Prediktive Parameter für ein Patienten relevantes Outcome nach Operation bei Karpaltunnel-Syndrom
*Predictive parameters of patients' relevant outcome following surgery for carpal tunnel syndrome*

J. Bauer[1], C. Ewald[1], E. Scholz[1], A. Weber[1]

[1]Universitätsklinikum Brandenburg an der Havel, Klinik für Neurochirurgie, Brandenburg an der Havel, Deutschland

#### Objective

The most common nerve entrapment syndrome is carpal tunnel syndrome (CTS). Clinical and instrumental findings are necessary to diagnose CTS. Decompression of the median nerve is recommended when conservative treatments fail. Although surgery is most beneficial, it may not lead to a favorable outcome for some patients. Therefore, a prospective study was conducted to examine prognostic factors for outcome following decompression surgery.

#### Methods

102 wrists were prospectively observed. Clinical, electrophysiologic, and neuro sonographic findings and self-reported scores were compiled 2 months before and 3 months after decompression. Parameters were compared to assess general changes. Two groups were identified with good and poor outcome based on self-reported symptom severity (SSS) and functional status scores (FSS). Data were analyzed using either student's t-test or Mann-Whitney U-test. To identify predictive parameters regression analyses were performed. Significant parameters were evaluated to determine cut-off values using ROC-curves.

#### Results

The follow-up revealed improved SSS and FSS. Examinations demonstrate improvement in nerve conduction and swelling of the median nerve. Multivariate regression indicated that diabetes mellitus, SSS and positive Phalen's sign were predictors of relative decrease in symptom severity. Whereas the age group and FSS have an impact on relative improvement of functional status. Logistic regression showed a good outcome for patients younger than 50 years, without diabetes mellitus and with high preoperative SSS. For a SSS of 3.2 or higher, surgery could be recommended. When considering functional status, only a high preoperative FSS predicted a good outcome. Therefore, a cut-off value of at least 2.6 is recommended.

#### Conclusion

Analyses demonstrated that decompression resulted in physiological benefits. However, the study was unable to identify multiple predictive parameters. Results indicated that patients over 50 years and those with diabetes mellitus had a higher risk of receiving inadequate benefit from surgery. However, self-reported SSS and FSS are necessary to provide professional consultations.

# Periphere Nerven | Peripheral Nerves

## V170 | BO-08

### Chirurgische Therapie entzündlicher peripherer Nervenkonstriktionen – Ergebnisse nach (intraneuraler) Neurolyse ohne Transplantation

***Surgical treatment of inflammatory peripheral nerve entwinement – Results after (intraneural) neurolysis without nerve transplantation***

H. Hurth[1], J. Kegele[1,2], N. Winter[2], A. Grimm[2], M. Tatagiba[1], M. U. Schuhmann[1]

[1]Universitätsklinikum Tübingen, Neurochirurgie, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Neurologie, Tübingen, Deutschland

#### Objective

Inflammatory processes with subsequent stricture formation may be responsible for poor clinical outcome of motor function following peripheral nerve inflammation such as neuralgic amyotrophy. The aim of this study was to investigate clinical and intraoperative findings in patients with surgically treated peripheral nerve entwinement.

#### Methods

In a retrospective analysis from 2015-2023, 17 nerve constrictions in 14 patients were surgically treated after sonographic diagnosis and included in this analysis. Clinical and diagnostic findings before and after surgery were assessed and the type of surgical procedure was evaluated.

#### Results

All patients underwent preoperative high-resolution neurosonography, which revealed the presence of a nerve stricture/entwinement. The mean patient age was 53 (±10.5) years. 64.3% of the patients were male, 35.7% were female. The stricture was located in 35.3% (n=6) each at the median and radial nerve, in 17.6% (n=3) at the musculocutaneous nerve and in 11.8% (n=2) at the suprascapular nerve. Neurolysis with epi- and perineurectomy was performed in 53.0% (n=9), epineurectomy in 23.5% (n=4) and neurolysis in 23.5% (n=4). No patient underwent transplantation. In 2 cases no clear constriction was identified intraoperatively. A high-grade paresis (M0-3) was present preoperatively in 88.2% (n=15), postoperatively in 23.5% (n=4); 11.8% (n=2) showed no clinical improvement. Surgery was performed M=6.5 months after symptom onset, the last follow-up was held M=5.5 months postoperatively. There was a significant correlation between type of surgical procedure and degree of postoperative paresis with better results after more aggressive procedures (epi-&perineurectomy > epineurectomy > neurolysis, *r=0.73, p=0.007*), but not between preoperative clinical status and type of surgery. There was no correlation between the extent of paresis and the location of the lesion.

#### Conclusion

A reliable diagnosis of peripheral nerve entwinement has only been possible since the establishment of high-resolution neurosonography. Our data show that sonography-guided intraneural neurolysis of the entwinement leads to good clinical results. Perineural neurolysis, on the other hand, often appears to be insufficient. The outcome results shown are comparable with literature reports, which have always included cases undergoing nerve transplantation. Transplantation might not be required if intraneural neurolysis with epi- and perineurectomy is performed.

# Periphere Nerven | Peripheral Nerves

## V171

### Verbesserung der Lebensqualität von Fazialisparese Patienten: FACE-Q® Evaluation der funktionellen Reanimation und Resymmetrisierung des gelähmten Gesichts von 66 Patienten.

***Improving facial palsy-specific quality of life: FACE-Q® evaluation of peripheral nerve reconstruction and facial re-symmetization in 66 patients***

R. Schäfer[1], M. Tatagiba[2], H. Lauer[3], A. Daigeler[3], K. Machetanz[2]

[1]HELIOS Dr. Horst Schmidt Kliniken Wiesbaden, Plastische, Rekonstruktive und Ästhetische Chirurgie, Wiesbaden, Deutschland
[2]Universitätsklinikum Tübingen, Department für Neurochirurgie und Neurotechnologie, Tübingen, Deutschland
[3]BG Klinik Tübingen, Hand-, Plastische, Rekonstruktive und Verbrennungschirurgie, Tübingen, Deutschland

#### Objective

Facial palsy – idiopathic, infectious or iatrogenic due to neurosurgical or ENT procedures – is the most frequent of cranial nerve lesion. Associated functional and aesthetic deficits impair the quality of life of patients. To determine treatment and outcome in our tertiary multidisciplinary facial nerve center, a retrospective observational study was performed of all patients treated between 2019 to 2023.

#### Methods

Observer-based analysis of facial function according to the House-Brackmann score (H&B) was compared to facial palsy-specific patient reported outcome measures (PROM) of the FACE-Q scale. Descriptive statistics for all measures were analyzed and correlations were calculated to compare facial palsy-specific instruments, as well as observer-based grading.

#### Results

In total, 66 patients (80% female, median age 50 years) with acute and chronic facial palsy were included. A severe palsy (H&B °V-VI) was recorded in 51% while moderate palsy (H&B °III-IV) was treated in 29%. Etiology of palsy was iatrogenic (i.e., after vestibular schwannoma resection) in 68% of cases, further etiologies were neurofibromatosis, idiopathic palsy, cavernomas and meningeomas. Twenty-six peripheral nerve transfers were conducted and 25 cases combined with ancillary symmetrizing static procedures. Reconstructing the motor unit by functional muscle transfer was required in seven cases. Revisions of three cases were due to unfavorable lid chains. Patient satisfaction was highest in patients receiving invasive treatment for mild palsy (H&B ° I-II), followed by patients with severe impairment (H&B °V-VI). PROM of social function and satisfaction was lowest in the moderate palsy group despite improvements in smiling and eating distress functional scores.

#### Conclusion

Peripheral facial nerve surgery alongside adjacent symmetrizing procedures prove to be enhancing muscular, social and psychological function, highly influencing quality of life for patients with all severities of paralysis. To fully assess the burden of disease of facial palsy patients, validated disease-specific assessment should be applied in addition to standardized observer-based ratings. Patients treated for mild paralysis achieved highest satisfaction scores by supercharging end-to-side nerve transfer and aesthetic eyelid procedures. All functions need to be considered in reconstructing, reanimating and re-symmetrizing the paralyzed face.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## V172

### Inzidenz und klinisches Management von Überdrainagen bei Kindern mit modernen Gravitations-Ventilen
*Incidence and management of overdrainage in pediatric hydrocephalus patients with modern gravitational Shunt-Valves*

H. C. Bock[1], F. Knerlich-Lukoschus[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Schwerpunkt Kinderneurochirurgie, Göttingen, Deutschland

#### Objective

CSF-overdrainage (OD) might become visible in short- or long-time Shunt-treatment with a variety of clinical symptoms or radiographic findings ranging from mild postural headaches to chronic hygroma or even acute subdural hematoma. Modern shunt valves prevent the siphoning-effect with anti-siphon-devices and gravitational units have fundamental influence on the current standards of modern CSF-valve technology. Even though OD may also occur despite the upfront use of those prophylactic technologies. The aim of this study is to determine incidence and clinical management of OD in pediatric hydrocephalus patients treated with modern gravitational valve shunts.

#### Methods

Using our institutional pediatric Hydrocephalus & Shunt Registry providing more than 700 individual shunt histories of varying hydrocephalus etiology, we analyzed clinical course of all patients who were equipped with gravitational valves right from the start. Initial valve-type and pressure level settings as well as all subsequent pressure level adjustments or surgical valve-type alterations were analyzed corresponding to clinical and neuroimaging findings. The inclusion criteria were initial use of a gravitational valve and complete institutional ventricular CSF-shunt history and follow up.

#### Results

223 patients met the inclusion criteria with a mean follow-up of 5.6 years. Patients were initially equipped with programmable differential pressure valve and a fixed-pressure gravitational unit (N=40) or a fixed differential pressure valve with a programmable gravitational unit (N=183). During entire follow-up, 72 patients (32%) developed clinical and/or radiographic signs of OD, which were effectively manageable by pressure level adjustments alone in 82% and surgical intervention in 18% of the cases.

#### Conclusion

Long-term follow-up monitoring of shunt-treated pediatric patients reveals a not negligible incidence of OD even though the shunt system is already equipped with a preventive gravitational unit. For the majority of these cases pressure level adjustments are capable to counteract corresponding clinical symptoms and radiographic signs, for a small number of cases with unsatisfactory adjustment-effect or technical dysfunction of the programmable unit, individual decision making for surgical revision of the differential- or the gravitational pressure unit is necessary.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## V173

### Expressionsprofile von Erythropoietin (EPO) und seinem Rezeptor EPOR in Neuroplakoden im fetalen Entwicklungsverlauf in einem Retinol-induzierten Myelomeningozelen(mmc)-Modell der Ratte.

***Fetal expression profiles of Erythropoietin (EPO) and its receptor (EPOR) in the neuroplacodes in a retinoic acid-induced myelomeningocele rat model***

I. Manczuk[1], F. Knerlich-Lukoschus[2], D. Hellmold[1], J. Cluever[1], M. Synowitz[1], J. Held-Feindt[1]

[1]UK-SH Campus Kiel, Neurochirurgie, Kiel, Deutschland
[2]UMG, Neurochirurgie Schwerpunkt Kinderneurochirurgie, Göttingen, Deutschland

#### Objective

Molecular targets for specifically stabilizing and improving the clinical course and outcome after fetal or postnatal mmc-repair surgeries are still lacking. Recently specific pro-inflammatory cytokine expression has been demonstrated in fetal and perinatal neuroplacodes in a retinoic acid-induced mmc rat model. To address the neuroprotective aspect as well, we now investigated the expression profiles of the cytokine effector/receptor-pair EPO and EPOR.

#### Methods

Time-dated Sprague-Dawley rats received all-trans retinoic acid (RA; 60 mg/kg) at E10. Control animals received olive oil only. Neuroplacodes and control lumbosacral spinal cord (sc) segments were isolated on fetal days E16, E18, and E22, and prepared for further investigations. EPO, EPOR, HIF1a, HIF2a, and standard cellular markers (GFAP, Nestin, NeuN, beta-III-Tubulin, and others) were investigated by real-time RT-PCR. To evaluate the cellular and anatomical expression patterns, immunohistochemical (IHC) procedures were applied.

#### Results

EPOR- and HIF2a-mRNA expression was elevated on day E16, E18 (EPOR: $p < 0.5$), and E22 (EPOR: $p < 0.05$; HIF2a $p < 0.5$) in mmc- compared to sc-control-tissue. EPO and HIF1a were expressed on equal mRNA levels in mmc- and sc-tissue. On days E16 and E18, EPOR-mRNA-expression intercorrelated with GFAP ($r > 0.95$). On E18 EPOR-mRNA intercorrelated also with BLBP-($r = 0.95$), Nestin-($r = 0.98$), and Musashi-($r = 0.95$)mRNA expression. IHC revealed co-staining of EPOR and EPO with HIF1a, HIF2a, Musashi1, and neuronal markers predominately in the ventral horn and central canal in neuroplacodes of all investigated time points.

#### Conclusion

Our studies identified elevated EPOR-mRNA expression in mmc-placodes throughout the investigated fetal time-course (E16 to E22). Co-staining of EPOR with neuronal markers in the ventral horn and Musashi1 in the central canal suggests that EPO-application may provide neuroprotective effects in the treatment of open spinal dysraphism. Along with our previous findings, a combination therapy consisting of anti-inflammatory and neuroprotective agents may serve as an adjuvant to the surgical mmc-repair to prevent subsequent complications like loss of motor function and development of tethered-cod-associated problems.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## V174

### Schädelwachstum bei Plagiozephalie-Patienten unter Helmtherapie
*Skull growth in plagiocephaly patients undergoing helmet therapy*

M. Lindemann[1], S. Borowski[2], N. Aboud[1], P. Huppke[2], C. Senft[1], P. Baumgarten[1]

[1]University Hospital Jena, Friedrich Schiller University, Department of Neurosurgery, Jena, Deutschland
[2]University Hospital Jena, Friedrich Schiller University, Department of Pediatric Neurology, Jena, Deutschland

#### Objective

MRI examinations are recommended for patients with microcephaly or when there´s a percentile escape during period of head growth. However, there remains uncertainty regarding its necessity. MRIs require sedation up to a specific age, which may potentially result in learning disorders.

Helmet treatment is a worldwide acknowledged method to improve motor function, quality of life and aesthetics in patients with plagiocephaly and endoscopically treated craniosynostosis patients.

The objective of this study is to assess microcephaly and percentile escape in head circumference in newborns receiving helmet therapy (HMT) for plagiocephaly.

#### Methods

290 patients between 1 and 17 months of age with diagnosed plagiocephaly were included into the study. All patients underwent HMT over 128 days on average (SD=83.48), with 3D scans (Rodin4D neo) taken of their heads before, during and after the treatment. 8 participants have been excluded owing to insufficient data. Ten patients were excluded due to either diagnosed craniosynostosis or discontinuation of helmet therapy.

The "German Health Interview and Examination Survey for Children and Adolescents" (KiGGS study) served as reference for the assessment of head circumference growth among boys and girls aged 4 to 30 months. The percentiles were calculated using the LMS-method.

#### Results

Out of 272 patients (94 females, 178 males), 238 had suitable parameters for the LMS-method. Four of the participants were born prematurely. The average age at the onset of therapy was 5.58 (SD=2.38) months, concluding at 9.78 months (SD=3.48). The median percentile before HMT was 50.00 (SD=39.57), which decreased significantly to 25.00 (SD=33.84) after HMT ($p<.001$). Only 61 patients showed percentile adherence during the treatment. The mean difference in head circumference was 21.51mm (SD=14.81), ranging from -44.40mm to 69.10mm. The clinical examination data revealed that the patients exhibit developmental progress consistent with their respective ages.

#### Conclusion

Based on our results, a significant decrease in head circumferential growth was observed following HMT. Even though patients did not show clinical signs of raised ICP, to ascertain the clinical relevance of this percentile escape, conducting longer follow-ups involving a larger cohort of patients is crucial.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## V175

### Aktueller Stand der Erfahrungen des neu eingerichteten multidisziplinären Zentrums für den Laparotomie-assistierten fetoskopischen 3-schichtigen Spina-bifida-Verschluss: die ersten 20 Fälle

***Update on the experiences of the new established multidisciplinary center for laparotomy-assisted fetoscopic 3-layer spina bifida repair: The first 20 cases***

B. Saß[1], C. Keil[2], I. Bedei[3], M. Pojskic[1], M. Gjorgjevski[1], R. Axt-Fliedner[3], S. Köhler[2], C. Nimsky[1]

[1]UKGM Marburg, Neurochirurgie, Marburg, Deutschland
[2]UKGM Marburg, Zentrum f. pränatale Medizin und fetale Therapie, Marburg, Deutschland
[3]Universitätskliniken Gießen und Marburg, Zentrum f. pränatale Medizin und fetale Therapie, Gießen, Deutschland

#### Objective

According to the Management of Myelomeningocele Study (MOMS), intrauterine repair of spina bifida aperta has been shown to reduce hindbrain herniation, lower the risk of shunt dependency and improve motor function compared to postnatal treatment. Open surgery requires a C-section and is associated with a lower gestational age at birth. We have introduced a 3-layer fetoscopic hybrid technique with exteriorized uterus in 2021. Here we give an update on the establishment of this technique based on the first 20 cases.

#### Methods

After laparotomy and externalization of the uterus 3 ports were placed under ultrasound guidance. The fetus was positioned for the procedure, then the placode is mobilized and a bovine dural patch is placed over the placode, then muscular and skin layers were closed.

#### Results

68 pregnants were counseled by the multidisciplinary team. Each of them was informed about options for prenatal and postnatal treatment, as well as termination of pregnancy. 20 patients underwent prenatal therapy (12 myelomeningoceles, 8 rachischisis). There were no maternal intraoperative complications, in 2 cases there was a mild pulmonal edema postoperatively. Ventricle width was < 10 mm in 8/20, median lesion length was 5 segments (range: 4 – 8). Motoric level was L4 in 5 and S1 in 15 cases. In 11 cases a 3-layer closure was achieved, in 9 cases only 2-layer closure was possible. The postoperative course 17/20 cases showed regredient hindbrain herniation. However, ventriculomegaly was present in 15/20 cases. 12 cases were delivered via C-section (8 cases due to breech position), median GA at delivery was 36 + 4 weeks, median neonatal weight was 2612 g at birth. 3 cases demanded postpartal revision surgery, of which one was a minor revision due to csf leackage, one demanded a skin flap, and one case multiple surgeries for skin expansion due to a large skin defect. 5/20 newborns demanded VP-shunting within the neonatal period.

#### Conclusion

Fetal therapy resulted in an overall good reversibility of hindbrain herniation and a relatively low shunt rate. In cases with no satisfactory intrauterine closure the herniation was not reversible until birth. Thus, in cases with challenging intrauterine skin defects, the technique may need to be optimized.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## V176

### Unterschiede im Berufs- und Privatleben deutscher Neurochirurg*innen
*Differences in professional and personal lives between German female and male neurosurgeons*

T. Miron[1], M. T. Forster[2], D. Nistor-Gallo[3], A. C. Lawson McLean[4], U. Eisenberg[5], J. Krüger[6], M. Hug[2]

[1]Helios Klinikum Berlin-Buch, Nerochirurgie, Berlin, Deutschland
[2]Universitätsklinik, Neurochirurgie, Frankfurt a. M., Deutschland
[3]Universitätklinikum, Erlangen, Deutschland
[4]Universitätsklinikum, Jena, Deutschland
[5]Klinikum, Eberswalde, Deutschland
[6]Universitätsklinikum, Erfurt, Deutschland

#### Objective

During the last two decades, the number of female neurosurgeons has markedly risen, as did men´s participation in childcare and housework. We aimed at investigating whether and to what extent there is a difference between male and female neurosurgeons in Germany regarding the balance of their professional and personal lives.

#### Methods

An anonymous electronic questionnaire consisting of 27 items was distributed to all members of the German Society of Neurosurgery (DGNC) in February 2021. Responses were stratified by gender and compared using Chi-square Fisher´s exact test or the T-test.

#### Results

A total of 1558 German neurosurgeons received the questionnaire, and 290 neurosurgeons (18.6% response rate; 27.6% of which females) aged 46.5 ± 11.4 years completed the survey. Female neurosurgeons were more likely to be single than their male colleagues (24.7% vs. 6.5%, p=0.000), and more frequently had no children (54.4% vs. 20.7%, p=0.000). Among respondents with children, 85.7% of female neurosurgeons had stayed off work for childcare, while 92.6% of male neurosurgeons reported that it was their spouses having stayed at home for childcare (p=0.000).

Regarding professional development, women faced greater challenges with longer average training times (7.6±2.1 vs. 6.7±1.2 years, p=0.003). Compared with their male colleagues, they experienced more frequently inequity at work (60.8% vs. 34.5%, p=0.000) and had the perception of obtaining a lower surgical case volume (39.7% vs. 74.0%, p=0.000).

#### Conclusion

According to the results of our survey, professional and personal lives differ significantly between male and female neurosurgeons in Germany. A paradigm shift regarding attitudes toward gender roles and collaborative solutions, especially at the institutional level, are needed, to promote gender equality in neurosurgery.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes | Hydrocephalus and Paediatric Neurosurgery – Various

## BO-06

### *Comparative analysis of ProGAV and ProGAV2.0 adjustable valves in pediatric hydrocephalus treatment: Survival and complication rate assessment*

M. Issa[1], F. Paggetti[1], A. W. Unterberg[1], A. El Damaty[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland

**Objective**

ProGAV and ProGAV2.0 adjustable valves are extensively utilized for treating hydrocephalus in pediatric patients. This study aims to conduct a comprehensive comparison between these two valves with respect to their survival and complication rates.

**Methods**

This retrospective study encompassed all pediatric patients who underwent proGAV or proGAV2.0 valve implantation at our neurosurgical clinic from May 2006 to August 2022. A comparative analysis was performed considering age, gender, follow-up duration, complication and survival rates, adjustments, spontaneous adjustments, and adjustment difficulty rates.

**Results**

Inclusion involved 380 cases (mean age of 5.35 ± 5.13 years; 54.5% males), comprising 195 cases (51.3%) with proGAV valve implantation and 185 cases (48.7%) with proGAV2.0. Early complications within the first month post-implantation were observed in 57 cases (15%). No significant differences were noted in valve implantation indications or age distribution between the two groups. Predominant indications for implantation were post-haemorrhagic hydrocephalus and idiopathic aqueduct stenosis for both valve types. Notably, proGAV valves exhibited a higher explantation rate compared to proGAV2.0 valves (64.6% vs. 37.3%, $p < 0.001$), along with elevated early post-implantation complication rates (20.5% vs. 9.2%, $p = 0.002$), and a significantly increased association with difficulties in valve adjustments and spontaneous adjustments ($p = 0.003$ and 0.002, respectively). ProGAV2.0 cases displayed notably enhanced clinical improvement within the initial 6 months after implantation ($p = 0.013$).

**Conclusion**

The findings of this study highlight the superior performance of the proGAV2.0 valve in terms of survival rate, complication rate, and maladjustment rate when employed in the treatment of pediatric hydrocephalus.

# Trauma und Neurointensiv – Verschiedenes 3 | Trauma – Various 3

## V177

### Analyse des räumlich-zeitlichen Verlaufs der vaskulären Verletzung und Regeneration nach experimentellem Rückenmarkstrauma

***Analysis of the spatiotemporal dynamic of vascular injury and revascularization following experimental spinal cord injury***

C. J. Entenmann[1], E. von Bronewski[1], L. Waldmann[1], L. Meyer[1], K. Kersting[1], L. Roolfs[1], M. Nieminen-Kelhä[1], I. Kremenetskaia[1], F. Heppner[2], M. G. Fehlings[3], P. Vajkoczy[1], V. Hubertus[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Klinik für Neuropathologie, Berlin, Deutschland
[3]Toronto Western Hospital and Krembil Neuroscience Institute, Toronto, Kanada

### Objective

Traumatic Spinal Cord Injury (SCI) remains a global burden due to the lack of restorative therapies. The early loss of functional vasculature is part of a complex secondary injury cascade that leads to ongoing tissue loss, spreading the injury to regions formerly unharmed. A deeper understanding of the pathophysiology and its timeframe is essential in the search for restorative therapies. Specifically, when evaluating the effects of local therapies, defining the regional extent of vascular injury is necessary. This study aims to characterize the temporal and spatial aspects of vascular injury and revascularization following experimental SCI in the mouse.

### Methods

Adult C57BL/6J mice (n=26) were subjected to thoracic (Th6/7) clip-compression SCI via modified aneurysm clip (5g, 60s) or sham injury (laminectomy). At days 1, 3, 7, 14, and 28 post surgery, animals (n=4/group) were sacrificed via intracardial fluorescein isothiocyanate (FITC)-Lectin perfusion to assess functional vasculature. Histological analysis (CD31, FITC-Lectin, Ki-67) was conducted to assess temporal and spatial vascular changes and endogenous revascularization within the epicenter of injury (+/-0,5mm) and two subsequent spinal cord regions with increasing distance from trauma epicenter (region 1: +/- 0,5-1mm, region 2: +/-1-3mm)

### Results

Loss of functional vasculature as measured by FITC-Lectin+ vessels was instantly assessable in trauma epicenter and subsequent region 1, being most severe at d3 ($p<0.01$). In region 2 significant loss of functional vasculature occurred only from d3 on ($p=0.0427$) and was restituted already on d7 ($p=0.1159$), while region 1 and trauma epicenter were restituted at d28 ($p=0.2713$, $p=0.1251$ respectively). Overall vessel density as measured by CD31+ signals was returned to baseline quicker (d3 epicenter, d14 regions 1+2). Revascularization as indicated by Ki67+ endothelial cells occurred in all regions after 3d ($p<0.01$), being most prominent in region 2.

### Conclusion

These findings deliver further insights into the temporal and spatial dynamics of the loss of functional vasculature and its restoration by endogenous revascularization following SCI. We demonstrate that vascular injury is most prominent in the first days after injury and spreads to wider regions surrounding the injury. While partial vascular regeneration occurs, it remains incomplete. The development of local therapies to ameliorate these events remain desirable.

# Trauma und Neurointensiv – Verschiedenes 3 | Trauma – Various 3

## V178

### Charakterisierung von Serumspurenelementen nach Rückenmarksverletzung im Rattenmodell.
*Characterization of serum trace elements in a spinal cord injury rat model*

O. Alhalabi[1], R. Heller[2,3,4], M. Maares[5], H. Haase[5], L. Schomburg[2], T. Chillon[2], A. Moghaddam[6], B. Biglari[7], S. Krieg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Institute for Experimental Endocrinology, Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Institute for Experimental Endocrinology, Berlin, Deutschland
[4]Bundeswehrkrankenhaus Berlin, Klinik für Unfallchirurgie, Orthopädie und Septisch-Rekonstruktive Chirurgie, Berlin, Deutschland
[5]Technische Universität Berlin, Department of Food Chemistry and Toxicology, Berlin, Deutschland
[6]Orthopädie und Unfallchrirurgie, Aschaffenburg, Deutschland
[7]BG Unfallklinik Ludwigshafen, Department of Paraplegiology, Ludwigshafen, Deutschland

#### Objective

Although trace elements play a pivotal role in facilitating inflammatory and regenerative cascades after injury, their role in neurological recovery after spinal cord injury (SCI) is still not well characterized. This study hence adopted a comprehensive approach to analyze trace elements (zinc, free zinc, and selenium) status and dynamics after experimental SCI in rats.

#### Methods

45 Wistar rats underwent laminectomy at the T9 level and were subsequently subjected to experimentally induced SCI. As a sham control, n=30 rats underwent laminectomy only. Serum samples were collected both before and 1, 3, 7, 14 and 28 days after the injury. Trace elements (zinc, free zinc, and selenium) were quantified using Total reflection X-ray fluorescence and correlated with serum cytokines. Furthermore, functional outcomes were assessed at day 14 post-injury, with results compared to the sham cohort using open-field locomotor scales (BBB score) and the CATWALK computer-based gait analysis.

#### Results

Significant fluctuations in trace element levels between days 1 and 14 post injury were noticed, especially for zinc to free zinc ratio, with a peak at the subacute phase, with a 25% increase in average zinc serum levels in SCI compared to sham rats on day 7 ($p<0.05$), and 15% on day 14 ($p<0.05$). For selenium, higher serum levels were noticed throughout the 28-day course in sham rats ($p<0,05$). Correlation analyses revealed a close interplay between zinc to free zinc ratio and proinflammatory serum cytokine levels. At day 14 after SCI, a correlation was noted between the recovery of BBB and CATWALK scores and the measured zinc to free zinc ratio at day 7 after injury.

#### Conclusion

The presented data highlight the role of free zinc in SCI pathophysiology and its interplay with systemic inflammation after SCI. In addition, a potential protective role of selenium could be noticed. Further in vitro interventional studies and correlation with human serum of SCI patients could facilitate the clinical translation of these findings.

# Trauma und Neurointensiv – Verschiedenes 3 | Trauma – Various 3

## V179

### Hyperspektrale Bildgebung erkennt erfolgreich Gewebeschäden nach Rückenmarksverletzung im Rattenmodell.
*Hyperspectral imaging successfully detects tissue damage in a spinal cord injury rat model*

O. Alhalabi[1], R. Heller[2,3,4], A. Studier-Fischer[5], L. Schomburg[2], T. Chillon[2], A. Moghaddam[6], B. Biglari[3], S. Krieg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Institute for Experimental Endocrinology, Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[3]BG Unfallklinik Ludwigshafen, Department of Paraplegiology, Ludwigshafen, Deutschland
[4]Bundeswehrkrankenhaus Berlin, Klinik für Unfallchirurgie, Orthopädie und Septisch-Rekonstruktive Chirurgie, Berlin, Deutschland
[5]Universitätsklinikum Heidelberg, Allgemein-, Viszeral- und Transplantationschirurgie, Chirurgische Klinik, Heidelberg, Deutschland
[6]Orthopädie und Unfallchrirurgie, Aschaffenburg, Deutschland

#### Objective

An intraoperative in situ evaluation of the extent of spinal cord injury (SCI) could provide a further modality for intra- and perioperative decision-making. Hyperspectral Imaging (HSI) is a novel, non-invasive diagnostic tool that could help differentiate between injured and healthy spinal cord tissue by identifying variations in tissue oxygenation and perfusion. Those in turn could be indicative of underlying neural damage. The aim of this proof-of-concept study, therefore, was to demonstrate the efficacy of HSI in estimating the extent of injury after SCI in an animal rat model.

#### Methods

After a laminectomy at T9, the TIVITA® Tissue system, a medically certified HSI camera, was used to acquire spectral data before and after experimentally induced clip-compression/contusion SCI in n=6 Wistar rats. The imaging process involved acquiring data across a broad wavelength range, focusing on the visible to near-infrared spectrum. Animals were sacrificed after 14 days and HSI findings were correlated with conventional immunohistochemistry analyses, serum cytokine data and functional outcomes (using an open-field locomotor scale and the CatWalk XT® computer-based gait analysis).

#### Results

Global principal component analyses (PCA) revealed a differential clustering between injured and non-injured spinal cord tissues based on mere spectral signatures. Moreover, quantitative analysis of HSI data showed a correlation with the injury extent after 14 days, as informed by cyst size in isolated spinal cord tissue, pro-inflammatory serum cytokine levels, and endpoint neurobehavioral parameters pertaining to locomotion and coordination of hind limbs.

#### Conclusion

HSI-derived data successfully identified SCI in a rat model. Its ability to provide detailed, in situ post-injury insights into the perfusion state of spinal cord tissue holds significant potential for both animal studies and future clinical applications. This study establishes a foundational approach for using HSI in SCI diagnostics, paving the way for its translation into clinical practice and application in the study of other spinal cord conditions.

# Trauma und Neurointensiv – Verschiedenes 3 | Trauma – Various 3

## V180

### Nutzung von Exosomen aus neuronalen Vorläuferzellen für die nicht-zellbasierte Regeneration bei Rückenmarksverletzungen

***Investigating the potential of exosomes from neuronal precursor cells in non-cellular repair of traumatic spinal cord injuries***

H. Wang[1], O. Alhalabi[1], X. Zha[1], G. Zheng[1], T. Skutella[2], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Ruprecht-Karls-Universität Heidelberg, Institut für Anatomie und Zellbiologie, Heidelberg, Deutschland

#### Objective

Secondary injury mechanisms in traumatic spinal cord injury (SCI) significantly hinder neural repair, particularly impeding neurite extension. Transplantation of neuronal precursor cells (NPCs) has been promising in neuroregeneration, potentially due to their secretomes. This investigation examines the role of NPC-derived exosomes (NPC-exos) in promoting neurite growth in vitro and facilitating spinal cord regeneration in a rat SCI model.

#### Methods

NPCs harvested from embryonic rat subventricular zones underwent culturing up to passage four. Isolation of NPC-exos was achieved via ultracentrifugation and filtration, followed by nanoparticle tracking analysis for quantification and characterization through transmission electron microscopy and western blotting. Proteomic analysis was conducted to determine their composition. The influence of NPC-exos on neurite growth was evaluated in PC12 cells and primary neuron cultures. Their regenerative capability was tested in vivo using a rat thoracic clip-compression SCI model.

#### Results

NPC cultures, characterized by high Nestin expression (97±2%) and absence of NeuN, GFAP, and Olig2, were successfully established. NPC-exos, marked by CD63, CD81, and TSG101, exhibited typical exosomal morphology with an average size of 147.5±67.5 nm. Proteomic analysis via liquid chromatography-mass spectrometry revealed significant enrichment in axonal guidance proteins like Netrin-1 (abundance 1.89x108; relative to GAPDH 0.834). NPC-exos treatment, in a range of MOIs (1x103-1x105), led to a dose-dependent increase in neurite length in both PC12 cells and primary neurons (e.g., NPC-exos high dose vs. control: 255.5±55 µm vs. 122±31 µm, $p<0.001$). Intrathecal administration of NPC-exos post-SCI in rats showed enhanced functional recovery (NPC-exos vs. control: 24±1 vs. 28±2 stepping errors in Gridwalk test, $p=0.0007$) as well as marked histological neuroregeneration.

#### Conclusion

Enriched with proteins crucial for axonal guidance and neurite growth, NPC-exos significantly promoted neurite extension in vitro and demonstrated substantial regenerative effects post-SCI in vivo. These outcomes indicate that NPC-exos could serve as an effective non-cellular approach for neural repair after SCI, warranting additional exploration.

# V181

## LPS-, IL-4- und TGF-β-induzierte Makrophagen fördern die Regeneration bei Rückenmarksverletzungen
*LPS, IL-4, and TGF-β induced macrophages promote regeneration in spinal cord injury*

X. Zha[1], H. Wang[1], O. Alhalabi[1], G. Zheng[1], M. Hatami[2], T. Skutella[2], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Ruprecht-Karls-Universität Heidelberg, Institut für Anatomie und Zellbiologie, Heidelberg, Deutschland

### Objective

Spinal cord injury (SCI) triggers a cascade of inflammatory responses, resulting in severe, chronic disability. Macrophages, known for their diverse phenotypes, play a crucial role in this process. This study investigates the potential of a combined treatment with lipopolysaccharide (LPS), Interleukin-4 (IL-4), and Transforming growth factor-beta (TGF-β) in inducing a macrophage subtype that fosters enhanced regeneration post-SCI.

### Methods

We established primary cultures of bone marrow-derived macrophages (BMDMs) from Wistar rats' femur and tibia. These BMDMs underwent co-incubation with various combinations and concentrations of LPS, IL-4, and TGF-β for 24 hours. Anti-inflammatory markers in induced BMDMs (iBMDMs) were assessed using qPCR and immunofluorescence staining. Neuron co-culture and in vitro assays evaluated safety and functionality. After a T9 clip-compression/contusion SCI, rats received intralesional injections of either iBMDMs or the three inducers. Over 28 days, we characterized and quantified the local inflammatory response, neuroregeneration, and motor function recovery, comparing results with untreated controls.

### Results

Post 24-hour stimulation with LPS, IL-4, and TGF-β, iBMDMs exhibited altered morphology and an anti-inflammatory profile. qPCR revealed significant increases in repair marker Arg1 and anti-inflammatory cytokine IL-10 in iBMDM ($p<0.05$), while pro-inflammatory factors iNOS, IL-12, and IL-1β did not show significant increases. Immunofluorescence confirmed protein expression levels of Arg1 and iNOS. Neuronal co-culture demonstrated no significant neuronal death ($p>0.05$). iBMDMs also showed enhanced in vitro phagocytic capabilities ($p<0.05$). Proteomics indicated numerous differentially expressed genes in iBMDMs, enriched in cell metabolism, immune regulation, inflammation, and phagocytosis. Post-SCI treatment with iBMDMs or inducers led to early shifts in the injured spinal cord's cellular and molecular inflammatory responses, and long-term improvements in histological neuroregeneration and motor function recovery, with the iBMDM transplantation group showing the most significant improvement.

### Conclusion

BMDMs can be induced by LPS, IL-4, and TGF-β into a subtype with anti-inflammatory and regenerative properties. This correlates with improved local inflammatory responses and enhanced neuroregeneration following experimental SCI, suggesting a promising therapeutic potential.

# V182

## Serielle transbulbäre Sonographie zur Feststellung einer Stauungspapille bei Patienten mit Druckmonitoring nach einem akuten intrakraniellen Ereignis

***Serial transbulbar sonography of optic disc swelling (papilledema) in comparison to intracranialpressure in patients with acute intracranial disease***

C. A. Saldivar Galli[1], A. E. Hartmann[1], T. Anneke[2], R. Lefering[3], G. Aburhabid[1], M. Nakamura[1]

[1]Krankenhaus Merheim, Neurochirurgie, Köln, Deutschland
[2]Krankenhaus Merheim, Anästhesiologie und operative Intensivmedizin, Köln, Deutschland
[3]Krankenhaus Merheim, Institut für Forschung in der operativen Medizin, Köln, Deutschland

### Objective

The identification of papilledema in patients with acute intracranial diseases such as trauma, bleedings and vascular diseases allows identification of increased ICP as measured by invasive intracranial pressure monitoring. Dynamic changes of ICP may be identified by transbulbar sonography.

### Methods

3 – 5 serial measurement of the optic disc (in mm above the retinal level) of both eyes to recognize papilledema (optic disc swelling, ODS) have been compared to measurement of IVP or parenchymatous pressure recording. Sonographic instrument was Hitachi Aloka Arietta V70 with a linear probe L64. We have arranged the longitudinal axis of the optic nerve with its central retinal artery to the longitudinal axis of the sonographic probe. Optic nerve sheath diameter (ONSD) was measured 30 mm behind the optic disc. The ICP data were compared to recording of ICP in mmHg. Papilledeam was correlated to the mean values of ICP measurements over periods of 24 hours, and the highest ICP values during these 24 hour periods and the actual ICP values at the time of the sonographic measurement.

### Results

In 22/33 patients the mean ICP was normal (below 14 mmHg). In 14 out of the 22 patients sonography revealed ODS, in 8 patients sonography was normal. 1 patient presented with normal mean ICP, however in 1 instance simultaneous swelling of OD. In 9 out of 33 patients ODS has not been observed , none of these 9 had increased ICP at any time. Transbulbar sonography to detect papilla swelling is a practical and reliable method that allows patients to be followed serially in the ICU without intracranial pressure monitoring.2 patients developed ODS during their treatment course. However, OD became normal during their course. ONSD (normally maximum 58 mm) was increased in 17 cases (59 – 79 mm). In 5 patients out of these 17 cases ICP was normal (maximum 14 mm Hg). We did not find any significant correlation between ICP and ONSD.

### Conclusion

Transbulbar sonography to detect papilla swelling is a practical and reliable method that allows patients to be followed serially in the ICU without intracranial pressure monitoring.

# V183

## Validierung eines neuen Scoring-Systems zur Risikovorhersage der sekundären lumbalen Instabilität (SLI) nach lumbaler Dekompression an 107 Patient:innen

***Validation of a new scoring system for predicting the risk of secondary lumbar instability (SLI) after lumbar decompression in 107 patients***

A. Abramovic[1], S. Lener[2], A. Koller[2], S. Hartmann[2], C. Thomé[2]

[1]Universitätsklinik für Neurochirurgie Medizinische Universität Innsbruck, Innsbruck, Österreich
[2]Medizinische Universität Innsbruck, Universitätsklinik für Neurochirurgie, Innsbruck, Österreich

### Objective

The surgical treatment of lumbar spinal stenosis remains controversial, as the factors qualifying patients for instrumentation of the thoracolumbar spine may not be fully met. Pure lumbar decompression poses the risk of developing secondary lumbar instability (SLI) with the need for subsequent instrumentation. Based on the most frequently described risk factors in the literature for the development of SLI, the authors have developed a new scoring system for predicting the risk of SLI. The aim of this study was to validate the predictive capability of the score.

### Methods

Between January and December 2018, 107 patients (45 female, 62 male; average age: 69 years) with lumbar spinal stenosis, treated with lumbar "over-the-top" decompression, were included in the study. BMI, gender, smoking history, age, previous lumbar surgeries, back pain, spondylolisthesis >5 mm, dynamic olisthesis >3 mm, segmental kyphosis >10°, disc height >6.5 mm, facet joint angle >50°, and facet joint effusions in the index segment were retrospectively evaluated and assessed using the scoring system (Fig. 1). The primary endpoint was defined as clinical deterioration requiring fusion of the preoperative segment at the 2-year follow-up.

### Results

In 26.2% of patients, mechanical back pain with a VAS>4 was observed. 22.4% had undergone previous surgery on the segment to be treated. The median SLI score was 6/14, with patients later requiring fusion (8.4%) exhibiting a significantly higher SLI score compared to those who did not develop SLI (9 vs. 6, p=0.013). The main factors associated with an increased SLI risk were disc height (>6.5mm), BMI, and the presence of olisthesis in the segment to be operated, with a relative risk of 2.8, 2.3, and 2.8, respectively.

### Conclusion

The new SLI score revealed significant differences in the pre-defined risk factors between patients with and without subsequent instrumentation of the index segment after lumbar decompression. Further studies are necessary to establish clear thresholds for a more efficient differentiation and to facilitate decision-making in the preoperative assessment of patients scheduled for decompression or fusion surgery.

Abb. 1

| Clinical Factors | Score |
|---|---|
| Mechanical low back pain | 2 |
| Age <70 years | 1 |
| BMI >30kg/m² | 1 |
| Female gender | 1 |
| Smoking history | 1 |
| Previous lumbar surgery (independent of lumbar segment) | 1 |

| Radiologic Factors | Score |
|---|---|
| Presence of listhesis (>5mm) | 1 |
| Dynamic listhesis (>2mm) | 1 |
| Disc height (>6.5mm) | 2 |
| Segmental kyphosis (>10°) | 1 |
| Facet joint angle (>50°) | 1 |
| Bilateral facet joint effusion (>1mm) | 1 |

# V184

## Pedikelschraubenlockerung bei Verwendung von Carbon-Fiber-verstärkten PEEK-Schrauben nach dorsaler Stabilisierung bei Spondylodiszitis

***Pedicle screw loosening in the use of carbon fiber-reinforced PEEK screws following posterior fusion for spondylodiscitis***

M. Lepshokov[1], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

### Objective

Screw loosening and halo formation around the screws in carbon fibre reinforced PEEK implants is under debate. This study aims to assess the frequency of pedicle screw loosening and safety in the use of Carbon/PEEK implants for treating pyogenic spondylodiscitis across spinal segments in the cases of one hospital.

### Methods

A retrospective analysis from 2017 to 2023 involved 142 patients after posterior fusion with using Carbon/PEEK implants, including a comprehensive review of medical records, MRI, and CT scans. Statistical analysis used descriptive statistics and Chi-square, with significance set at $p < 0.05$.

### Results

The study group consisted of 92 males (65%) and 50 females (35%), with an average age of 69.54 years (±12.5). Surgeries were conducted at a single level in 108 patients (76%), at two levels in 14 patients (10%), and at 3 to 5 levels in 20 patients (14%). Posterior fusion procedures were conducted across various spinal segments: cervicothoracic junction in 1 patient (0.7%), thoracic spine in 29 patients (20.4%), thoracolumbar junction in 7 patients (4.9%), and lumbar spine in 105 patients (73.9%). Screw loosening was observed in 16 patients (11.3%): in the thoracic spine for 4 patients (2.8%), at the thoracolumbar junction for 3 patients (2.1%), and in the lumbar spine for 9 patients (6.3%). These differences were statistically significant (Chi-Square = 8.06; $p = 0.045$). Repeat surgical procedures due to screw loosening were performed in only 1 case (0,7%).

### Conclusion

Screw loosening was observed in 16 patients (11,3%), and repeat surgical intervention was only necessary in a single patient. Thus, examining a six-year treatment history of spondylodiscitis patients using Carbon/PEEK implants suggests their sufficient safety. No increased risk of screw loosening was observed. However further studies including more patients are required before final conclusions can be drawn.

# V185

## Linderung rezidivierender Iliosakralgelenksschmerzen durch ultraschallgesteuerte autologe Injektionen mit plättchenreichem Fibrin

***Reducing recurrent sacroiliac joint pain with ultrasound-guided autologous platelet-rich fibrin injections***

I. Vasilikos[1], K. Argiti[1], A. Stathi[1], K. Joseph[1], V. Ravi[1], R. Rölz[1], J. Beck[1], U. Hubbe[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

### Objective

Low back pain (LBP) is a common symptom with socioeconomic and medical consequences. In up to 30% of LBP cases, the pain originates from the sacroiliac joint (SIJ). Despite multiple microinvasive interventions such as corticosteroid infiltrations, many patients experience symptom recurrence and reduced quality of life. Platelet-rich fibrin (PRF) is an autologous biomaterial that is easily prepared from patient blood and encapsulates a high concentration of growth factors. Its regenerative and anti-inflammatory properties have led to its widespread use in maxillofacial, orthopedic, and plastic surgery. This study retrospectively analyzed the effects of PRF infiltration in a series of patients with recurrent symptoms despite previous corticosteroid injections.

### Methods

A series of 13 patients (3 men and 10 women; mean age, 54 years) with chronic relapsing bilateral SIJ irritation despite multiple previous corticosteroid injections (range, 1-4) were referred to our institution for treatment. PRF was prepared from 120 ml of blood from each patient. Then it was injected percutaneously under ultrasound guidance at the sacroiliac level. The Numeric Pain Related Scale (NPRS) and Roland-Morris Disability Questionnaire (RMDQ) were used to evaluate the efficacy of the treatment at a mean follow-up of 3 months after the procedure.

### Results

After PRF treatment, SIJ-associated pain was reduced in all patients. Both NPRS and RMDQ showed a statistically significant and clinically meaningful reduction from before (NPRS, 5±1; RMDQ, 11±3) to 3 months after the intervention (NPRS, 3±1, RMDQ,3±2) ($p \leq 0.05$). There were no adverse effects associated with the PRF intervention.

### Conclusion

Ultrasound-guided autologous platelet-rich fibrin injections appear to be a safe alternative for the relief of recurrent SIJ pain. Our results showed a statistically significant reduction in SIJ symptoms after ultrasound-guided PRF injection. Further clinical studies are needed to validate our findings.

# V186

## Translaminäre Bandaugmentation zur Prävention der proximalen junktionalen Kyphose bei thorakolumbaler Korrekturspondylodese

***Translaminar spinal tether augmentation for the prevention of proximal junctional kyphosis in thoracolumbar deformity correction***

T. A. Sargut[1], A. Almahozi[1], E. Verigos[2], D. Tkatschenko[1], P. Vajkoczy[1], N. Hecht[1]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland
[2]Barts and the London School of Medicine, London, Vereinigtes Königreich

### Objective

In order to prevent proximal junctional kyphosis (PJK) in multisegmental deformity correction, proximal tether augmentation using semirigid spinal ligaments has been described in biomechanical studies and case series. However, clinical data on the use of tether augmentation in Germany are limited. This study examines the application and results of translaminar tether augmentation in addition to multisegmental instrumentation for deformity correction.

### Methods

Data from 61 patients who underwent navigated thoracolumbar deformity correction at our center between 08/2019 and 05/2023 were retrospectively collected. Of these patients, 25/61 (41%) received proximal tether augmentation, which was fixed translaminar 1 and 2 vertebral body levels above the uppermost instrumented vertebral body. The control group consisted of 36/61 (59%) patients who underwent thoracolumbar deformity correction without tether augmentation during the same period. Radiographic parameters of PJK and sagittal balance were determined using pre- and postoperative full-spine radiographs. PJK was defined as an increase in the sagittal Cobb angle above 10° between the the uppermost instrumented vertebra and the vertebra two levels above. Univariate logistic regression was used to analyze complications and the rate of PJK over time.

### Results

All 25 patients in the tether group underwent technical tether augmentation without intraoperative or perioperative complications. Patients in the tether group showed a significantly lower rates of PJK compared to the control group (11.4% vs. 37.1%; $p = 0.03$). Based on the odds ratio, the probability of developing PJK was increased by a factor of 3.1 in patients without band augmentation. The rate of revision surgery due to PJK tended to be lower in the band augmentation group (8% vs. 13.8%), howether this was not statistically significant ($p > 0.05$).

### Conclusion

The present study provides evidence that proximal translaminar tether augmentation can be reliably performed in adult spinal deformity correction and can prevent the development of radiographically detectable PJK. Further studies are required to definitively assess the clinical outcome, with regard to the prevention of revision surgery.

# Spinal – Verschiedenes 4 | Spinal – Various 4

## V187

### Risikofaktoren für ein Versagen der vorderen Platte nach vorderer zervikaler Korpektomie und Fusion.
***Risk factors for anterior plating failure after anterior cervical corpectomy and fusion.***

A. Togyzbayeva[1], S. B. Bingöl[1], O. Gembruch[1], M. Darkwah Oppong[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

Anterior cervical corpectomy and fusion (ACCF) is a common surgical treatment technique used for various cases of degenerative, traumatic, infectious, or oncologic cervical spine lesions. Postoperative courses might be complicated due to certain surgery- and disease-related morbidity. In this retrospective study, we addressed the rate and risk factors for anterior plating failure (APF) after ACCF.

#### Methods

All consecutive cases of ACCF treated at our institution between 08/2008 and 04/2023 were included (n=99). The baseline demographic, clinical and radiographic parameters of patients were recorded. The postoperative imaging was reviewed and analyzed regarding occurrence of APF after ACCF.

#### Results

APF was observed in 15 cases, accounting for 15.2% of the total. It was found that female patients had a higher incidence of APF after ACCF compared to male patients (21.2% vs 8.5%, p=0.081). Additionally, patients with pre-existing arterial hypertension were also more susceptible to APF (25.7% vs 9.4%, p=0.03). Several surgical and anatomical risk factors were significantly associated with APF. The number of corpectomies performed had a notable impact, with APF occurring in 3% of cases after one vertebral body removal, 33% after two, and 66.7% after three or more (p<0.0001). Furthermore, the level of the lower index vertebral body played a role, with the highest rate of APF observed in C7 (36.4%) and Th1 (50%), while the lowest rates were seen in C4 (8.3%) and C5 (5.7%) (p=0.043). Implant height was also found to be a significant factor, with the mean height of the cage being 38.1 cm compared to 26.6 cm (p<0.0001), and the mean height of the anterior plate being 58.8 cm compared to 47.9 cm (p=0.001). Finally, the position of the cage in the sagittal plane was associated with APF, with a higher incidence when placed at the middle of the vertebral body (26.9%) compared to the anterior margin (11%) (p=0.052).

#### Conclusion

The challenge of anterior plating may arise in cases of varying severity of ACCF, potentially leading to the need for revision surgery. Individuals who require longer stabilization constructs and those with involvement of the lower cervical bodies are particularly at risk of experiencing APF.

# V188

## Postoperative radiologische Untersuchungen nach ACDF-Operationen bei symptomatischen degenerativen Bandscheibenerkrankungen über 1 bis 3 Höhen

***Routine postoperative follow-up imaging after ACDF surgery of 1 to 3 level symptomatic degenerative disc disease***

D. Monden[1,2], A. F. Kalaji[2], F. Schwarz[2], C. Senft[2], P. Baumgarten[2]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

### Objective

A common treatment of cervical degenerative disc disease is anterior cervical discectomy and fusion (ACDF). The postoperative follow-up can consist of just clinical follow-up or in some centers also of repetitive X-ray imaging or even CT scans. The aim of our study was to evaluate the rationale for repetitive routine imaging after ACDF by comparing imaging results regarding graft location or dislocation, clinical outcome and the impact on decision making for revision surgery.

### Methods

A total of 154 patients underwent 1-, 2- and 3-level ACDF surgery from 2015 to 2018. Lateral and posterior-anterior (PA) cervical radiographs as well as CT scans were retrospectively reviewed. X-ray checks were performed postoperatively during the inpatient stay, after 6 weeks, 3 months and 6 months, while a final CT scan was carried out after 1 year. Outcome measurements were ventral, dorsal and lateral dislocation, subsidence and adjacent-level ossification, graft position as well as clinical complaints.

### Results

The mean age of our cohort was 56.3 years. Mean follow-up was 12 months. 1-level ACDF was performed in 80 patients (51.9%), 2-level ACDF was performed in 55 patients (35.7%) and 3-level ACDF was performed in 19 patients (12.3%). Graft subsidence and dislocation occurred significantly more during the first 6 weeks after surgery (all measurements, $p<.0001$) than after 6 weeks. Thus, final follow-up correlated significantly with the first radiographic control (immediate postoperative, $p<.0001$ for all dislocations and $p=0.0004$ for subsidence) and second control (after 6 weeks, $p<.0001$ for all measurements). An anterior, lateral or posterior dislocation was detected during the final CT scan in a total of 42 patients (27.3%). Cage subsidence was found in 43 patients (27.9%). A total of 32 patients (20.8%) were symptomatic at the time of the final check-up. Revision surgery was performed in 4 of 154 patients (2.6%). Of these, 2 patients (50%) were revised due to clinical symptoms, while 2 patients (50%) were revised due to imaging findings alone. Interestingly, symptoms did not correlate with imaging findings ($p=0.203$). There was no significant correlation of imaging and the decision to perform revision surgery ($p=0.498$).

### Conclusion

Our data suggest that long-term postoperative radiographic controls might not be mandatory after ACDF surgery since early postoperative X-ray already significantly correlates with last imaging after one year.

# Tumor – Metastasen und Gliome | Tumour – Metastases and gliomas

## V189

### Stellenwert der primären und wiederholten chirurgischen Resektion bei Patienten mit multiplen Hirnmetastasen
*Benefit of primary and repeated surgery on survival in patients with multiple brain metastases*

A. N. J. Sagerer[1], M. Lucas[1], I. Y. Eyüpoglu[1], S. Hennig[1], G. Schackert[1], T. Juratli[1]

[1]Klinik und Poliklinik für Neurochirurgie, Universitätsklinikum und Medizinische Fakultät Carl Gustav Carus, Dresden, Deutschland

#### Objective

Primary and repeated surgical resection of brain metastases (BM) alleviates symptoms and can improve patients" survival. However, the benefit of resecting multiple BM, particularly of recurrent ones, is controversial due to patients" limited life expectancy. This study evaluates the impact of resecting multiple BM on patients" survival.

#### Methods

Clinical data from 533 patients (211 female, 322 male) who underwent BM surgery at our hospital within 12 years were reviewed. Overall (OS) and progression-free (PFS) survival were estimated using the Kaplan-Meier estimator. In addition, follow-up data, adjuvant treatment and tumor recurrence were collected.

#### Results

Of the patients, 268 (50.3%) had a single BM, 112 (21%) had two or three (oligo), and 153 (28.7%) had four or more (multiple) BM. The incidence of multiple BM was highest in small cell lung cancer (52%), followed by lung adenocarcinoma (37%). The median OS of patients with multiple BM was 6.7 mons. Regarding the extent of resection (no. of residual BM after primary surgery) on OS: patients with 0 or 1 residual BM had a significantly longer (11.1 mons.) OS compared to those with 2 or 3 residual BM (7.9 mons., $p<0.05$) or >3 residual BM (5.1 mons., $p<0.001$). In parallel, PFS also depended on the total amount of residual intracranial lesions after primary surgery (0 or 1 BM left: 6.6 mons. vs. 4.6 mons. (2 or 3 BM left ($p<0.05$)) vs. 4.6 mons. (>3 BM left ($p<0.01$)). Multivariate analysis revealed an Odds ratio (OR) >1 for extent of resection and PFS (no. of residual BM 0 or 1 vs. 2 or 3: OR 1.6 ($p=0.003$); no. of residual BM 0 or 1 vs. >3: OR 1.5 ($p=0.01$). 32.7% of patients with multiple BM underwent a second surgery for recurrence. Although this group demonstrated a slightly better OS compared to those who did not receive repeated surgery (7.7 vs. 6.2 mons.), the difference was not statistically significant ($p=0.95$). Notably, the long-term survival rate (OS >24 mons. post-first resection) in patients who underwent repeated resections for multiple BM was only 6%. However, this rate showed variability depending on the primary cancer type, extending to an average of 85.4 mons. in patients with lung adenocarcinoma.

#### Conclusion

The number of multiple BM varies across different cancer types, but it does not necessarily indicate a poor prognosis. The impact of a more extensive resection (no. of residual BM) on both OS and PFS in cases of resected multiple BM following adjuvant therapy warrants attention.

# Tumor – Metastasen und Gliome | Tumour – Metastases and gliomas

## V190

### Fallzahlen und Behandlung von zerebralen Metastasen in Deutschland im Jahr 2022
*Management of cerebral metastases in Germany in 2022*

M. A. Kamp[1], C. von Sass[1], L. Fink[1], B. van Oorschot[2], C. Jungk[3]

[1]Medizinische Hochschule Brandenburg, Zentrum für Palliativmedizin und Neuropalliativmedizin, Rüdersdorf bei Berlin, Deutschland
[2]Universitätsklinikum Würzburg, Interdisziplinäres Zentrum für Palliativmedizin, Würzburg, Deutschland
[3]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland

#### Objective

This study aims to assess adult inpatient care for patients with cerebral metastases in Germany, focusing on therapeutic interventions and mortality rates, in line with the current guideline recommendation for palliative care initiation within 8 weeks of advanced cancer diagnosis.

#### Methods

In this cross-sectional study, we conducted a retrospective analysis of hospital quality reports from 2022. Patient cases diagnosed with C79.3, either as a primary or secondary diagnosis, were included, encompassing dual-coded primary and secondary diagnoses.

#### Results

In 2022, 71,787 hospital cases treated adult patients with cerebral metastases, with 49.8% being female and 53.4% aged over 65. Neurosurgical departments handled 11.2% of cases, with lung carcinoma (62%), breast cancer (12%), malignant melanoma (6.4%), colo-rectal cancer (3.8%), and kidney tumors (2.4%) being primary diagnoses.

Tumor resection, according to German Cancer Society criteria, occurred in 9.4% (6,748 cases), employing microsurgical techniques (5,253 cases), navigation systems (3,948 cases), and electrophysiological monitoring (1,442 cases). Inpatient radiation therapy was coded in 611 cases (0.9%) and chemotherapy and immunotherapy in 15,714 and 15,333 cases, respectively (21.9% and 21.4% of total cases). Specialized palliative care (SPC) was provided in 10,962 cases (15.2%).

The mortality rate was 13.1% for the total cases, with 4.5% in cases where tumor resection took place during the inpatient stay. 91/302 deceased patients had previously received specialized palliative care (30,1%).

#### Conclusion

This study serves as a benchmark for inpatient care in cerebral metastases cases, involving 71,787 patients. The overall mortality rate was 13.1%, with a specific rate of 4.5% in cases undergoing tumor resection. The proportion of patients with SPC-contact is lower than recommended (Earle et al 2008). The findings provide valuable insights into the current state of care for these patients.

# Tumor – Metastasen und Gliome | Tumour – Metastases and gliomas

## V192

### Fertilitätserhalt und Familienplanung bei Patienten mit niedriggradigem Gliom.
*Preservation of fertility and family planning in patients with low-grade glioma*

A. R. Brüning[1,2], M. Reischl[1], J. Coburger[3], C. Jungk[4], J. S. Onken[5], M. Nadji-Ohl[6], D. Mielke[7], K. Kniese[8], A. Nabavi[8], V. Rhode[7], O. Ganslandt[6], P. Vajkoczy[5], S. Krieg[4], C. R. Wirtz[3], R. Gerlach[2], M. Czabanka[1], M. T. Forster[1]

[1]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[2]Helios Klinikum Erfurt, Klinik für Neurochirurgie, Erfurt, Deutschland
[3]Universitätsklinikum Ulm, Klinik für Neurochirurgie, Ulm, Deutschland
[4]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[5]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[6]Klinikum Stuttgart, Klinik für Neurochirurgie, Stuttgart, Deutschland
[7]Universitätsklinikum Göttingen, Klinik für Neurochirurgie, Göttingen, Deutschland
[8]KRH Klinikum Region Hannover Nordstadt, Klinik für Neurochirurgie, Hannover, Deutschland

#### Objective

Low-grade glioma (LGG) almost unavoidably undergo malignant transformation, requiring adjuvant treatment at the latest at this stage of tumor disease. Given the predominantly young patient age at the time of LGG diagnosis and the high 5-year survival rate of up to 95%, we aimed at analyzing the utilization of fertility preservation measures and the influence of glioma diagnosis on family planning in LGG patients.

#### Methods

Adult LGG patients having been enrolled prospectively in the LoG-Glio registry since 2015 were approached in order to retrospectively evaluate repercussions of glioma on their family life with questionnaires.

#### Results

131 LGG patients were contacted by phone, and 42 patients (32%), with 22 being females, completed the questionnaire. For 4 (18%) female and 1 (5%) male patient, the diagnosis influenced family planning.

9 (41%) women and 7 (35%) men had an active desire to have children at the time of diagnosis and 11 (50%) women and 8 (40%) men were already mothers or fathers. 5 (25%) men but only 1 (5%) woman initiated fertility-preserving measures using sperm cryopreservation or egg freezing. In men, a total of 5 children were born after the diagnosis had been made, with all pregnancies occurring naturally and all children having been born healthy. Among female patients, 4 (18%) women became pregnant during the course of their illness, with all pregnancies described as uncomplicated and all children born healthy and via vaginal delivery. At the time of the survey, 13 (65%) men and 14 (64%) women were in a stable relationship with the same partner as at the time of diagnosis. However, while 12 (60%) male and 16 (73%) female patients declared that tumor diagnosis had an impact on their relationship, only 4 (20%) male and 10 (45%) female patients reported on a positive influence. Furthermore 8 (40%) men and 6 (27%) women reported on a negative influence.

#### Conclusion

Diagnosis of glioma has a major impact on family planning and on relationship in both, female and male patients. However, according to our data, fertility-preserving measures are predominantly initiated by male patients. Most importantly, pregnancies occurring during the course of disease were uneventful, and all children were born healthy. Further research is necessary for better counseling patients and individual patient-centered therapy planning.

# Tumor – Metastasen und Gliome | Tumour – Metastases and gliomas

## V193

### Stationäre operative Versorgung neuroonkologischer Patienten
*Inpatient surgical treatment for neuro-oncological tumors in Germany*

M. A. Kamp[1], C. von Sass[1], L. Fink[1], M. Rapp[2], M. Sabel[2], C. Freyschlag[3], M. T. Foster[4], M. Stein[5], C. Jungk[6]

[1]Medizinische Hochschule Brandenburg, Zentrum für Palliativmedizin und Neuropalliativmedizin, Rüdersdorf bei Berlin, Deutschland
[2]Heinrich-Heine-Universität Düsseldorf, Klinik für Neurochirurgie, Düsseldorf, Deutschland
[3]Medizinische Universität Innsbruck, Klinik für Neurochirurgie, Innsbruck, Österreich
[4]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[5]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[6]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland

#### Objective

Surgical intervention remains a cornerstone in the treatment of neuro-oncological tumors. This study delves into the incidence and mortality rates associated with neuro-oncological surgeries in Germany from 2019 to 2020.

#### Methods

Data on neuro-oncological tumor resections were extracted from German hospitals' quality reports between 2019 and 2022. Adhering to the DKG definition for neuro-oncological operations, our investigation focused on OPS codes 5-015.0, 5-015.1, 5-015.3, 5-015.4, 5-016.0, 5-016.2, 5-016.4, 5-016.6, 5-017.1, 5-035, and 5-075. The mortality rate was defined as the rate of fatal hospital cases based on the total number of cases.

#### Results

A total of 131,658 hospital cases met the inclusion criteria, with 67,706 involving females (51.4%) and 63,947 males (48.6%). Intracranial tumor tissue excision/destruction occurred 80,963 times (61.5%), encompassing 5,184 cases related to skull bone tumors (3.4%), 4,065 cases related to cranial nerve tumors (3.1%), 10,814 cases related to pituitary tumors (8.2%), and 36,581 cases related to spinal tumor tissue (27.8%, with multiple mentions possible). Primary diagnoses included malignant brain neoplasms (C71) in 26,037 cases (19.8%), cerebral metastases (C79.3) in 19,142 cases (14.5%), benign meningeal neoplasms (D32) in 25,469 cases (19.3%), cranial nerve neoplasms (D33.3) in 4,095 cases (3.1%), and pituitary tumors in 8,993 cases (6.8%). Of all cases, 64,286 (49%) were treated in hospitals with over 1000 beds.

Microsurgical technique accounted for 114,193 cases (86.7%), fluorescence-guided technique for 15,763 (11.9%), and intraoperative neurophysiological monitoring for 44,302 cases (33.7%). Among the 131,658 cases, 3,449 resulted in death, reflecting a 2.6% mortality rate. Notably, mortality was unrelated to hospital size and fluorescence-based surgery but significantly associated with intraoperative neurophysiological monitoring ($p < 0.001$; Chi-squared test) and hospital sponsorship (public vs. non-profit vs. private; $p < 0.001$; Chi-squared test).

#### Conclusion

This study marks the inaugural determination of tumor resection cases and associated mortality rates in Germany. With over 130,000 neuro-oncological tumor resections conducted in a span of four years, the recorded mortality rate stands at 2.6%. This work serves as a foundational benchmark for future research in this domain.

# V194

## Geschlechtsspezifische Unterschiede im systemischen Immunphänotyp bei Glioblastom-Patienten
*Sex-biased differences in the systemic immune phenotype in glioblastoma patients*

A. Ryba[1], C. Maire[1], A. Rünger[1], F. Krystian[1], J. Gempt[1], M. Westphal[1], K. Lamszus[1], M. Mohme[1]

[1]University Medical Center Hamburg-Eppendorf, Department of Neurosurgery, Hamburg, Deutschland

### Objective

Glioblastoma (GBM) is the most common malignant brain tumor with short survival rates despite standard therapy. Male GBM patients present a 1.6-fold higher incidence and show a less favorable prognosis compared to their female counterparts. Sex differences in cancer are widely recognized and aside from influences including sex chromosomes, hormones, diet and behavioral factors, variations in the immune system might also contribute to progression and therapy response. Recent studies in a murine model discovered a higher responsiveness for anti-PD1 therapy and higher frequency of exhausted T-cells in male GBM. We therefore investigated sex-biased differences in the human immune response in GBM.

### Methods

Patients with primary and recurrent CNS-WHO°4 GBMs, aged >18 years, were included. Flow cytometric analyses were performed on peripheral blood lymphocytes (PBLs) using multicolor antibody staining panels. Soluble immune markers were analyzed using the multiplex immune assays. Immune cell subsets within the tumor were analyzed based on their gene-expression signature.

### Results

Flow cytometry showed that male patients with pGBM demonstrated significantly lower levels of naïve CD8+ T cells in PBL (p=0.012) and higher PD-1 expression on CD8+ T cells (p=0.037). In contrast, females had notably higher levels of the purinergic marker CD73 (p=0.009). Furthermore, male pGBM patients displayed elevated levels of CD8+ effector memory T-cells (p=0.008) and CD8+ early-like T-cells (p=0.036). Clinical data shows that GBMs in female patients were located more frequently in the frontal and parietal lobe and showed a higher incidence of seizures. Additionally, female patients had a significantly higher ratio of lymphocytes to monocytes. A total of n=33 patients, who received anti-PD-1 treatment, did not show significant differences in OS based on gender. Nevertheless, we discovered that during anti-PD-1 therapy, female patients displayed notably elevated levels of soluble immune checkpoint markers in comparison to their male counterparts.

### Conclusion

This study reveals significant differences in the immune system between genders in GBM. Males exhibit a distinct immune activation/exhaustion profile with increased expression of checkpoint markers, while females show higher activity in the purinergic pathway. These findings imply that gender-specific immune variations might impact responses to immunotherapy, warranting further research to explore their relevance in personalized treatment for GBM patients.

# Tumor – Gliome 3 | Tumour – Gliomas 3

## V195

### Palliativmedizinische Versorgung maligner Gliome in Deutschland
*Palliative care for malignant gliomas in Germany*

L. Fink[1], C. von Sass[1], H. Golla[2], M. Dibué[3], M. T. Foster[4], R. Goldbrunner[5], C. Senft[6,7], A. Lawson McLean[6,7], M. Hellmich[8], N. Dinc[6], R. Voltz[9], H. Melching[9], C. Jungk[10], B. van Oorschot[11], M. A. Kamp[3]

[1]Medizinische Hochschule Brandenburg, Zentrum für Palliativmedizin und Neuropalliativmedizin, Rüdersdorf bei Berlin, Deutschland
[2]Universität zu Köln, Zentrum für Neurochirurgie, Würzburg, Deutschland
[3]Medizinische Hochschule Brandenburg, Zentrum für Palliativmedizin und Neuropalliativmedizin, Rüdersdorf bei Berlin, Deutschland
[4]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[5]Universität zu Köln, Zentrum für Neurochirurgie, Köln, Deutschland
[6]Universitätsklinikum Jena, Klinik mit Poliklinik für Neurochirurgie, Jena, Deutschland
[7]Universitätsklinikum Jena, Zentrum für Neuroonkologie, Jena, Deutschland
[8]Universität zu Köln, Institut für Medizinische Statistik und Bioinformatik, Köln, Deutschland
[9]Deutsche Gesellschaft für Palliativmedizin, Berlin, Deutschland
[10]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[11]Universitätsklinikum Würzburg, Interdisziplinäres Zentrum für Palliativmedizin, Würzburg, Deutschland

#### Objective

Current guidelines advocate the inclusion of palliative care for all patients with advanced tumor disease within 8 weeks after first diagnosis. This study aims to determine the number of malignant glioma patients who either pass away in a hospital or are transferred to a hospice between 2019 and 2022, along with the count of in-patient cases with malignant glioma patients receiving specialized palliative care interventions.

#### Methods

In this cross-sectional study, we conducted a retrospective analysis using data obtained from hospital quality reports covering the years 2019 to 2022. To ascertain the number of cases for patients diagnosed with C71, we tallied patients with C71 as their primary or secondary diagnosis, including those with dual-coded primary and secondary diagnoses. By subtracting the number of double-coded cases from the total cases where a C71 code appeared as either primary or secondary diagnosis, we obtained our final count. The data underwent statistical analysis for evaluation.

#### Results

Among the total of 101,192 hospital cases recorded between 2019 and 2022, which involved patients diagnosed with malignant gliomas, 6,129 patients (6% of all hospital cases with malignant glioma) passed away in the hospital, and an additional 2,798 cases (2.8%) saw patients being transferred to a hospice. In 10,592 hospital cases, constituting 10.5% of the total, patients diagnosed with malignant gliomas received complex or specialized palliative medical care. This rate remained consistent even during the COVID-19 pandemic. Notably, there was a significant lower frequency of complex or specialized palliative care treatments observed in patients aged under 65 years ($p < 0.0001$) and among male patients diagnosed with malignant gliomas ($p_{adjusted} = 0.016$). Among patients who had malignant gliomas and passed away in hospital, specialized palliative care was provided in 2,479 out of 6,129 hospital cases, constituting 40.4%.

#### Conclusion

Despite being a life-threatening disease with limited prospects, only around 10% of hospitalized malignant glioma cases, and about 40% of patients who pass away in the hospital, receive specialized palliative care. This rate seems notably low when juxtaposed with the prevalence of complex symptoms in these patients. The dual

objective should involve efforts to enhance the rate of palliative care for individuals with malignant gliomas, alongside identifying and analyzing barriers to palliative care through additional studies.

# Tumor – Gliome 3 | Tumour – Gliomas 3

## V196

### Erhöhte BDNF-Spiegel bei Glioblastom-Patienten: Untersuchung der Auswirkungen auf die T-Zell-Funktion
*Elevated BDNF levels in glioblastoma patients: Exploring the impact on T Cell function*

A. Ryba[1], C. Maire[1], K. Kolbe[1], S. Heinemann[1], K. Fita[1], R. Drexler[1], K. Pantel[2], J. Gempt[1], M. Westphal[1], F. Ricklefs[1], H. Wikman-Kocher[2], S. Riethdorf[2], K. Lamszus[1], M. Mohme[1]

[1]University Medical Center Hamburg-Eppendorf, Department of Neurosurgery, Hamburg, Deutschland
[2]University Medical Center Hamburg-Eppendorf, Department of Tumor Biology, Hamburg, Deutschland

### Objective

Glioblastoma (GBM) has a detrimental prognosis and no treatment to date has demonstrated long-term effectiveness. The success of immune checkpoint therapy in treating other immunogenic cancers brings hope for immune-based strategies, particularly for the long-term management of GBM. Therefore, a deep understanding of GBM's immunobiology is crucial for shifting towards an immunotherapy-focused treatment approach. Our objective was to uncover changes in the circulating immune profile of GBM patients relative to those with other brain tumors, aiming to pinpoint soluble immune markers that could serve as potential biomarkers and targets for therapy.

### Methods

We conducted an analysis of 30 different immune markers in plasma of 208 participants, including primary and recurrent GBM, cerebral metastases, meningioma and healthy donors (HD), using bead-based multiplex immune assays. In a smaller subset, we employed a high-sensitivity discovery biomarker platform to assess an expanded set of 368 immunological markers. Furthermore, we conducted flow cytometry analysis out of peripheral blood mononuclear cells (PBMC).

### Results

We detected a distinct immune signature of patients with GBM, which markedly differed from other brain tumors and defined by an increased prevalence of soluble immune checkpoint markers along with elevated levels of proinflammatory markers. Notably, we identified a specific subset of GBM patients that exhibited elevated levels of BDNF, alongside increased proinflammatory markers, immune checkpoints and vascular factors. Furthermore, GBM patients with higher levels of BDNF demonstrated a significantly shorter survival ($p=0.008$). Our proximity extension assay also revealed an upregulation of an additional 130 cytokines in the high BDNF cohort, which were associated with proinflammatory processes, as well as neuronal networking and cell metabolism. Additionally, flow cytometry of PBMCs from this subgroup showed significant alterations on surface markers regulating T activation.

### Conclusion

In summary, we were able to delineate a specific immune profile of soluble markers in GBM patients, distinguishing them from those with other brain tumors and HDs. Furthermore, we identified a particular subset of GBM patients who exhibit higher levels of BDNF along proinflammatory markers and immune checkpoints. This distinct immunological profile not only affects survival rates in GBM patients but also demonstrates variations in immune response.

## V197

### Optimierung der Immuntherapie bei Glioblastomen: Synergetische Effekte von CAR-T-Zellen und Checkpoint-Inhibitoren in einem *ex vivo* Glioblastom Organoid Modell

***Enhancing glioblastoma immunotherapy: Synergistic effects of CAR T-Cells and checkpoint inhibitors in a patient-derived ex vivo glioblastoma organoid model***

C. Rumpel[1], M. Alsalkini[1], V. Cibulkova[1], J. Hübner[2], C. Monoranu[3], A. F. Keßler[1], T. Schulz[1], C. Hagemann[1], R. I. Ernestus[1], M. Löhr[1], M. Breun[1], T. Nerreter[2], V. Nickl[1]

[1]Universität Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Universität Würzburg, Medizinische Klinik, Würzburg, Deutschland
[3]Universität Würzburg, Pathologisches Institut, Abteilung für Neuropathologie, Würzburg, Deutschland

#### Objective

Glioblastoma (GBM) represents a challenge in neurooncology due to high malignancy and limited therapeutic options. Despite advances in multimodal therapy, the prognosis remains dismal. Immunotherapies, including checkpoint inhibitors (CPIs), have shown limited efficacy, partly due to the intricate interplay with the tumor microenvironment (TME). This study aimed to explore potential synergistic effects of Chimeric Antigen Receptor (CAR) T-cells and CPIs in an *ex vivo* patient-derived organoid model of GBM.

#### Methods

Enhanced patient-derived organoids (ePDOs) from three different GBM patients were cultured in triplicates with allogeneic peripheral blood mononuclear cells (PBMCs) for 48 hours to enhance TME characteristics. ePDOs were subjected to treatment with CPIs (either anti-PD1, anti-LAG-3, anti-TIM3 or anti-CTLA4; dosage: 10 µg/ ml), CAR T-cells (effector/target: 1/4), and a combination of both treatment approaches. We used untreated ePDOs as a control. Apoptosis of tumor-associated antigen (TAA) positive cells was quantified via immunofluorescence double staining with TAA and CC3 as an apoptosis marker after 16 hours, 24 hours, and 36 hours of co-incubation. CD4+-cell proliferation was quantified via immunofluorescence double staining with CD4 and Ki67 as a proliferation marker. For statistical analysis, one-way ANOVA was performed.

#### Results

Our findings revealed significant synergistic effects of combining CTLA4-CPI with CAR T-cells, resulting in increased apoptosis rates compared to individual treatments. The most pronounced effects were observed after 36 hours, correlating with the highest apoptosis rate. Remarkably, the combination of CAR T-cells and CTLA4-CPI exhibited a significantly higher apoptosis rate compared to untreated ePDOs ($p=0.0152$) and CTLA4-CPI treatment only ($p=0.0385$). Interestingly, the combination of LAG3- and PD1-CPI with CAR T-cells induced a significantly higher proliferation of CD4+ T-cells compared to untreated ePDOs ($p=0.0005$ and $p=0.0042$), respectively.

#### Conclusion

This study highlights the potential of a synergistic combination of CAR T-cells and CPIs in the treatment of GBM, analyzing TAA apoptosis and CD4+ T-cell proliferation rates. These results emphasize the promise of this approach for enhancing immunotherapeutic outcomes in GBM patients, providing a potential path toward improving the prognosis of this devastating disease.

# Tumor – Gliome 3 | Tumour – Gliomas 3

## V198

### Die Hemmung der Protein Tyrosin Phosphatase PTP1B mittels dem small molecule Claramine inhibiert die EGF-vermittelte Wachstumssteigerung in Glioblastozellen durch Hemmung des MAPK Signalwegs

***Inhibition of the protein tyrosine phosphatase PTP1B by the small molecule inhibitor claramine inhibits growth stimulation by EGF in glioblastoma cells via inhibition of the MAPK pathway***

E. Dietel[1], H. Edlund[1], F. Gaunitz[1], J. Meixensberger[1], E. Güresir[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

#### Objective

Since most EGFR-targeted therapies do not significantly prolong progression-free survival and overall survival, new ways to inhibit tumor-promoting pathways, such as the MAPK pathway and AKT signaling, need to be found. Recently, the protein phosphatase PTP1B has been shown to be a regulator of EGFR activation and also interferes with MAPK and AKT signaling. In this study, we used the selective PTP1B inhibitor claramine to investigate the role of PTP1B in downstream signaling of EGFR in glioblastoma cells.

#### Methods

Cell culture

Ten different glioblastoma cell lines were cultured in DMEM supplemented with 10% FCS, 1% glutamine, and 1% penicillin/streptomycin.

Viability assay

Viable cells were determined by measuring ATP in cell lysates using the CellTiter-Glo Luminescent Cell Viability Assay (CTG, Promega, Mannheim, Germany) .

Western Blots

Immunoblotting of samples of T98G lysates treated with EGF and/or claramine was used to assess the activation of EGFR, ERK1/2 and AKT.

#### Results

We identified GBM cell lines that respond to EGF by incubating them for two days with 10 ng/ml and 100 ng/ml EGF in FBS-free and FBS-containing DMEM media. Cell lines U343, T98G, MZ18, and MZ54 showed a significant increase in cell viability upon EGF treatment. To determine whether claramine impaired the growth of GBM cells stimulated by EGF, the cells of lines T98G and MZ54 were incubated in the absence and presence of EGF (10 ng/ml and 100 ng/ml) and in the absence or presence of claramine (5 µM). Here, claramine abolished the EGF-induced increased cell viability (Figure 1). Immunoblotting showed activation of the MAPK signaling pathway under EGF stimulation in T98G cells. Co-administration of claramine and EGF reduced MAPK pathway activation compared to the control group. No significant change was observed in the activation of EGFR under claramine (Figure 2).

#### Conclusion

These results show that claramine inhibits the MAPK signaling pathway downstream of EGFR. Thus, selective PTP1B inhibition inhibits EGFR-induced MAPK pathway activation in glioblastoma cells and could overcome resistance to EGFR-targeted therapies.

Abb. 1

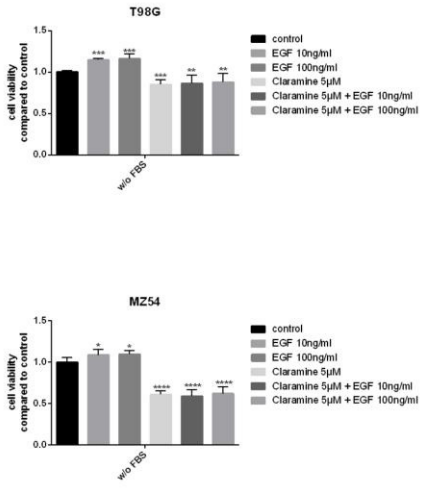



**Figure 1.** Viability of cells from the GBM lines T98G and MZ54 under the influence of EGF and Claramine.

Abb. 2

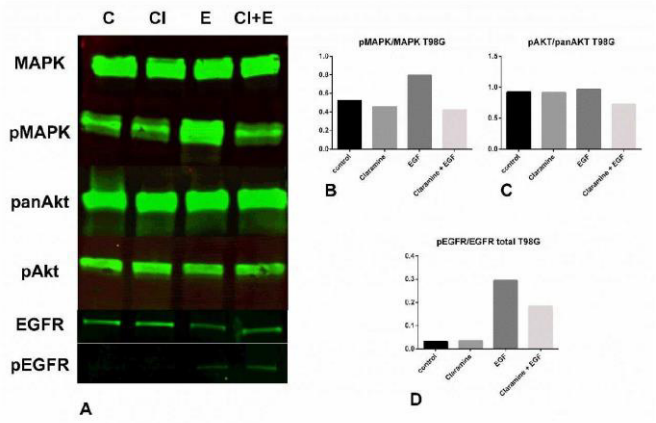



**Figure 2.** Activation of the MAPK pathway and the EGFR under the influence of EGF and Claramine.

# Tumor – Gliome 3 | Tumour – Gliomas 3

## V199

### PGRMC1 und PLOD2 steuern die Interaktion zwischen Tumorzellen und neutrophilen Granulozyten in der Mikroumgebung des Glioblastoms

***PGRMC1 and PLOD2 mediate the tumor-neutrophil interactions in the glioblastoma microenvironment***

C. A. Dumitru[1], K. P. Stein[1], B. Neyazi[1], A. Rashidi[1], C. Mawrin[2], I. E. Sandalcioglu[1]

[1]Universitätsklinikum Magdeburg, Neurochirurgie, Magdeburg, Deutschland
[2]Universitätsklinikum Magdeburg, Neuropathologie, Magdeburg, Deutschland

#### Objective

Accumulating evidence indicates that glioblastoma (GBM) microenvironment contains significant numbers of infiltrating neutrophil granulocytes, which interact with the GBM cells in a bi-directional manner to promote tumor progression. The mechanisms of these interactions are poorly understood thus far. Our study aimed to characterize the effect of GBM cells on key biological functions of neutrophils that are typically associated with a pro-tumor phenotype. In this context, we assessed the roles of PGRMC1 and PLOD2, as these factors were recently linked to GBM progression and the poor outcome of GBM patients.

#### Methods

The functional studies were performed on peripheral blood neutrophils isolated from healthy donors and stimulated *ex vivo* with supernatants from two different GBM cell lines (H4 and U251). The neutrophils were additionally stimulated with supernatants from H4 and U251 cells stably transfected to downregulate PGRMC1 and PLOD2. The *in situ* studies were performed on tissue microarrays from patients with confirmed IDH wild-type GBM (n=279).

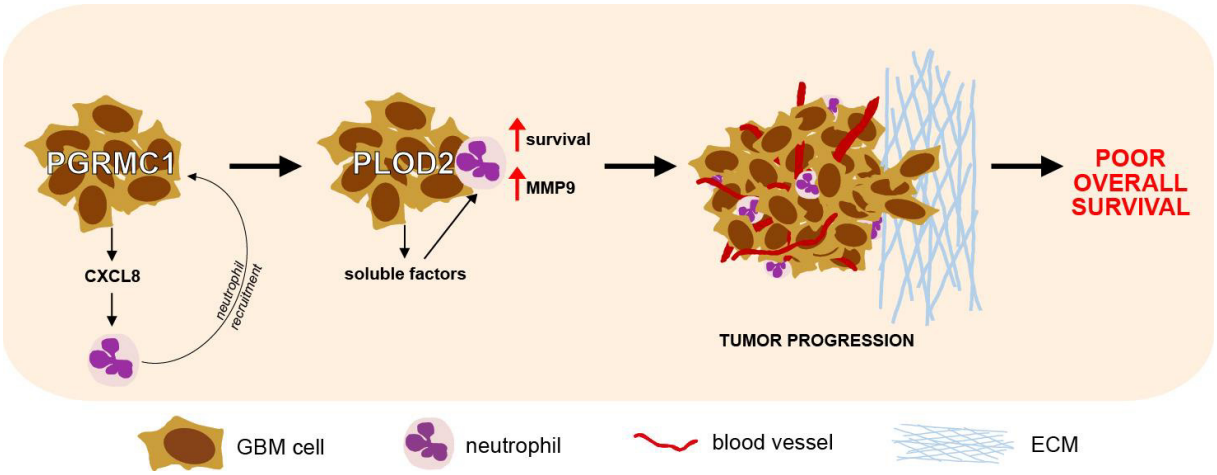
#### Results

GBM supernatants induced neutrophil recruitment (chemotaxis), prolonged their survival and promoted the release of MMP9 by neutrophils. The supernatants from PGRMC1 knock-down GBM cells had a markedly weaker chemotactic effect on neutrophils, which was a consequence of reduced CXCL8 levels. These findings were supported by *in situ* studies, where we found a significant correlation between the numbers of tumor-infiltrating neutrophils and the levels of PGRMC1 in the tumor cells. While PGRMC1 knock-down did not affect neutrophil survival or the release of MMP9, PLOD2 knock-down suppressed the stimulatory effect of GBM cells on both neutrophil functions. In line with these findings, GBM patients with synchronous high levels of PLOD2 and neutrophil infiltration had a significantly shorter overall survival compared to the other groups of patients.

#### Conclusion

Our study shows that GBM cells release soluble factors which can recruit neutrophils to the tumor tissue and induce them to aquire tumor-promoting functions. The recruitment of neutrophils is mediated via a PGRMC1-CXCL8 axis, while PLOD2 mediates the release of -yet unidentified- factors that stimulate neutrophils to produce high levels of pro-angiogenic and pro-invasive MMP9. These findings contribute to a better understanding of GBM pathophysiology and may foster the development of novel therapeutic strategies against these tumors.

Abb. 1


PGRMC1
CXCL8
neutrophil recruitment
PLOD2
soluble factors
survival
MMP9
TUMOR PROGRESSION
POOR OVERALL SURVIVAL
GBM cell
neutrophil
blood vessel
ECM

# Tumor – Gliome 3 | Tumour – Gliomas 3

## V200

### Die Bedeutung der neoadjuvanten Checkpointinhibition in der Behandlung des Rezidiv-Glioblastoms
*Role of neo(adjuvant) checkpoint inhibition in recurrent glioblastoma*

H. Krenzlin[1], A. Dauth[2], F. Corr[2], H. Ubbens[2], C. Sommer[2], B. Alessandri[3], F. Ringel[3], N. Keric[3]

[1]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Institut für Neuropathologie, Mainz, Deutschland
[3]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Glioblastoma has a dismal prognosis. After recurrence treatment options are limited. Anti-PD-1 antibody Pembrolizumab demonstrated benefit as adjuvant monotherapy in multiple types of cancer- except glioblastoma. It is stipulated that neo-adjuvant immune checkpoint inhibition together with reresection and adjuvant alkylating chemotherapy might lead to sustained anti-tumor immune responses and clinical benefit in patients with recurrent glioblastoma.

#### Methods

Patients aged ≥18 years with recurrent IDH wild-type glioblastoma (CNS WHO grade 4) scheduled for surgical debulking were included. Eligibility criteria included Eastern Conference Cooperative Oncology Group (ECOG) Score ≤2, first line therapy with at least radiotherapy, unequivocal evidence of tumor progression. Patients received pembrolizumab 200 mg intravenous infusions 14±5 days prior to- and every three weeks after re-surgery additionally to CCNU (up to six-week cycles). To examine CPI response, transcriptome sequencing (RNAseq), T-cell receptor sequencing in tumor samples and detection of inflammatory cytokines (Il-1a, Il-1b, Il-6, Il-8, TNF-a, IFN-y, MCAF, GM-CSF) in blood using ELISA and qPCR, was performed.

#### Results

A total of ten patients received neoadjuvant pembrolizumab prior to re-resection. Mean age was 54.7 years (33-68), female:male ratio was 8:2. Complete resection was achieved in 70.0%, gross total resection in 10.0%, partial resection in 10.0% and biopsy in 10.0%. A total of 10 neoadjuvant and 24 adjuvant cycles of CPI were given. Fever associated with CPI occurred in 2 patients. No severe adverse occurred. Overall PFS was 12.9±3.6 months and OS 28.2±6.5 months. After re-surgery, mean PFS was 5.0±1.1 months, mean OS was 15.3±4.9 months. 6 out of 10 patients are still alive.

Lower levels of INF-y and Interleukine-6 and -8 after neoadjuvant CPI were associated with a longer OS (p=0.05) but not PFS (p=0.69). RNAseq revealed distinct longitudinal transcriptome changes in response to neoadjuvant CPI. Similar longitudinal changes were detected regarding the immune contexture, TCR diversity and clonality.

#### Conclusion

Neoadjuvant checkpoint inhibition is well tolerated and associated with distinct changes to tumor transcriptome and immune milieu. These findings suggest that the neoadjuvant administration of PD-1 blockade enhances the local and systemic anti-tumor immune response and may represent a more efficient approach to the salvage treatment of this uniformly lethal tumor.

# Innovation und Technik – Verschiedenes | Innovation and technology – Various

## V201

### Therapie postoperativer motorischer Defizite mittels repetitiver navigierter transkranieller Magnetstimulation – eine Multicenter-Analyse

*Improving postsurgical paresis in brain tumor patients by transcranial magnetic stimulation*

T. Rosenstock[1], T. Picht[1], M. Engelhardt[1], U. Grittner[2], M. Mönch[2], P. Vajkoczy[1], J. P. Lavrador[3], A. Mirallave-Pescador[4], F. Vergani[3], M. Schwendner[5], A. Schröder[6], L. Kram[5], H. Zhang[5], S. Prabhu[7], S. Prinsloo[7], B. Meyer[6], S. Ille[5], S. Krieg[5]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Institut für Biometrie und Klinische Epidemiologie, Berlin, Deutschland
[3]King's College Hospital Foundation Trust, Neurosurgical Department, London, Vereinigtes Königreich
[4]King's College Hospital Foundation Trust, Neurophysiology Department, London, Vereinigtes Königreich
[5]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[6]Klinikum rechts der Isar, Technical University of Munich, Department of Neurosurgery, München, Deutschland
[7]The University of Texas MD Anderson Cancer Center, Department of Neurosurgery, Houston, TX, Deutschland

#### Objective

Recently, reduction of transcallosal inhibition by contralateral navigated repetitive transcranial magnetic stimulation (nrTMS) improved neurorehabilitation of glioma patients with new postoperative paresis. This multicentric study examines the effect of postoperative nrTMS in brain tumor patients to treat surgery-related upper extremity paresis in the first days after surgery.

#### Methods

This is a secondary analysis of two randomized and two one-arm studies in brain tumor patients with new/progressive postoperative paresis in four centers in US, UK and Germany. Patients underwent either low frequency contralesional nrTMS or sham stimulation followed by physiotherapy. Outcome was assessed on postoperative day 1, 7, and after 3 months using British Medical Research Council (BMRC) score, Fugl-Meyer assessment (FMA), Karnofsky Performance Scale (KPS) and National Institutes of Health Stroke Scale (NIHSS).

#### Results

A total of 135 patients (mean age of 53.8 years, 60 women) were included, of whom 21 patients were treated in sham groups. Linear mixed models showed an advantage for the treatment group for the BMRC (7 days: OR 4.22; 95%CI: 1.08-16.52; 3 months: OR 10.85, 95%CI: 1.32-89.26) and KPS (7 days: MD 11, 95%CI: 3.19; 3 months: MD 11, 95%CI: 2.19), less pronounced for the FMA (7 days: MD 0.42, 95%CI: -0.23-1.06; 3 months: MD 0.26, 95%CI: -0.43-0.95). A stronger treatment effect was evident with proven ischemia on the postoperative MRI. To observe an improvement by at least one grade at 3 months, the NNT for the entire cohort is 4 (BMRC) and 3 patients (KPS), respectively.

#### Conclusion

Our multicenter data confirm the positive treatment effect of nrTMS on postoperative paresis with a considerably low NNT - especially if caused by ischemia.

# Innovation und Technik – Verschiedenes | Innovation and technology – Various

## V202

### Korrelation eines neuen Anatomisch Funktionellen Aphasie Screenings (AFAS) mit kortikalen und subkortikalen Läsionen bei linksseitigen Hirntumoren

***Correlation of a novel Anatomical Functional Aphasia Screening (AFAS) with cortical and subcortical lesion locations in left-sided brain tumors***

N. Knobloch[1], M. G. Prem[1], C. Buszello[1], G. Reiß[1], J. Linn[1], I. Y. Eyüpoglu[1], S. B. Sobottka[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Dresden, Deutschland

#### Objective

Identifying specific functional deficits of anatomical lesions in the eloquent cortical and subcortical language network is challenging, especially for German-speaking patients, due to a lack of appropriate language assessment tools. This study presents a novel Anatomical Functional Aphasia Screening (AFAS), based on the dual stream model of language.

#### Methods

We examined 55 patients (age range 20-87 years) with left-hemispheric brain tumors or epileptogenic lesions. The study considered variables such as age, gender, handedness, education, tumor localization, and histology. Most patients underwent AFAS and MRI/DTI pre-, post-operatively, and after 3-months, totaling 107 examinations. AFAS, encompassing 43 subtests, assesses auditory and visual receptive and expressive language functions, including naming, reading, writing, calculation, phonology/phonetics, articulation, semantics, lexicon, syntax, situational comprehension, working memory, figural description, and face recognition. The average examination time was 35.8 minutes.

#### Results

Patients were categorized based on lesion location. Certain AFAS subtests were predictive of specific tract disruptions and/or cortical lesions. Key subtests for UF (temporopolar or frontolaterobasal, n=6) included naming of famous faces/places. For FAT (Broca, supplementary motor area, n=9), significant tests were phonological and semantical fluency, and spelling (nonsense words). For AF (Broca, superior temporal gyrus, n=7), critical subtests included phonological odd word out, phonological and semantical fluency, word formation, reading comprehension, and syntactical sentence construction. For IFOF/ILF/MdLF (temporodorsal, n=18), reading aloud, reading comprehension, word formation, and sentence construction were notable. For IFOF/UF (fronto-insular, n=10), reading comprehension and naming of famous faces/places were significant, and for IFOF/ILF/AF (dorsotemporoparietal, n=5), spelling, sentence completion, word generation, and syntactical sentence construction were key.

#### Conclusion

AFAS offers precise and individualized language testing for neurosurgical patients. It facilitates anatomical functional correlation of specific language task deficits with cortical lesions and/or white matter tract disruptions and may predict functional regeneration potential. (UF: uncinate fascicle; FAT: frontal aslant tract; AF: arcuate fascicle; IFOF: inf. frontooccipital fascicle; ILF/MdLF: inf./mid. longitudinal fascicles)

V204

## Thrombembolie-Risiko nach Operationen an intrakraniellen Tumoren unter intraoperativer Anwendung einer intermittierenden pneumatischen Kompression der Beine: Protokoll einer prospektiven, randomisierten, einfach verblindeten Multicenter-Studie (TRIPCON)

***Intraoperative intermittent pneumatic compression (IPC) reduces incidence of venous thromboembolism in patients undergoing craniotomy: Protocol of randomized multi-center, single-blind trial (TRIPCON)***

M. Scheer[1], G. Schenk[1], C. Strauss[1], S. Rampp[1], J. Prell[1]

[1]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland

### Objective

Venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE), is a common complication in craniotomy patients. The duration of surgery has been identified as a risk factor for the development of VTE. In a pilot study, the use of intermittent pneumatic venous compression (IPC) dramatically reduced the incidence of VTE. Despite randomisation, a significant difference in the duration of surgery between the groups limited the validity of this result. The study was underpowered to compensate for this problem. We now present the protocol of a DFG-approved multicentre trial (TRIPCON).

### Methods

All patients receive medical compression stockings and LMWH from the first postoperative day. The therapy group receives IPC stockings intraoperatively. Post-operatively, all patients receive lower extremity duplex sonography to detect/exclude DVT within the first seven post-operative days. Contrast-enhanced chest CT is the gold standard for the detection of PE and is performed in cases of clinical suspicion of PE.

### Results

The incidence of VTE is the primary endpoint. The distinction between symptomatic and asymptomatic, aetiologies, influence of lesion type, duration of surgery and mortality will be evaluated as secondary endpoints.

The pilot study showed a VTE incidence of 26% in the control group versus 7% in the treatment group. To avoid overly optimistic treatment effect assumptions, we assume VTE rates of 9% and 24% in the treatment and control groups, respectively, and thus calculated a number of 127 patients per treatment group. Assuming a similar dropout rate as in the previous study (approximately 13%), 146 patients per group will need to be recruited.

An interim analysis will be performed after 50% of patients have been enrolled in order to adjust the sample size if necessary.

### Conclusion

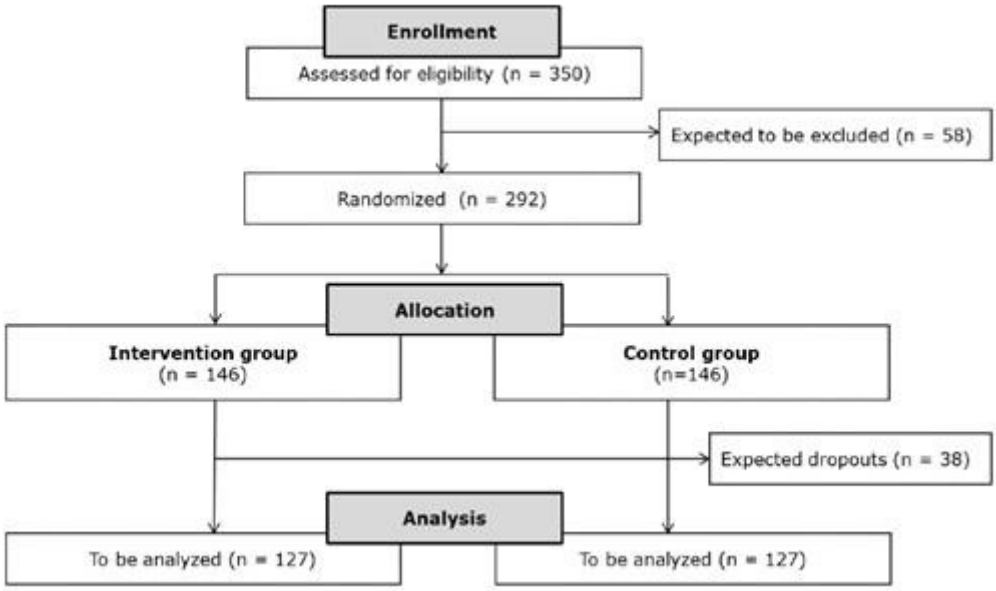
If this trial shows that intraoperative IPC reduces the risk of VTE to the extent observed in our pilot study (number needed to treat: 5.24), the potential benefit to neurosurgical patients would be significant. The results would potentially influence treatment guidelines by providing the high quality evidence needed to make robust recommendations.

Abb. 1

| Time point | Trial measure |
|---|---|
| Perioperatively | Graduated compression stockings |
| Surgical procedure | IPC (activated/not activated) |
| Starting on first postsurgical day | LMWH according to the specific standards of the respective center |
| Surgery to 7th postoperative day | Doppler-sonography: Primary (incidence of VTE) and secondary endpoints |
| Surgery to 7th postoperative day | Assessment of safety |

Abb. 2

**Flow Chart:**



# V205

## Topographisches Mapping des primär sensorischen Kortex mittels Intraoperativer Optischer Bildgebung
*Topographic mapping of the primary sensory cortex with intraoperative optical imaging*

M. Oelschlägel[1], W. H. Polanski[2], G. Steiner[1], E. Koch[1], T. Juratli[2], I. Y. Eyüpoglu[2], S. B. Sobottka[2]

[1]TU Dresden, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Klinisches Sensoring und Monitoring, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

### Objective

Intraoperative Optical Imaging (IOI) is a non-invasive imaging technique that is able to visualize functional areas of the cerebral cortex. Therefore, minimal changes in cortical optical properties are detected and evaluated. The physiological origin of the optical signal are changes in cortical hemodynamics that are following neuronal activation. Here, we are demonstrating the potential of the method for a detailed mapping of different body parts and their corresponding areas within primary sensory cortex (PSC).

### Methods

Measurements were performed on five patients that underwent surgical resection of lesions near the PSC (3 female, 2 male patients, median age 54 years). Different body parts of the patients (arm, hand, leg) were intraoperatively stimulated (tactile/electrical) and IOI data was acquired simultaneously. The localization of the activated regions within IOI was mapped onto anatomical MRI and plausibility was assessed in accordance to expected anatomical localization for the different regions. In two patients, IOI results were additionally compared towards preoperatively acquired fMRI datasets. Therefore, a quantitative approach using the Dice coefficient (DC) for assessment of activation overlap between fMRI and IOI was applied.

### Results

The results reveal in all five patients well delineated activated regions using the IOI technique. Furthermore, in all patients a plausible topographic distribution of the activated regions along the PSC were observed and results were in correspondence to electrophysiological measurements. Comparing IOI and fMRI activation, the brain areas that were activated in fMRI showed also in IOI a significant higher level of activity. The DICE coefficient evaluation reveals a good spatial agreement between both modalities for tactile stimulation of the hand (DC = 0.48 for patient #1 respectively DC = 0.61 for patient #2).

### Conclusion

IOI is in combination with a suitable stimulation method and paradigm able to identify distinct regions that are representing different body parts on PSC. Therefore, the method can provide valuable information about the localization of different functional areas during surgery.

# Innovation und Technik – Verschiedenes | Innovation and technology – Various

## V206

### Intraoperative KI-basierte Analyse und Diagnose intraduraler extramedullärer spinaler Tumore mit stimulierter Raman-Histologie (SRH)

***Intraoperative AI-based analysis and diagnosis of intradural extramedullary spinal tumors by Stimulated Raman Histology (SRH)***

P. Scheffler[1], N. Neidert[1], J. Strähle[1], D. Erny[2], V. Sacalean[1], B. Mizaikoff[3], I. Vasilikos[1], D. H. Heiland[1], J. Beck[1], A. El Rahal[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[2]Universitätsklinikum Freiburg, Klinik für Neuropathologie, Freiburg i. Br., Deutschland
[3]Universität Ulm, Institut für analytische und bioanalytische Chemie, Ulm, Deutschland

#### Objective

Intraoperative Stimulated Raman Histology (SRH) has been reported to be fast and accurate in the assessment of neurooncological lesions. However, the use of SRH in spinal tumors, especially intradural extramedullary tumors (IDEM), is not well described. Meningiomas and schwannomas are the most common IDEM pathologies; metastases, ependymomas, hemangioblastomas, and other tumor entities may also occur. Surgical resection is the primary step in the treatment of all these lesions, but the surgical approach and aggressiveness may depend on histopathological diagnosis. Here, we report our results from intraoperative AI-based analysis of SRH images for differentiating between various IDEM.

#### Methods

Between 2021 and 2023, intraoperative Stimulated Raman Histology (SRH) images from 46 patients were acquired using the NIO Laser Imaging System (Invenio Imaging Inc). Patients were assigned to separate training, validation and test datasets. The respective SRH images were subdivided into patches measuring 224x224 pixels. We trained and tested different neural networks based on the ResNet and Vision Transformer architectures for histopathological classification using definitive histopathological diagnoses as labels. Three diagnostic classes were created: "Meningioma", "Schwannoma", and "Other".

#### Results

Our best model based on the ResNet-50 architecture was able to differentiate between schwannomas, meningiomas, and other spinal tumors with an accuracy of 100% in our test set.

#### Conclusion

This study shows the potential of the AI-based analysis of intraoperative SRH-images and the clinical application in neurosurgery. Our approach is able to discriminate the most common intradural extramedullary lesions. AI- and SRH-based diagnosis is able to contribute to clinically meaningful surgical decision-making.

# Tumor – Neuromonitoring | Tumour – Neuromonitoring

## V207

### Vergleich des epiduralen vs. kortikalen motor mappings bei Operationen von motorisch eleoquent gelegenen Hirntumorläsionen

***Comparison of epidural and cortical motor mapping in eloquent brain tumours***

F. Staub-Bartelt[1], B. Opgen-Rhein[2], M. Rapp[1], M. Sabel[1]

[1]Universitätsklinikum Düsseldorf, Neurochirurgie, Düsseldorf, Deutschland
[2]Universitätsklinik Düsseldorf, Neurochirurgie, Düsseldorf, Deutschland

#### Objective

Direct electrical stimulation (DES) is an essential technique to identify the motor system and to avoid permanent deficits during brain tumour surgery. Combined use of a monopolar stimulator and a grid electrode placed on the M1 cortex can reliably map these structures at both cortical and subcortical levels. This method necessitates the direct stimulation hence exposure of M1, which can be technically problematic in recurrent cases due to adhesion of dural structures, suggesting the application of an epidural stimulation. Therefore, we compared the epidural motor mapping with direct cortical motor mapping data to assess the reliability and comparability of epidural stimulation parameter.

#### Methods

The study included patients with brain lesions, situated in the central area of the parietal lobe, presenting with no deficits or deficits accompanied by preserved motor function, who were scheduled for primary resection. Prior to dural incision, a matrix was created using the craniotomy as a template, perforated at 1 cm intervals across the matrix. Subsequently, the matrix was placed on the dura, and monopolar stimulation was applied at all perforated locations until reaching 15 mA or observing an electromyography (EMG) response. Motor thresholds (MT) and clinical responses were compared to cortical mapping data obtained after dural opening and matrix application on the cortex. Clinical outcomes, tumour locations, and histopathological results were also collected.

#### Results

Data from 35 patients have been included in the analysis. At 166 stimulation was performed with positive MEP recording.140 points could be stimulated epidural and cortical, mean MT epidural was 10.94 and cortical 10.74 mA. In 57 of these 140 points (40.7%) the MT was higher in epidural stimulation (mean difference 1.53 mA) and in 43 points (30.7%) cortical MT was higher (mean difference 1.47 mA). 13 points could only be stimulated epidural with a mean MT of 13.77, the same mean MT was seen in 13 points which could only be stimulated at the cortical surface.

#### Conclusion

In this preliminary analysis, we demonstrated that MEPs could be reliably evoked through epidural stimulation of the M1 cortex. However, when compared to direct cortical stimulation, a difference in MT was observed in about two-thirds of stimulated points. To further assess the discrepancy in MT, additional data acquisition is requiredand ongoing prospective studies will provide more insights.

# Tumor – Neuromonitoring | Tumour – Neuromonitoring

## V208

### Welches Elektrodensetting ist das Beste um Muskelsaktionspotenziale der unteren Extremitäten auszulösen im Rahmen von supratentoriellen Eingriffen?

***What is the best electrode setting to elicit motor evoked potentials in the muscles of lower extremities during supratentorial surgery?***

F. Komboz[1], J. B. Wemhoff[1], A. Nazarenus[1], D. Mielke[1], V. Rohde[1], T. Abboud[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland

### Objective

Eliciting intraoperative motor evoked potentials (MEP) in the muscles of lower extremities using transcranial electrical stimulation (TES) can be challenging and is often associated with undesired patient movement due to the required high current intensity, which bears the risk of stimulation at the brain stem level. The aim of this study was to determine the best setting of scalp electrodes with the minimal current intensity to elicit MEP in the lower extremities during supratentorial surgery.

### Methods

Patients who underwent surgery for a supratentorial lesion between 2019 and 2022 were prospectively included in the study. Exclusion criteria were preoperative epilepsy and motor deficit. TES- MEP were elicited with corkscrew electrodes using each of the following combination for all muscles: C1<->C2, C3<->C4, C3/4<->Cz and C3/4<->Cz+6. MEP were recorded bilaterally from M. abductor pollicis, M. tibialis anterior and M. abductor hallucis and motor threshold was established for each muscle and electrode combination. Stimulation intensities were analyzed to determine the electrode combination with the lowest stimulation value and the one with the best selectivity.

### Results

Seventy patients were included in the study. Mean age was 60±15.8 years. A total of 5880 measurements were performed. Rate of successful stimulation of the contralateral leg muscles was 95.71% (mean 118.6 mA) for C1<->C2, 99.64% (mean 83.00mA) for C3<->C4, 98.93% (mean 96,53mA) for C3/4<->Cz+6 and 93.21% (mean 146,49mA) for C3/4<->Cz.

The lowest stimulation for eliciting MEP in the leg muscles was achieved with C3<->C4 ($P < 0.001$). The best results considering the side selectivity were achieved by C3/4<->Cz+6 ($P < 0.001$).

### Conclusion

Eliciting MEP in the lower extremities was possible using many electrode combinations. While C3<->C4 enabled MEP recording with the lowest current intensities, C3/4<->Cz+6 was the most selective one and might be superior in supratentorial surgery to avoid stimulation at the brain stem level.

# Tumor – Neuromonitoring | Tumour – Neuromonitoring

## V209

### Die Einwirkung von eloquenten Hirntumoren auf die Erregbarkeit der primär-motorische Rinde
*Influence of eloquent brain tumors on excitability of the primary motor cortex*

J. Wermelinger[1], K. Lutz[1], H. Lenggenhager[2], K. Seidel[1]

[1]Inselspital, Universitätsklinik für Neurochirurgie, Bern, Schweiz
[2]Universität Bern, Medizin, Bern, Schweiz

#### Objective

The effects of motor eloquent brain tumors on cortical excitability and the motor network are still not completely understood. In this study, we compare the motor evoked potential (MEP) resting motor threshold (RMT) during preoperative transcranial magnetic stimulation (TMS) examination with the baseline MEP motor threshold (MT) of intraoperative neurophysiological monitoring (IOM) in relation to various clinical and tumor characteristics.

#### Methods

We included 65 patients with motor eloquent tumors who underwent surgery with IOM and had a preoperative TMS examination. The TMS-RMT and the IOM-MT of the abductor pollicis brevis muscle (APB) were collected. A previously defined threshold ratio was used for TMS ($TMS\text{-}RMT_{ratio}=TMS\text{-}RMT_{tumor}/TMS\text{-}RMT_{healthy}$), and similarly for IOM ($IOM\text{-}MT_{ratio}=IOM\text{-}MT_{tumor}/IOM\text{-}MT_{healthy}$), as surrogate markers for cortical excitability analysis. Additionally, a random forest (RF) classifier was used to see whether a machine learning (ML) algorithm was able to distinguish healthy from tumor side IOM MEPs.

#### Results

Tumor side TMS-RMT was significantly higher than healthy side TMS-RMT ($TMS\text{-}RMT_{ratio}$ = 112%), and tumor side IOM-MT was significantly higher than healthy side IOM-MT ($IOM\text{-}MT_{ratio}$ = 152%). There was a significant positive linear correlation between the $TMS\text{-}RMT_{ratio}$ and the $IOM\text{-}MT_{ratio}$. For tumors in the precentral gyrus, the average $TMS\text{-}RMT_{ratio}$ and $IOM\text{-}MT_{ratio}$ were significantly higher than 100% ($TMS\text{-}RMT_{ratio}$ = 123% and $IOM\text{-}MT_{ratio}$ = 158%). Furthermore, the RF model achieved 87% accuracy on the IOM MEP data classification task.

#### Conclusion

We observed a lower excitability in the tumor hemisphere compared to the healthy hemisphere, both pre- and intraoperatively. Low excitability in preoperative TMS generally correlated with lower intraoperative excitability. In particular, tumors in the precentral gyrus seem to affect the excitability of the motor system more than tumors in other cortical regions, with the healthy side being more excitable than the tumor side. Finally, a standard ML algorithm was able to classify healthy and tumor side MEPs accurately with our data, indicating that there might be additional neurophysiological markers of excitability in MEPs.

# V210

## Kortiko-kortikal evozierte Potenziale des Arcuate-Faszikels bei der minimal-invasiven Gliomchirurgie unter Verwendung der Penfield-Stimulation

***Cortico-cortical evoked potentials of the arcuate fascicle in minimally invasive glioma surgery guided by Penfield stimulation***

K. Seidel[1], J. Wermelinger[1], P. Alvarez-Abut[1], V. Deletis[2], A. Raabe[1], D. Zhang[1], P. Schucht[1]

[1]Inselspital – Universitätsspital Bern, Abteilung für Neurochirurgie, Bern, Schweiz
[2]Albert Einstein College of Medicine, New York, NY, Vereinigte Staaten

### Objective

We investigated the feasibility of recording cortico-cortical evoked potentials (CCEPs) in patients with low- and high-grade glioma. We compared CCEPs during awake and asleep surgery, as well as those stimulated from the functional Broca area and recorded from the functional Wernicke area (BtW), and vice versa (WtB). We also analyzed CCEP properties according to tumor location, histopathology, and aphasia.

### Methods

We included 20 patients who underwent minimally invasive surgery in an asleep-awake-asleep setting. Strip electrode placement was guided by classical Penfield stimulation of positive language sites and fiber tracking of the arcuate fascicle (Figure 1). CCEPs were elicited with alternating monophasic single pulses of 1.1 Hz frequency and recorded as averaged signals. Intraoperatively, there was no post-processing of the signal (Figure 2).

### Results

Ninety-seven CCEPs from 19 patients were analyzed. There was no significant difference in CCEP properties when comparing awake versus asleep, nor BtW versus WtB. CCEP amplitude and latency were affected by tumor location and histopathology. CCEP features after tumor resection correlated with short- and long-term postoperative aphasia.

### Conclusion

CCEP recordings are feasible during minimally invasive surgery. CCEPs might be surrogate markers for altered connectivity of the arcuate fascicle. This study may guide the incorporation of CCEPs into intraoperative neurophysiological monitoring.

Abb. 1

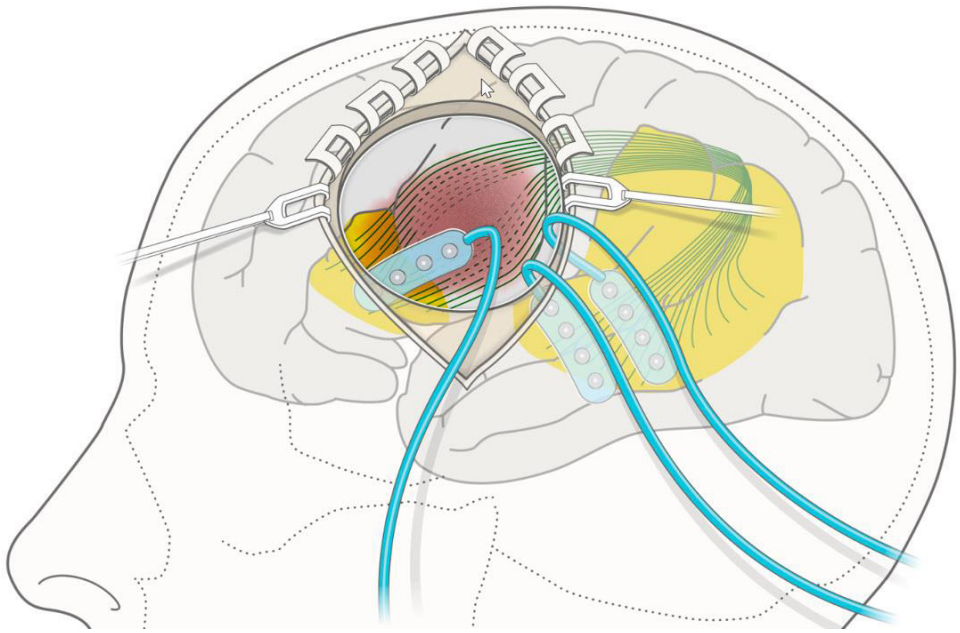
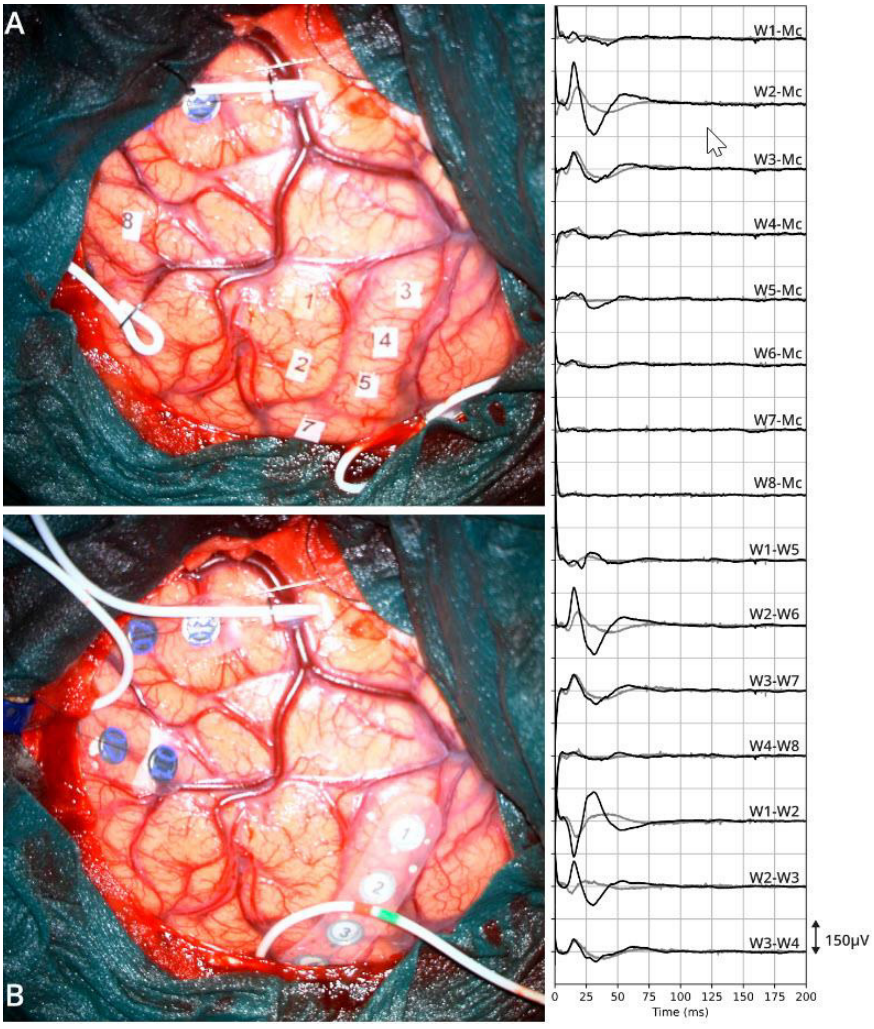


Abb. 2


A
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W1-W2
W2-W3
W3-W4
150µV
0 25 50 75 100 125 150 175 200
Time (ms)

# Tumor – Neuromonitoring | Tumour – Neuromonitoring

## V211

### Reduzierte visuelle Funktionen in neuropsychologischen Testungen bei Patienten mit Hirntumor im Bereich der radiatio optica

***Impaired visual cognitive functioning in patients with brain tumors in the projection zone of the optic radiation***

K. Hense[1], N. O. Schmidt[1], K. Rosengarth[1]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland

#### Objective

A brain tumor along the visual pathway may affect different domains of general visual functioning as the visual field but also visual cognitive functioning. The aim of this study was to characterize these possible deficits using neuropsychological tests covering various visual cognitive functions in patients with tumors in the projection zone of the optic radiation.

#### Methods

In total, data from 49 patients (23 female, mean age 51.69 years) prior to tumor surgery were included in this study. Based on the tumor location, patients were assigned to a group with tumors in the projection zone of the optic radiation (23 patients, thereof 3 patients with reported visual field impairments) and to a group with tumors with no local association to the optic radiation (26 patients).

Neuropsychological testing included Rey-Osterrieth Complex Figure - Copy (visuo-constructive functions), Rey-Osterrieth Complex Figure - 30min Recall (visual memory), Trail Making Test A (visuo-motor speed; visual attention), Digit Symbol Coding (visuo-motor speed; visual attention), and Corsi Block Span task (visual working memory). The raw scores of the individual tests were transformed into standardized z-values and subsequently into percentile ranks based on the respective norm sample taking the age of the patients into account.

#### Results

When comparing the two patient groups using Mann-Whitney U tests, patients with tumors in the projection zone of the optic radiation showed lower percentile ranks in the Rey-Osterrieth Complex Figure - Copy ($p = .048$) and Rey-Osterrieth Complex Figure - 30min Recall ($p = .005$) tests. There was also a trend in the Digit Symbol Coding test ($p = .081$), while both patient groups showed comparable results in the Trail Making Test A and Corsi Block Span task.

#### Conclusion

Neuropsychological assessments can provide valuable information on preoperatively existing deficits, as was shown in this study using the example of brain tumors in the projection zone of the optic radiation. These patients showed reduced performance in visuo-constructive functions, visual memory, and visuo-motor speed. The results also indicate that deficits can exist throughout different domains, which emphasizes the complexity of the visual system.

# V212

## *Strukturelle Repräsentationen rechts-hemisphärischer frontaler Sprechtrakte korrelieren mit Aphasie und Dysarthrie Schweregraden bei Hirntumorpatient:innen*
## *Structural representations of right-hemispheric frontal speech tracts correlate with aphasia and dysarthria severity in brain tumor patients*

L. Kram[1,2], H. Zhang[1,2], B. Neu[1], A. Schröder[1], B. Meyer[1], S. Krieg[1,2], S. Ille[1,2]

[1]Klinikum rechts der Isar, Technische Universität München, Department of Neurosurgery, München, Deutschland
[2]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland

### Objective

The inferior frontal gyrus links perisylvian language and speech networks via a hyper-direct pathway to the subthalamic nucleus (HP) and the frontal aslant tract (FAT). Alterations to these pathways are frequently related to speech disorders. Still, the exact role of these pathways in the context of speech and language disorders needs to be better understood. Thus, this study examined the association between language disorders (aphasia) and speech disorders (dysarthria) with the structural representation of FAT and HP.

### Methods

The presence and severity of speech and language disorders were evaluated by a speech and language therapist for 55 left-hemispheric brain tumor patients treated between 11/2016 and 08/2020. Post-hoc bi-hemispheric tractography of HP and FAT was performed, and the respective tract fiber count relative to whole brain fiber count was calculated to examine the inter-individual structural tract representation.

### Results

Correlational analyses linked higher right-hemispheric FAT and lower right-hemispheric HP tract ratios to worse aphasia ($p \leq 0.03$, respectively). Additionally, milder dysarthria was associated with more pronounced right-hemispheric HP ($p=0.01$). Since aphasia and dysarthria severity positively correlated ($p=0.01$), the association of right-hemispheric HP and aphasia may have been impacted by the presence of dysarthria.

### Conclusion

Our results suggest a structural basis for language and speech performance variance. The association of right-hemispheric HP with dysarthric severity may indicate higher recruitment of right-hemispheric speech systems compensating for the left-hemispheric breakdown. Additionally, the right-hemispheric FAT was more pronounced in patients with worse aphasia, potentially suggesting structural compensatory processes as a response to the left-hemispheric language network disruption.

# Spinal – Verschiedenes 5 | Spinal – Various 5

## V213

### Zu krank für eine Operation oder zu krank, um nicht operiert zu werden? Eine Bewertung von septischen Patienten mit Spondylodiszitis – die 2SICK-Studie der EANS Wirbelsäulen-Sektion

***Too sick to have surgery or too sick to not have surgery? An evaluation of septic patients with spondylodiscitis – The 2SICK study by the EANS Spine Section***

A. Kramer[1,2], S. G. Thavarajasingam[1,3,2], J. Neuhoff[4,2], H. Subbiah Ponniah[3], B. Meyer[5], E. Shiban[2,6], B. Davies[2,7], A. K. Demetriades[2,8], F. Ringel[1,2]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Spondylodiscitis Study Group, EANS Spine Section, Brussels, Belgien
[3]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich
[4]Berufsgenossenschaftliche Unfallklinik Frankfurt am Main, Center for Spinal Surgery and Neurotraumatology, Frankfurt a. M., Deutschland
[5]Klinikum rechts der Isar, Technical University of Munich, Department of Neurosurgery, München, Deutschland
[6]Universitätsklinikum Augsburg, Department of Neurosurgery, Augsburg, Deutschland
[7]Addenbroke's Hospital, Cambridge University Hospital NHS Healthcare Trust, Department of Academic Neurosurgery, Cambridge, Vereinigtes Königreich
[8]NHS Lothian, Edinburgh University Hospitals, Edinburgh Spinal Surgery Outcome Studies Group, Department of Neurosurgery, Division of Clinical Neurosciences, Edinburgh, Vereinigtes Königreich

#### Objective

The management of septic spondylodiscitis presents a clinical challenge, with debates surrounding the timing of surgical intervention. The 2SICK study addresses the gap in evidence concerning the efficacy of early surgery versus conservative management in these critically ill patients.

#### Methods

A multicentric, international retrospective cohort study was conducted, encompassing cases from 2015-2022. Patients were stratified by treatment modality (early surgery within 3 days of admission, delayed surgery after 3 or more days of non-surgical stabilisation, and conservative therapy). Chi-square tests, univariate analyses, stepwise and regularization-boosted multivariate regression analyses were used to examine outcome differences in mortality and relapse of spondylodiscitis.

#### Results

A total of 189 patients, with a mean age of 69 years, were evaluated. Among these, 36 underwent conservative therapy, 79 underwent early surgery, 74 received delayed surgery. The subgroup undergoing delayed surgery exhibited the lowest mortality rates, with 4.1% In comparison, the mortality rates for early surgery and conservative therapy were 28.2% and 27.8%, respectively. The ideal time frame for delayed surgery, in terms of mortality, was found to between 10 and 14 days from admission. Accounting for confounders, delayed surgery was found to be significantly associated with decreased mortality ($p<0.01$) compared to conservative therapy, early surgery with increased mortality compared to conservative therapy ($p<0.05$). Positive predictors of mortality were found to be age, reduced GFR, raised creatinine, multiple organ failure, and cervical location of the infection, erosion of endplates, presence of psoas abscess and tachycardia at admission ($p<0.05$). Negative predictors were days between admission and surgery and presence of epidural abscess ($p<0.05$).

#### Conclusion

Delayed surgery was found to be associated with significantly less mortality compared to early surgery and conservative therapy in patients with septic spondylodiscitis. The likely optimal window for surgery is 10 to 14 days from admission. The strongest predictors of death were early surgery within 3 days of admission, vertebral endplate erosion, and multiple organ failure.

Abb. 1

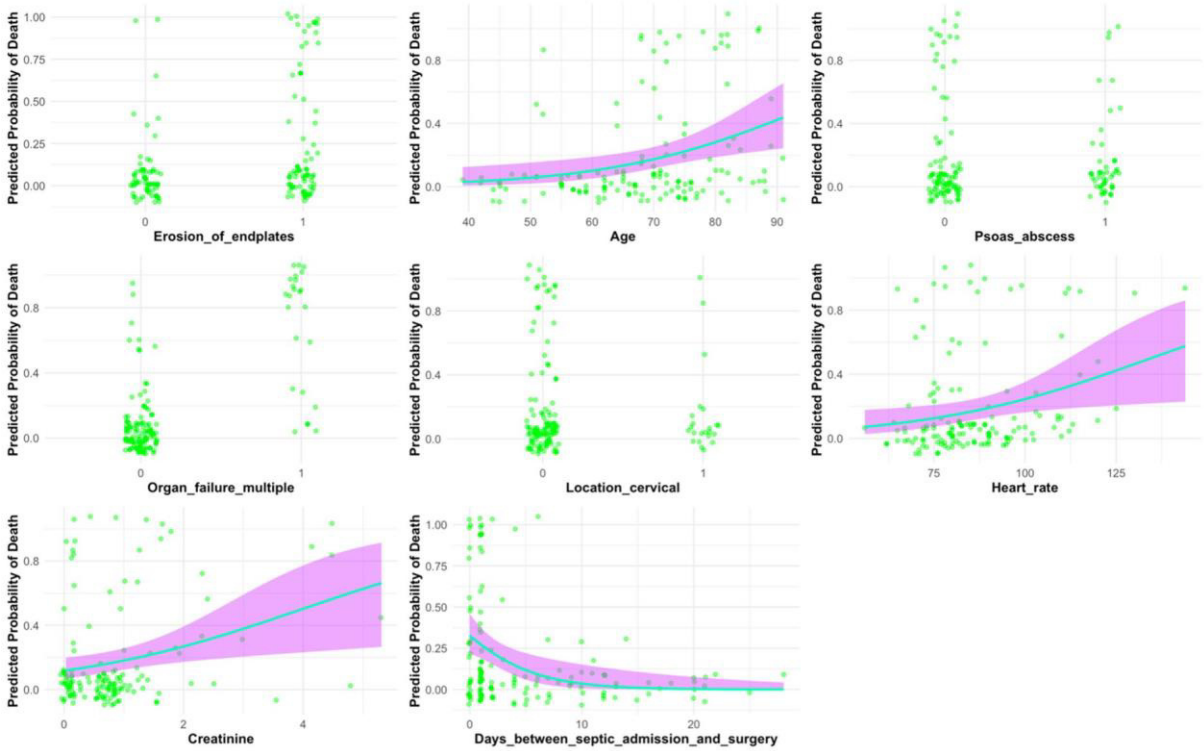
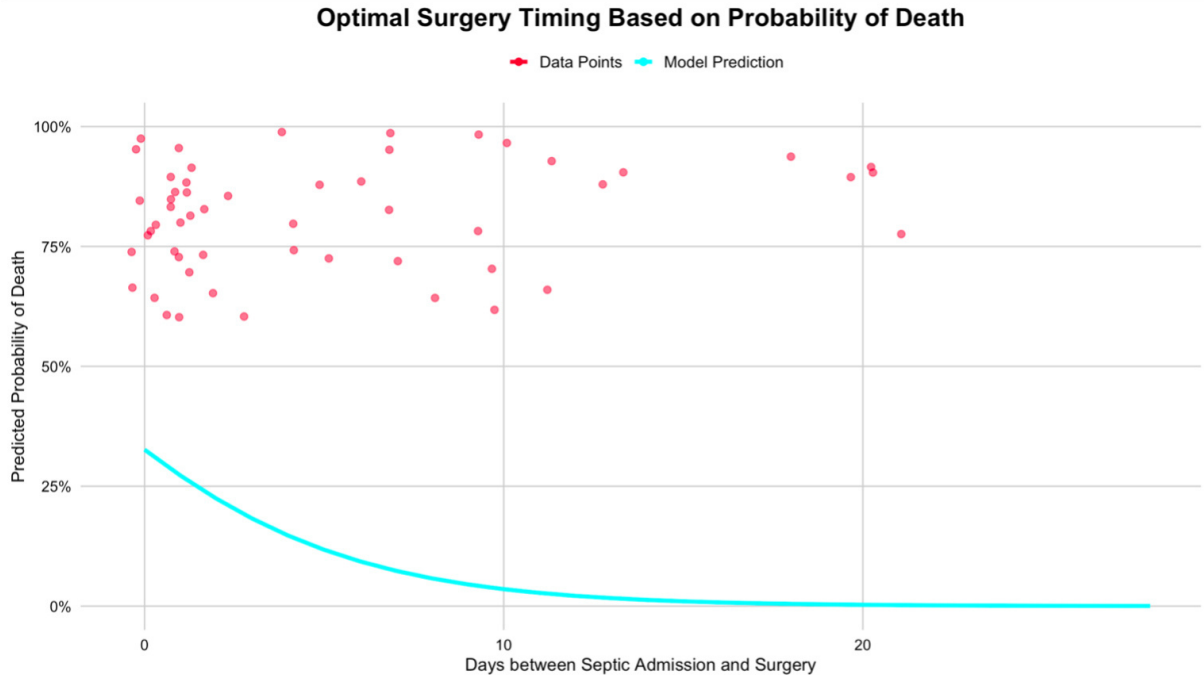

Predicted Probability of Death
Erosion_of_endplates
Age
Psoas_abscess
Organ_failure_multiple
Location_cervical
Heart_rate
Creatinine
Days_between_septic_admission_and_surgery

Abb. 2


Optimal Surgery Timing Based on Probability of Death
Data Points
Model Prediction
Predicted Probability of Death
100%
75%
50%
25%
0%
0
10
20
Days between Septic Admission and Surgery

# Spinal – Verschiedenes 5 | Spinal – Various 5

## V214

### Eine Propensity-Score-Matched-Multicenter-Kohortenstudie zum Vergleich der Mortalität bei konservativer vs. chirurgischer Behandlung der pyogenen Spondylodiszitis

***A propensity-score-matched multicenter cohort study comparing mortality in conservative vs. surgical treatment of pyogenic spondylodiscitis***

A. Kramer[1], J. Neuhoff[2], S. G. Thavarajasingam[3], A. K. Jörger[4], H. S. Ponniah[5], D. S. C. Ramsay[5], B. Davies[6], B. Meyer[4], F. Kandziora[2], E. Shiban[7], A. Demetriades[8], F. Ringel[3]

[1]Universitätsmedizin Mainz, Neurochirurgie, Mainz, Deutschland
[2]Berufsgenossenschaftliche Unfallklinik Frankfurt am Main, Wirbelsäulenchirurgie und Neurotraumatologie, Frankfurt a. M., Deutschland
[3]Universitätsmedizin Mainz, Klinik mit Poliklinik für Neurochirurgie, Mainz, Deutschland
[4]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[5]Imperial College NHS Healthcare Trust, Faculty of Medicine, London, Vereinigtes Königreich
[6]Cambridge University Hospital, Department of Academic Neurosurgery, Cambridge, Vereinigtes Königreich
[7]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland
[8]Edinburgh University Hospitals, Department of Neurosurgery, Edinburgh, Vereinigtes Königreich

#### Objective

The optimal treatment approach for patients with spinal infections remains a topic of debate and fundamentally different therapeutic concepts are observed within Europe. This study aimed to compare outcomes between conservative and surgical treatment in primary pyogenic spondylodiscitis using an international cohort analysis.

#### Methods

The study utilized retrospective data from spine centers (2017-2022) on primary spondylodiscitis, comparing treatments through propensity score matching of the conservative and surgical patient cohorts. Primary outcome was mortality, secondary outcomes included neurological impairment and infection relapse.

#### Results

A total of 392 patients were analyzed, with a mean age of 68 years (155 females, 237 males). Among them, 95 cases received conservative treatment (CoT) and 297 cases underwent surgery (SuT). The majority of conservatively treated patients were in the United Kingdom (CoT 81, SuT 7), while the majority of surgically treated cases were in Germany (CoT 14, SuT 290). In the pre-matched analysis, there were no significant differences in disease characteristics between the two groups. However, the overall mortality rate was significantly higher in the conservative treatment group ($p<0.001$). The propensity-matched analysis resulted in two equal cohorts of 95 patients each. The matched analysis revealed a significantly higher mortality rate in the conservative treatment group (24.2% for CoT vs. 6.3% for SuT, $p<0.01$). There were no significant differences in relapse (CoT 6.3%, SuT 7.3%, $p=0.64$) or neurological status at discharge (CoT 22.1%, SuT 14.7%, $p=0.27$).Multivariate regression analysis revealed that age, white cell count, conservative treatment, diabetes, and malignancy were identified as significant predictive factors for mortality. Regarding relapse, both white cell count and age were found to be significant predictive factors. In terms of neurological status, age emerged as the sole significant predictive factor.

#### Conclusion

This international data analysis, with its inherent limitations, supports the growing evidence of significantly reduced mortality rates associated with surgical therapy compared to conservative treatment for primary pyogenic spondylodiscitis. Although relapse rates and neurological deficits did not differ significantly between

the two approaches, the findings highlight the importance of considering surgical intervention to improve patient outcomes in these cases.

# Spinal – Verschiedenes 5 | Spinal – Various 5

## V215

### Die Bedeutung der gleichzeitigen infektiösen Endokarditis bei Patienten mit Spondylodiszitis und isoliertem spinalem Epiduralempyem und die diagnostische Genauigkeit der modifizierten Duke-Kriterien

***The impact of concomitant infective endocarditis in patients with spondylodiscitis and isolated spinal epidural empyema and the diagnostic accuracy of the modified Duke criteria***

M. M. Hijazi[1], T. Siepmann[2], I. El-battrawy[3], A. Aweimer[3], P. Schröttner[4], M. Mirus[5], D. Podlesek[1], G. Schackert[1], T. Juratli[1], I. Y. Eyüpoglu[1], A. Filis[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neurologie, Dresden, Deutschland
[3]Universitätsklinikum Bochum, Kardiologie, Bochum, Deutschland
[4]Universitätsklinikum Carl Gustav Carus Dresden, Mikrobiologie, Dresden, Deutschland
[5]Universitätsklinikum Carl Gustav Carus Dresden, Anästhesie, Dresden, Deutschland

#### Objective

The co-occurrence of infective endocarditis (IE) and primary spinal infections (PSI) such as spondylodiscitis (SD) and isolated spinal epidural empyema (ISEE) represents a life-threatening infection that requires multidisciplinary management to be successful. Therefore, we aimed to characterize the clinical phenotypes of PSI patients with concomitant IE and evaluate the accuracy of the modified Duke criteria.

#### Methods

We conducted a retrospective cohort study comparing PSI patients with IE (PSICIE) and without IE (PSIWIE) who underwent surgery at our spine center between 2002 and 2022 to identify significant differences.

#### Results

Methicillin-susceptible Staphylococcus aureus (MSSA) was the most common pathogen in PSICIE group (13 patients, 54.2 %) and aortic valve IE was the most common type of IE (12 patients, 50%). Hepatic cirrhosis ($p < 0.011$; OR: 4.383; 95% CI: 1.405 - 13.671), septic embolism ($p < 0.005$; OR: 4.387; 95% CI: 1.555 - 12.380), and infection with Streptococcus spp. and Enterococcus spp. ($p < 0.003$; OR: 13.830; 95% CI: 2.454 - 77.929) were identified as significant independent risk factors for the co-occurrence of IE and PSI in our cohort. The modified Duke criteria demonstrated a sensitivity of 100% and a specificity of 66.7% for the detection of IE in PSI patients. Pathogens were detected more frequently via blood cultures in the PSICIE group than in the PSIWIE group (PSICIE: 23, 95.8% vs. PSIWIE: 88, 62.4%, $p < 0.001$). Hepatic cirrhosis (PSICIE: 10, 41.7% vs. PSIWIE: 33, 21.6%, $p = 0.042$), pleural abscess (PSICIE: 9, 37.5% vs. PSIWIE: 25, 16.3%, $p = 0.024$), sepsis (PSICIE: 20, 83.3% vs. PSIWIE: 67, 43.8%, $p < 0.001$), septic embolism (PSICIE: 16/23, 69.6% vs. PSIWIE: 37/134, 27. 6%, $p < 0.001$) and meningism (PSICIE: 8/23, 34.8% vs. PSIWIE: 21/152, 13.8%, $p = 0.030$) occurred more frequently in PSICIE than in PSIWIE patients. PSICIE patients spent more time in the hospital than PSIWIE (PSICIE: 43.5 [33.5 - 53.5] days vs. PSIWIE: 31 [22 - 44] days, $p = 0.003$).

#### Conclusion

We report distinct clinical, radiological, and microbiological phenotypes in PSICIE and PSIWIE patients and further demonstrate the diagnostic accuracy of the modified Duke criteria in patients with PSI and concomitant IE. In the high-risk population of PSI patients, the modified Duke criteria might benefit from amending pleural abscess, meningism, and sepsis as minor criteria and hepatic cirrhosis as major criterion.

Abb. 1

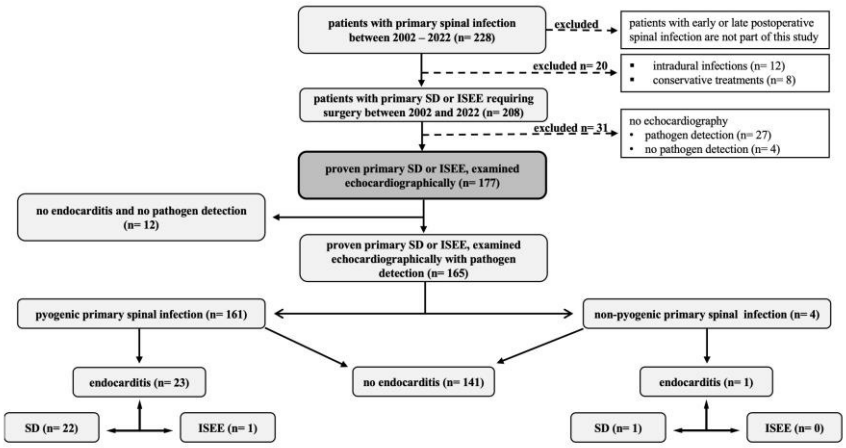
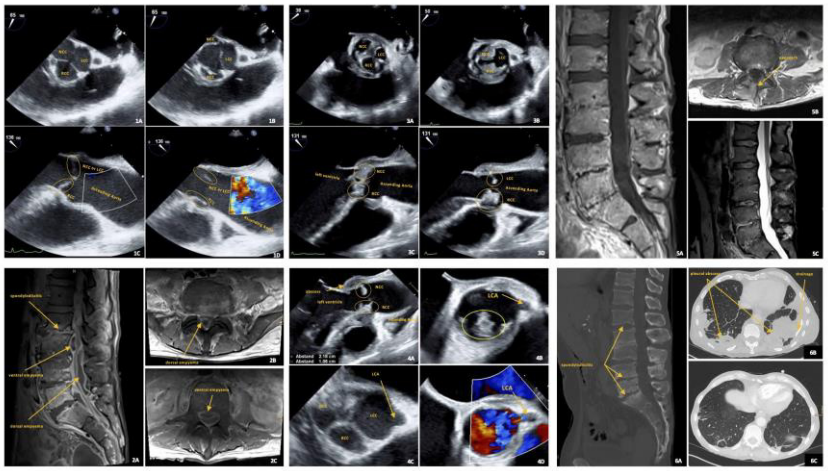

patients with primary spinal infection between 2002 – 2022 (n= 228)
excluded
patients with early or late postoperative spinal infection are not part of this study
excluded n= 20
intradural infections (n= 12)
conservative treatments (n= 8)
patients with primary SD or ISEE requiring surgery between 2002 and 2022 (n= 208)
excluded n= 31
no echocardiography
pathogen detection (n= 27)
no pathogen detection (n= 4)
proven primary SD or ISEE, examined echocardiographically (n= 177)
no endocarditis and no pathogen detection (n= 12)
proven primary SD or ISEE, examined echocardiographically with pathogen detection (n= 165)
pyogenic primary spinal infection (n= 161)
non-pyogenic primary spinal infection (n= 4)
endocarditis (n= 23)
no endocarditis (n= 141)
endocarditis (n= 1)
SD (n= 22)
ISEE (n= 1)
SD (n= 1)
ISEE (n= 0)

Abb. 2



# Spinal – Verschiedenes 5 | Spinal – Various 5

## V216

### Die chirurgische Behandlung Spinaler Metastasen des Thorakolumbalen Übergangs – Indikationen, Management und Morbidität anhand einer multizentrischen Registerstudie.

***Surgical treatment of spinal metastases at the thoracolumbar junction – factors influencing surgical decision-making, management, and morbidity according to a multicentric registry***

V. Hubertus[1,2], A. Wagner[3], A. Karbe[4], L. G. Köpke[3], B. Kunze[5], S. Borchert[5], F. Kilinç[6], N. Nissimov[1], M. Mariño[7,8], C. Buhre[1], M. Czabanka[6], M. Dreimann[5], S. O. Eicker[9], L. Viezens[3], H. S. Meyer[4], B. Meyer[10], P. Vajkoczy[1], J. S. Onken[1,2]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, Berlin, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Orthopädie und Unfallchirurgie, Hamburg, Deutschland
[4]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[5]Wirbelsäulenzentrum Markgröningen, Wirbelsäulenchirurgie, Markgröningen, Deutschland
[6]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Neurochirurgie, Frankfurt a. M., Deutschland
[7]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[8]Helios Klinikum Berlin-Buch, Neurochirurgie, Berlin, Deutschland
[9]Lubinus Clinicum, Wirbelsäulenchirurgie, Kiel, Deutschland
[10]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland

#### Objective

Spinal metastases of the thoracolumbar junction (TLJ) pose a significant risk for spinal instability and necessitate special considerations regarding surgical advance. Longer patient survival thanks to improved oncologic therapies may justify more extensive instrumented surgery. The aim of this study is to analyze the standard of care in a large multicentric cohort of patients with TLJ metastases regarding surgical indications, management, and associated morbidity.

#### Methods

Patients with TLJ metastases were enrolled at five German academic spine centers between 2010-2022. Data on epidemiology, surgery, clinical status, and outcome was retrospectively assessed. Surgical advance was sorted according to three groups: i) decompression only, ii) decompression + posterior instrumentation, and iii) decompression + 360° instrumentation + vertebral body replacement. Sole biopsies or kypho-/vertebroplasties were excluded.

#### Results

396 patients met the inclusion criteria. 15% (n=59) were treated with sole decompression (i), 59% (n=235) with posterior instrumentation (ii), and 26% (n=102) with additional vertebral body replacement (iii). Patients treated with sole decompression (i) presented more frequently with acute neurological deficits (64% i vs. 34%/28% ii/iii, $p<0.001$) and lower physical status (KPS 70 in i/ii vs. 80 in iii). Surgical complications occurred in 14% (n=55), slightly more frequently in groups receiving instrumentation (15% ii, iii vs. 8% i, $p>0.05$). Reoperations were necessary in 16% (n=65), due to SSI (29%, n=19), local recurrence (23%, n=15), and hardware failure (18%, n=9, i-iii, $p>0.05$). Median postoperative survival was 10 months, with the shortest postoperative survival in i) with 6 months (21 ii /37 iii, $p<0.05$). The occurrence of complications reduced postoperative survival drastically in all groups ($p=0.002$).

#### Conclusion

In this large multicentric patient cohort with TLJ metastases, 85% (n=337) were treated with instrumented spine surgery, including 192 (28%) 360° instrumentations with vertebral body replacement. Postoperative

complication rate was moderate with 14%, similar between groups. Postoperative survival was longer in instrumented cases and drastically reduced by the occurrence of postoperative complications, independent of surgical complexity.

# Spinal – Verschiedenes 5 | Spinal – Various 5

## V217

### Carbon-PEEK Implantate in der spinalen Onkologie –multizentrische Erfahrungen über den Einfluss auf das postoperative Management.

***The role of carbon-fiber reinforced PEEK implants in oncologic spine surgery – A multicenter experience on implications for postoperative patient management***

V. Hubertus[1,2], A. Wagner[3], D. Jankovic[4], M. Turgut[4], D. Kalasauskas[4], S. Lener[5], R. Gmeiner[5], H. Miller[1], M. Brüsseler[1], C. Buhre[1], G. Acker[1,2,6], N. Hecht[1,2], J. S. Onken[1,2], S. E. Combs[7], C. Thomé[5], F. Ringel[4], P. Vajkoczy[1], B. Meyer[3]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, Berlin, Deutschland
[3]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[4]Universitätsklinikum Mainz, Neurochirurgie, Mainz, Deutschland
[5]Medical University of Innsbruck, Neurochirurgie, Innsbruck, Österreich
[6]Charité – Universitätsmedizin Berlin, Cyberknife-Zentrum, Berlin, Deutschland
[7]Klinikum rechts der Isar, Technische Universität München, Radioonkologie, München, Deutschland

#### Objective

Carbon-fiber reinforced PEEK (CFRP) implants have been used safely for spine instrumentations in spinal oncology and promise improved imaging follow-up and radiotherapy treatment planning. However, data on the implant`s routine use in the clinical setting with implications for surgical complications and reoperations is scarce. The aim of this study is to analyze one of the largest multicentric patient cohorts to date with CFRP implants routinely used for the surgical treatment of spinal oncologic disease.

#### Methods

Patients treated with CFRP instrumentations due to spinal oncological disease were enrolled between 2015-2022 at four participating tertiary spine centers in Germany and Austria. Data on patient`s epidemiology, clinical satus, surgery, and outcome was collected retrospectively. Data management was performed using a multicentric REDCap® database.

#### Results

A total of 457 patients with CFRP instrumentations of spinal tumors at the thoracic and lumbar spine were enrolled in the study. Most patients received decompression and instrumentation (67%, n=308), with additional cage implantation in 33% (n=149). In most cases, image-guided navigated screw implantation was performed (70%, n=321). Postoperative complication rate was 13% (n=61), and mostly due to surgical site infections (n=32). Postoperative MRI was performed in 19% (n=87), with MRI findings prompting revision surgery in 15 cases. Postoperatively, 65% (n=278) of all patients received adjuvant irradiation therapy, and 32% (n=124) routine MRI follow-up, where local tumor recurrence was detected in 35% (n=44).

#### Conclusion

With this study, we present one of the largest multicentric cohorts of patients routinely treated with CFRP instrumentations for spinal oncologic disease. We report a low overall surgical complication rate of 13%. Direct postoperative MRI was performed in a minority of patients and prompted revision surgery in only a few cases. Routine MRI follow-up was received by less than a third of patients. Although CFRP implants hold the potential to improve the quality of imaging follow-up and facilitate ameliorated adjuvant irradiation planning, its routine clinical use remains limited.

# Spinal – Verschiedenes 5 | Spinal – Various 5

## V218

### Das Ausmaß der präoperativen BSCB-Schädigung korreliert mit der neurologischen 1-Jahres-Erholung nach chirurgischer Dekompression

***The extent of preoperative BSCB damage correlates with 1-year neurological recovery after surgical decompression***

T. P. Schmidt[1], S. Hinnenberg[1], K. Jütten[1], U. Bertram[1], C. A. Müller[1], H. R. Clusmann[1], C. Blume[1]

[1]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland

#### Objective

The pathophysiology of degenerative cervical myelopathy (DCM) involves chronic compression-induced damage to the spinal cord, resulting in secondary effects such as the disruption of the blood-spinal cord barrier (BSCB). Our data has already demonstrated that surgical decompression leads to short-term BSCB recovery three months postoperatively.

#### Methods

This prospectively controlled cohort study investigates BSCB disruption in both pre- and postoperative DCM patients, aiming to correlate these findings with one-year postoperative outcomes. The study included 50 DCM patients (21 females; 29 males; mean age: 62.9 ± 11.1 years), with a 11-person loss to follow-up. All patients underwent a neurological examination and DCM-associated modified Japanese Orthopaedic Association Score (mJOA) were evaluated. To assess the preoperative BSCB status, blood and cerebrospinal fluid (CSF) samples were collected. Albumin, immunoglobulin (Ig) G, IgA and IgM quotients for CSF/serum were standardized and calculated following Reiber diagnostic criteria.

#### Results

Notably, all preoperative CSF/serum quotients correlated significantly with one-year postoperative mJOA (*all* $p < .03$), with IgAQ showing robust significance after Bonferroni correction ($p = .003$). Furthermore, a smaller preoperative CSF/serum quotient corresponded to a more substantial postoperative improvement in mJOA after one year: IgAQ (p = .011), AlbQ ($p = .018$) and IgGQ ($p = .008$).

#### Conclusion

This study reinforces previous findings indicating the presence of BSCB disruption and recovery in DCM patients. Interestingly, the preoperative extent of BSCB damage seems to negatively correlate with better postoperative neurological recovery. BSCB disruption could be a crucial pathomechanism in DCM patients, holding significance for treatment and clinical recovery.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 4

## V219

### Analyse der Liquor-Drainage und Hirndruckspitzen bei Patient:innen mit Subarachnoidalblutungen

***Analysis of cerebral spinal fluid drainage and intracranial pressure peaks in patients suffering from subarachnoid hemorrhage***

A. Früh[1], P. Truckenmüller[1], D. Wasilewski[1], P. Vajkoczy[1], S. Wolf[1]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland

#### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) is a life-threatening condition with substantial morbidity and mortality. Elevated intracranial pressure (ICP), due to disrupted cerebrospinal fluid (CSF) dynamics, is a critical concern, typically managed via external ventricular drainage (EVD). The Earlydrain trial showed that an additional prophylactic lumbar drainage (LD) post-aneurysm treatment improves neurological outcomes. This study aims to further investigate the influence of the volume of CSF drainage and ICP peaks on patient outcomes after aSAH.

#### Methods

This is a sub-study a prospective multicenter randomized controlled trial. Ethics approval was granted (No. 4171). Outcomes were the modified Ranking Scale (mRS) after 6 months, dichotomized in mRS 0-2 as favorable and 3-6 as unfavorable, and the occurrence of secondary infarctions. We analyzed CSF drainage amounts and ICP values of patients recruited in the first 8 days of their clinical course. Repeated measurements were addressed with generalized estimation equations.

#### Results

CSF drainage and ICP values of 287 patients were investigated. Mean total amount of CSF drainage within the first eight days after treatment of the SAH was 1052 +- 659 ml and did not differ between patients with favorable and unfavorable outcome. Patients without secondary infarctions showed more CSF drainage through LD at days 4 to 8. CSF volumes drained through EVD systems were significantly higher in patients with unfavorable outcome, even after adjustment for baseline hemorrhage severity. In 98 patients where both EVD and LD drainage was performed, higher percentages of LD volume were significantly associated with favorable outcome. No significant relationship of ICP with the occurrence of secondary infarctions was detected. Maximum values of measured ICP after the bleeding event, particularly above 25 mmHg, were significantly associated with worse outcome.

#### Conclusion

Higher percentages of CSF drainage through a lumbar system showed better outcomes. This may indicate a potential quantity-dependent protective effect through lumbar drainage. Maximizing the volume drained through a LD and routinely performed ICP measurement to strictly prevent ICP peaks may be useful.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 4

## V221

### Hörverlust bei adulten Ratten führt zu kognitiver Verminderung der visuell-räumlichen Aufmerksamkeit und reduzierter Ultraschallvokalisation während sozialer Interaktion

***Hearing loss in adult rats leads to cognitive deterioration in visuospatial attention and reduced ultrasonic vocalization during social interaction***

M. Stenzel[1], M. Alam[1], J. Jelinek[1], J. K. Krauss[1], K. Schwabe[1], M. Johne[1]

[1]Medizinische Hochschule Hannover, Experimentelle Neurochirurgie, Hannover, Deutschland

#### Objective

Hearing loss in the elderly has been associated with difficulties in speech comprehension and cognitive decline. Not least, it is a possible risk factor for dementia. We already showed that hearing loss leads to reduced neuronal activity in the medial prefrontal cortex (mPFC). To investigate the impact on cognitive function and communication, we here tested adult rats in behavioral paradigms for motor activity, attention and impulse control, as well as social interaction, including ultrasonic vocalization (USV).

#### Methods

In a cohort of adult male Sprague Dawley rats, hearing loss was induced under anaesthesia with intracochlear injection of neomycin (n=11). Naive (n=10) and sham-operated rats (n=7) served as control. Hearing loss was verified after surgery with auditory brainstem response (ABR) measurement. Furthermore, the rats were tested for motor activity (Open Field) and social interaction before surgery and at week 1, 2, 4, 8, 16, and 24 after surgery. From week 8 onwards, the rats were tested in the Five Choices Serial Reaction Time Task (5CSRTT) for visuospatial attention, impulse control, learning, and memory. In this paradigm, rats have to react to a light stimulus in one of five holes of the aperture, which is shortened from session to session.

#### Results

In the Open Field, deafened rats moved faster and a longer distance than the controls (both $p<0.05$). Social interaction was significantly less between cage mates in the deafened rats ($p<0.05$) and the count of USV was significantly reduced in deafened rats in week 4 ($p<0.05$). Learning the 5CSRTT was significantly impeded in the deafened group ($p<0.05$). Moreover, the accuracy, associated with attention, was reduced in deafened rats ($p<0.05$). Looking at the omission rate, the deafened rats seemed to be less likely to miss a trial ($p<0.05$). For training and retesting it is worth mentioning that the deafened rats had a significantly shorter latency between correct responding and getting the reward ($p<0.05$).

#### Conclusion

Hearing loss in adult rats leads to hyperlocomotion and less USV. Furthermore, these rats exhibit deficits in initial visuospatial attention as evidenced by a lower accuracy rate and delayed comprehension of the new task. These cognitive impairments may be associated to compromised neuronal activity in the mPFC, as shown in a prior publication. Therefore, this model could serve as a valuable tool for investigating the effect of neuromodulatory stimulation on cognitive decline attributed to hearing impairment.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 4

## V222

### Die Wirksamkeit der lumbalen Liquor-Drainage zur Reduzierung des mittels CT-Scans gemessenen intrakraniellen Blutvolumens bei Patienten mit aneurysmatischer Subarachnoidalblutung

***Efficacy of lumbar CSF drainage in reducing intracranial blood volume measured by CT scans among patients with aneurysmal subarachnoid hemorrhage***

R. Mertens[1,2], M. A. Iqbal[1], Z. Shaked[1], K. Kersting[1], K. Krantchev[1], A. Janas[1], J. Nawabi[3], P. Vajkoczy[1], S. Wolf[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, BIH Charité Junior Clinician Scientist Program, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Klinik für Neuroradiologie, Berlin, Deutschland

#### Objective

The EARLYDRAIN randomized trial demonstrated that the application of a lumbar drainage (LD) following aneurysmal subarachnoid hemorrhage (aSAH) reduces the burden of secondary infarction and decreases the rate of unfavorable outcomes (1). The underlying pathophysiological reason for outcome improvement remained unclear. We investigated the hypothesis that an additional lumbar drain leads to faster removal of subarachnoid blood from the intracranial space, compared to no drainage or drainage via EVD only.

#### Methods

Longitudinal non-contrast-enhanced CT scans of 68 patients participating in EARLYDRAIN from a single institution were manually segmented using the ITK-SNAP tool. CT imaging was performed solely on clinical indication, and timing was not mandated in the study protocol. Basal SAH, cortical SAH, subdural hematoma, intracerebral and intraventricular hemorrhage were quantified. The decline in CT blood volume over time was analyzed according to actual treatment with or without a lumbar drain and compared with generalized additive models.

#### Results

A total of 28 patients with 133 CT scans were treated with LD and 40 patients with 216 CT scans were treated without LD. No significant difference was found for demographic data between both groups. Total hemorrhage burden in the CT scan on admission was unevenly distributed among all patients, with a median of 29.1 ml (range 4.4 ml to 100.0 ml). No significant difference was noted between the LD and NoLD groups concerning initial hemorrhage volume after SAH (p=0.14). LD use led to a faster reduction of total blood volume in the first 14 days (p=0.0003), with a maximum difference in CT scans performed between day 3 and 5. This decline was most prominent in the cortical SAH blood volume (p=0.0027), and lesser in the intraventricular (p=0.069), basal SAH (p=0.073), parenchymal (p=0.11) and subdural (p=0.277) components.

#### Conclusion

In this preliminary analysis of the CT scans from roughly one-fourth of patients recruited in the EARLYDRAIN trial, lumbar drains appear to contribute to a more rapid reduction of intracranial blood volume measured by CT. This may indicate a potential mechanism serving as explanation for the improved outcome by early application of a lumbar drain in patients with aneurysmal SAH. Further analysis is warranted.

1. Wolf S, et al: JAMA Neurol 2023; 80(8):833-842

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 4

## V223

### Haptoglobin mildert die durch Liquor-Hämoglobin induzierte neurologische Symptomatik in einem Schafmodel
*Haptoglobin attenuates cerebrospinal fluid hemoglobin-induced neurological deterioration in sheep*

B. Thomson[1], N. Schwendinger[1], K. Beckmann[2], T. Gentinetta[3], D. Couto[3], S. Wymann[3], V. Verdon[3], R. M. Buzzi[4], K. Akeret[1], P. W. Kronen[5], E. Weinberger[1], U. Held[6], F. Seehusen[2], H. Richter[2], D. J. Schaer[4], M. Hugelshofer[7,1]

[1]Universitätsspital Zürich, Klinik für Neurochirurgie, Zürich, Schweiz
[2]Universität Zürich, Tierspital, Zürich, Schweiz
[3]CSL Behring AG, Bern, Schweiz
[4]Universitätsspital Zürich, Innere Medizin, Zürich, Schweiz
[5]Veterinary Anesthesia Service International, Winterthur, Schweiz
[6]Universität Zürich, Biostatistik und Epidemiologie, Zürich, Schweiz
[7]Universitätsmedizin Mannheim, Klinik für Neurochirurgie, Mannheim, Deutschland

#### Objective

Secondary brain injury (SBI) occurs with a lag of several days post-bleeding in patients with aneurysmal subarachnoid hemorrhage (aSAH) and is a strong contributor to mortality and long-term morbidity. aSAH-SBI coincides with cell-free hemoglobin (Hb) release into the cerebrospinal fluid. This temporal association and convincing pathophysiological concepts suggest that CSF-Hb could be a targetable trigger of SBI. However, sparse experimental evidence for Hb"s neurotoxicity in vivo defines a significant research gap for clinical translation.

#### Methods

We modeled the CSF-Hb exposure observed in aSAH patients in conscious sheep, which allowed us to assess neurological functions. Twelve animals were randomly assigned for three-day bi-daily intracerebroventricular (ICV) injections of either Hb or Hb combined with the high-affinity Hb scavenger protein haptoglobin (Hb-Hp, CSL888).

#### Results

Repeated CSF sampling confirmed clinically relevant CSF-Hb concentrations. This prolonged CSF-Hb exposure over three days resulted in disturbed movement activity, reduced food intake, and impaired observational neuroscores. The Hb-induced neurotoxic effects were significantly attenuated when Hb was administered with equimolar haptoglobin. Preterminal magnetic resonance imaging (MRI) showed no CSF-Hb-specific structural brain alterations. In both groups, histology demonstrated an inflammatory response and revealed enhanced perivascular histiocytic infiltrates in the Hb-Hp group, indicative of adaptive mechanisms. Heme exposure in CSF and iron deposition in the brain were comparable, suggesting comparable clearance efficiency of Hb and Hb-haptoglobin complexes from the intracranial compartment.

#### Conclusion

We identified a neurological phenotype of CSF-Hb toxicity in conscious sheep, which is rather due to neurovascular dysfunction than structural brain injury. Haptoglobin was effective at attenuating CSF-Hb-induced neurological deterioration, supporting its therapeutic potential.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 4

## V224

### Vorhersage der Entwicklung eines VP-Shunt bedürftigen Hydrozephalus bei PatientInnen mit Subarachnoidalblutung mittels maschinellem Lernen basierend auf einer Zeitdatenanalyse von Liquorwerten.
*Machine learning prediction of shunt-dependence in patients with subarachnoid hemorrhage based on time-series data of cerebrospinal fluid markers*

K. Frank[1], M. Manu[1], P. Shalchian-Tehran[1], M. Nakamura[1]

[1]Klinikum Köln-Merheim, Universität Witten/Herdecke, Neurochirurgie, Köln, Deutschland

#### Objective

Hydrocephalus is a common complication in patients with aneurysmal subarachnoid hemorrhage (SAH), resulting in a permanent shunt dependency in 8.9% to 48%[1]. We sought to validate a machine learning algorithm for predicting shunt-dependence in patients with subarachnoid hemorrhage (SAH) based on the initial post-ictal CT scan and simple CSF markers time-series data.

#### Methods

The CSF cell count, erythrocyte count, protein and lactic acid levels from 44 patients with SAH and ventricular drain, collected during the first 12 days after the event were so far characterized retrospectively in order to create a time series data. Using custom-written routines in Python, we first sought to extract meaningful features that capture the difference between the time series data of the shunt-dependent and shunt-independent patients.

The relevant CT features were extracted by passing the CT stack as input to a pre-trained deep network (ResNet50). Afterwards, in this new feature space, we trained and tested a random forest, multilayer perceptron and logistic regression classifier for predicting shunt dependency.

#### Results

Of the 44 patients, 39% developed a shunt-dependent hydrocephalus (8/17 male, 9/17 female). The parametric and non-parametric statistical test revealed statistically significant differences in the normalized mean cell count and in the erythrocyte cell count trend over time (Mann-Kendall p=0.039 and Sen"s slope p=0.047, figure 1). Based on these engineered features, a random forest classificator achieved an accuracy of 89% in correctly identifying shunt-dependent/shunt-independent patients (precision 0.88 for shunt-independent and precision 1 for shunt-dependent patients).

#### Conclusion

A random forest classificator based on features extracted from simple time series CSF data, revealing the significance of slower degradation of erythrocytes in CSF, can achieve a high accuracy in predicting shunt-dependence. We expect an improvement in the classificatory task with addition of the imaging data.

Abb. 1

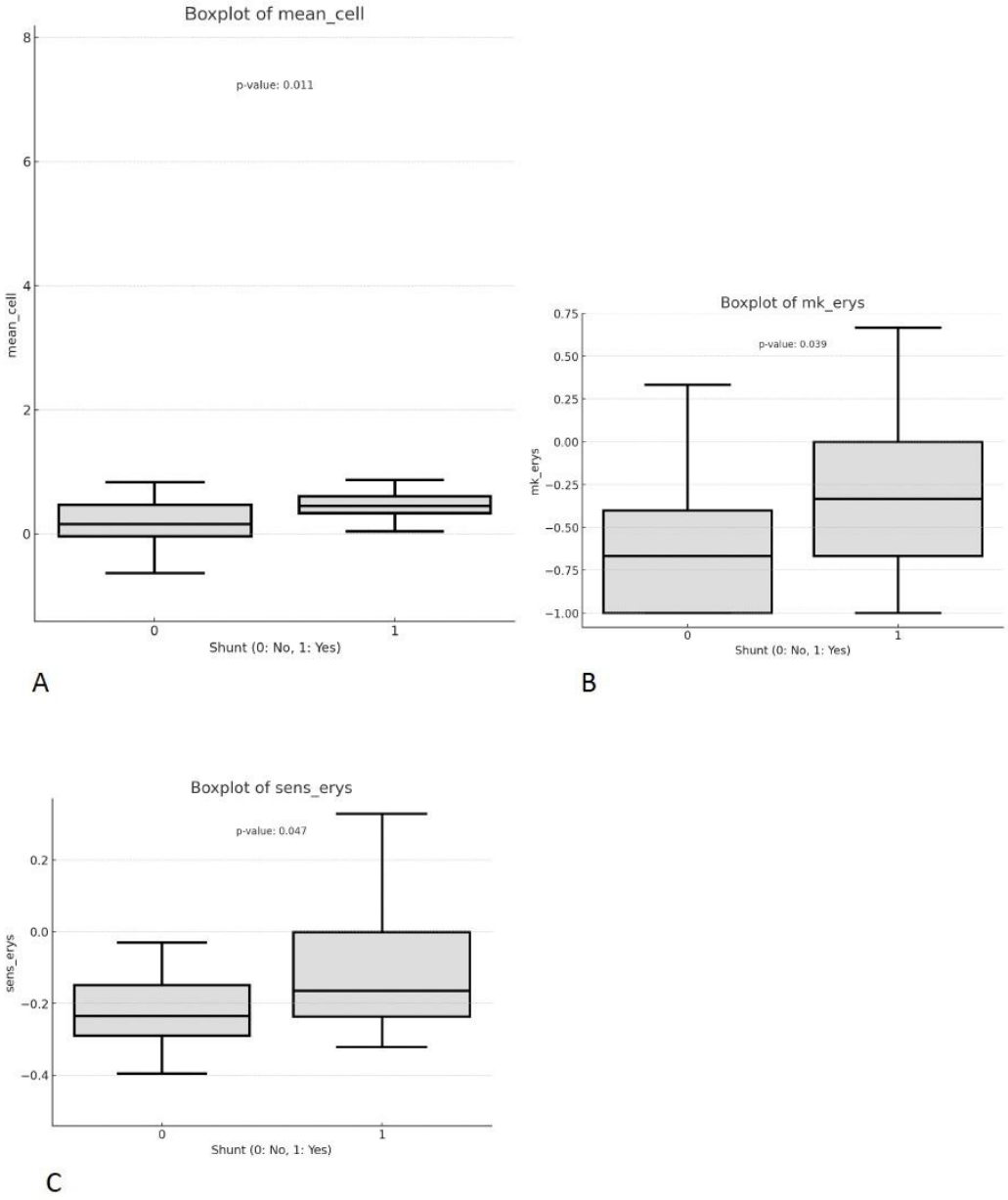



**Figure 1 A-C.** Significant differing variables between the shunt-dependent and shunt-independent patients. A) Boxplot of the mean cell count (p=0.011). B) Boxplot of Mann Kendall trend of erythrocyte count (p=0.039). C) Boxplot of Sen's slope trend of erythrocyte count (p=0.047).

Abb. 2

**Literature**


1 Xie, Z. *et al.* Predictors of Shunt-dependent Hydrocephalus After Aneurysmal Subarachnoid Hemorrhage? A Systematic Review and Meta-Analysis. *World Neurosurg* **106**, 844-860.e846, doi:10.1016/j.wneu.2017.06.119 (2017).

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V225

### Tumor-assoziierte Mikroglia/Makrophagen modulieren das Fortschreiten maligner Glome durch xCT und angiogene Genexpression

***Tumor-associated microglia/macrophages modulate progression of malignant glomas via xCT and angiogenic gene expression***

E. Yakubov[1], D. Chen[2], N. Savaskan[3], K. M. Schebesch[1]

[1]Paracelsus Medical University, Department of Neurosurgery, Nuremberg, Deutschland
[2]Shenzhen People's Hospital, Jinan University, Department of Otorhinolaryngology, Shenzhen, China, Volksrepublik
[3]University Medical School Hospital, Universitätsklinikum Erlangen (UKER), Friedrich-Alexander University Erlangen-Nürnberg (FAU), Department of Neurosurgery, Erlangen, Deutschland

#### Objective

Malignant gliomas, known for their aggressive and invasive nature, are intricately engage with tumor-associated microglia/macrophages (TAMs). TAMs impact on tumor progression and finely tune the tumor microenvironment. We could show that xCT (SLC7A11)-positive cells were identified surrounding newly formed vessels as shown in previous studies. This investigation aimed to clarify the relationship between xCT and microglia/macrophages, given the extensive infiltration of microglia/macrophages in glioblastoma.

#### Methods

Samples of brain tissue collected during surgery were analysed from 25 patients with astrocytomas (CNS WHO grades 2 - 4) or epilepsy (control group). The samples were homogenized, and the conditioned media from TAMs or glioma cells were analyzed for their amino acids metabolome. The RNA was isolated and qRT-PCR was conducted to determine pro-inflammatory (classical; CD14, CD86), pro-angiogenic (alternative; Arg-1, CD163, CD206, CD209) or xCT markers. The frozen sections were further characterized by immunofluorescence and immunohistochemistry.

#### Results

The presence of xCT over-expression in IDH wild-type glioblastomas distinguished them from normal brain tissue or mutated IDH astrocytomas (CNS WHO geade 2 – 3). Co-localization of xCT with CD68, a general microglia marker, was observed in snap-frozen specimens. A higher average TAM count in the tumor compared to peritumoral regions indicated a potential role for TAMs in glioblastoma development. Across tissue samples, M2 phenotype markers were expressed differently, and TAM activation status was correlated with the tumor grade. The level of amino acid secretion was also related to the grade of the glioma.

#### Conclusion

Through the expression of pro-angiogenic markers and the secretion of several amino acids with pro-angiogenic factors, TAMs may contribute to vascularization in human glioblastoma. The recruitment and heightened density of TAMs in tumors have been associated with unfavourable prognosis in cancer patients. Reprogramming TAMs to the M1 phenotype therefore will be a central target for effective immunotherapy against malignant gliomas.

**Keywords:** Neuro-oncology, Glioblastoma, Tumor-associated microglia, amino acid, xCT

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V226

### CMV induzierte Modulation des Immunmikromillieus beim Glioblastom
***CMV infection in glioblastoma – Oncomodulation through changes to the glioma immune landscape***

H. Krenzlin[1], F. Corr[2], P. Einhäuser[2], N. Lemmermann[3], F. Ringel[2], S. Lawler[4], N. Keric[2]

[1]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Neurochirurgischen Klinik und Poliklinik, Mainz, Deutschland
[3]Universitätsmedizin Mainz, Institut für Virologie, Mainz, Deutschland
[4]Brown University, Department of Pathology and Laboratory Medicine, Providence, RI, Vereinigte Staaten

#### Objective

Immune evasion and suppression lead to unchecked tumor growth in glioblastoma. Avoidance of tumor cell recognition through immunosurveillance can be mediated by downregulation of Major Histocompatibility Complex I (MHC-I) levels. Cytomegalovirus (CMV) has been implicated in tumor progression. Here, CMV-associated changes in the glioblastoma immune landscape were characterized in vitro and in a murine glioblastoma model.

#### Methods

GL261Luc2 murine glioblastoma cells were infected with murine CMV (mCMV). qRT-PCR was performed to assess viral replication *in vitro*. The expression levels of MHC class I and II were analyzed by flow cytometry and immunofluorescence staining in mouse. In addition, RNA sequencing of GL261Luc2 cells before and after infection with mCMV was performed. The composition of tumor immune infiltrates was analyzed in latently mCMV infected and naive mice *in vivo*.

#### Results

*In vitro*, infection of mouse glioblastoma cells (GL261Luc2) with mCMV resulted in short periods of viral replication. MHC-I cell surface expression was reduced after mCMV infection by approximately 60% compared with non-infected tumor cells ($p < 0.0001$). Viral regulators of antigen presentation (vRAP) were shown to be responsible for MHC-I downregulation using a recombinant mCMV (vRAP) lacking the known immune evasion genes. RNA sequencing of mCMV infected GL261Luc cells revealed 2711 differentially expressed genes ($p < 0.005$). Of particular interest was the downregulation of MHC-I-associated genes *H2-Q1-10* and *Tap1* d after CMV infection. *In vivo*, the mCMV immediate early gene (IE1) was detected in brains of mCMV+ animals after tumor implantation and increased during tumor growth. mCMV+ mice had significantly shorter survival than controls, depending on initial tumor size ($P<0.001$). Tumor immune infiltrates in mCMV infection were characterized by B cell infiltrates and low levels of NK cell infiltration.

#### Conclusion

CMV leads to immune evasion mediated MHC-I downregulation in murine glioblastoma. The landscape of immune cell infiltrates is shifted toward B cell infiltration and reduced numbers of NK cells. Thus, CMV infection in glioblastoma may contribute to unchecked tumor growth in glioblastoma by increasing immune evasion.

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V227

### *EVA, ein neuer therapeutischer Ansatz zur Behandlung von Glioblastomen*
### *EVA, a novel therapeutic targeting rationale for the treatment of glioblastoma*

T. Rusch[1], K. Zhao[2], A. Neubauer[1], C. Nimsky[2], J. Bartsch[2]

[1]Philipps-Universität Marburg, Hämatologie, Onkologie und Immunologie, Baldingerstrasse, Deutschland
[2]Philipps-Universität Marburg, Klinik für Neurochirurgie, Marburg, Deutschland

#### Objective

Current standard adjuvant therapy of glioblastoma multiforme (GB) using temozolomide (TMZ) frequently fails due to therapy resistance.Thus, novel therapeutic options are highly demanded. Apoptosis induction in GB cells is inefficient due to high abundance of apoptosis inhibitory proteins of the XPO/Bcl family. We explored a strategy of combining apoptosis inducers with anti-apoptosis inhibitors. We evaluated the efficacy of TMZ, Methotrexat (MTX), and Cytarabine (Ara_C) (inducers of apoptosis) in combination with XPO1-/Bcl-2/Mcl-1 inhibition (preventers of apoptosis) in GB cell lines and in primary GB-like stem cells (GSCs).

#### Methods

Dose-response curves were generated in GB cell lines and GB stem-like cells (GSCs) by using cell titer glow, Caspase 3 activity assays, and FACS analyses. Regulation of apoptosis-related genes was analyzed by quantitative PCR and Western Blots. Optimized drug combinations were tested for their ability to affect cell cycle of GB and GSCs as well as their effect on neuronal apoptosis ***in vivo***using mouse brain slice cultures.

#### Results

MTX (IC50: 71 nM ± 47) and Ara_C (IC50: 2334 nM ± 2315) are more potent to induce apoptosis of GB cell lines and primary GSCs than TMZ. Quantitative PCR analyses revealed that genes encoding for anti-apoptotic proteins (Bcl-2, Mcl-1, XPO-1) were upregulated in response to inhibitors Venetoclax (Bcl-2 inhibitor), A1210477 (A121, Mcl-1 inhibitor), and Eltanexor (XPO-1 inhibitor) in a compensatory mode. In all GB cells tested, the optimal reduction of cell viability was achieved by a combination of MTX (55 nM), Venetoclax (1mM), A121 (1mM), and Eltanexor (10 nM), all applied in sublethal doses (EVA), but very effective in combination. Colony formation assays resulted in low numbers of resistant cell clones of GB cells, clearly distinct from a significantly larger number of resistant cell clones formed in the presence of TMZ. Combinations of MTX (55 nM) and Ara_C (500 nM) with EVA, respectively, were also tested in healthy mouse brain slice cultures and showed no significant toxicity in combined stainings for Hoechst stain, Propidiumiodid, and Caspase 3.

#### Conclusion

We conclude that a drug combination of Bcl and XPO-1 inhibitors with either TMZ, Ara_C, or MTX reduces cell viability in vitro and is expected to have low side effects ***in vivo***. The high efficacy of MTX/Ara_C with EVA in GSCs suggests that these drugs, a suitable application route provided, could be tested as a novel therapeutic option for GB patients.

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V228

### Dexamethason hat einen epigenetischen Effekt auf die DNA-Methylierung bei Glioblastoma
***Dexamethasone presents an epigenetic effect on DNA methylation in glioblastoma***

A. M. Barciszewska[1], A. Belter[2], M. Giel-Pietraszuk[2], I. Gawronska[2], M. Naskręt-Barciszewska[3]

[1]Karol Marcinkowski University of Medical Sciences, Neurosurgery and Neurotraumatology, Posen, Polen
[2]Polish Academy of Sciences, Institute of Bioorganic Chemistry, Posen, Polen
[3]Polish Academy of Sciences, Institute of Bioorganic Chemistry, Posen, Polen

#### Objective

Dexamethasone (DEX) is a first-line antiedematic drug for glioblastoma (GBM) patients. There is some evidence it also inhibits GBM cell proliferation and migration, thus iinfluencing patients" outcome. However, other studies show that the use of DEX is associated with poor treatment outcome in GBM patients. The exact mechanism of DEX action is not clear, and no definitive conclusion has yet been reached on its benefits in neurooncological treatment. Temozolomide (TMZ) is a first-line chemotherapeutic in GBM.

Epigenetics offers a connection between genetic and environmental factors that influence the development of the disease. The best-characterized epigenetic mark is 5-methylcytosine (m5C) in DNA. The aim of that project is to show the effects of DEX administration on the total DNA methylation level in glioblastoma.

#### Methods

Using the nucleotide post-labeling method, we analyzed the total amount of m5C in DNA of GBM (T98G, U118, U138), cancer (HeLa) and normal (HaCaT) cell lines treated with DEX, and a combination of DEX and with TMZ.

#### Results

We adjusted the DEX doses to the ones achieved in the central nervous system during treatment. We observed dose-dependent increase in total DNA methylation in all cell lines. However, the exposition of GBM cells to the combination of DEX and TMZ caused an adverse synergistic effect resulting in DNA demethylation in high doses of both drugs. In lower concentrations of both drugs DEX kept the increased DNA methylation and attenuated the demethylating effect of TMZ.

#### Conclusion

Total DNA methylation changes in glioma cell lines under DEX treatment suggest the new mechanism of that drug action and promote clinical implications for adjusting DEX and TMZ therapy in GBM patients. Our results show the potential and possible obstacles of the combined therapy of TMZ with DEX. Our experiments show that combined therapy with both drugs leads to total DNA hypomethylation in high doses of both drugs. Therefore the conclusion would be to adjust DEX administration during TMZ chemotherapy.

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V229

### Intrakavitäre Applikation von Ozon bei Patienten mit Rezidiv-Glioblastom- erste Ergebnisse einer Salvage-Therapie

***Intracavitary application of O2/O3 in recurrent glioblastoma – Initial results of a salvage therapy***

C. Bettag[1], S. Hernandez-Duran[1], T. Abboud[2], V. Rohde[1], C. von der Brelie[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland

#### Objective

As Glioblastoma (GBM) cells prefer hypoxemia to maintain their tumor-forming capacity, Ozone (O3) has been shown to inhibit tumor proliferation and induce apoptosis due to reactive oxygen species. However, little is known about the usefulness of O3-application in patients suffering from GBM. The present study reports initial experience with adjuvant intracavitary O3-application in patients with recurrent GBM.

#### Methods

Patients underwent surgery for recurrent GBM followed by the implantation of an intracavitary catheter being connected to a subcutaneous reservoir in reasonable distance to the skin incision. In an outpatient setting, 10 ml of O2/O3 with a concentration of 40µg/ml was applied into the resection cavity following CSF aspiration. Therapy was repeated every two to seven weeks.

#### Results

A total of 187 applications were performed in 13 patients (7 female) with a median age of 59.8 (range 36-72) years after surgery for recurrent GBM with implantation of the O2/O3-catheter since July 2020. Each patient underwent a median of 8.0 (3-74) applications. The median interval between each application was 2.5 (2-7) weeks. The median interval from the first to the last application was 22.0 (4-154) weeks. At the analysis cut off date, 5/13 (38%) patients are alive. The median progression free survival (PFS) after surgery for recurrence was 6.1 (3.2-37.1) months. The median overall survival (OS) after surgery for recurrence was 10.2 (3.6-37.1) months. Two of 13 patients (10.5%) suffered from a postoperative CSF-fistula and were successfully treated with a lumbar drainage. No complications, especially no infectious complications, related to the application were observed.

#### Conclusion

Initial experience leads to the conclusion that application of O2/O3 via an intracavitary catheter is safe and feasible. Survival might be improved taking into account the limited number of patients.

# Tumor – Gliome 4 | Tumour – Gliomas 4

## V230

### Individualisierte multimodale Immuntherapie zusätzlich zur Standarttherapie des Glioblastomas verbessert das Überleben

***Individualized multimodal immunotherapy added to standard care of glioblastoma multiforme improves the overall survival***

P. Zilliken[1]

[1]IOZK, Neuroonkologie, Köln, Deutschland

#### Objective

We added individualized multimodal immunotherapy to the standard of care during maintenance chemotherapy of glioblastoma (immunogenic cell death therapy, oncolytic virus injections and modulated electro hyperthermia)

and after chemotherapy active specific immune therapy with dendritic cell vaccines (IO-Vac) and modulatory immunotherapy were given.

We describe the retrospective analysis of 50 adults, taken out of a database following a predefined clinical profile without further bias.

We observed a clear overall survival without major adverse reactions in comparison to published data.

The treatment concept takes into account dynamic changes of tumour biology and tumour-host-interaction.

#### Methods

IOZK obtained the approval on 27th May 2015 to produce IO-Vac to treat patients within the legal framework of individualized treatment.

All patients treated between 27.05.2015 and 01.01.2022 were taken into data set with a further observation period until July 2022.

A retrospective analysis was performed.

#### Results

A total of 50 adults out of 218 patients older than 18 (23 female and 27 male) were registered as IDH1 wild type and were divided according to the registered MGMT promotor methylation status

22 patients (12 female and 10 male) had methylated and 28 patients (11 female and 17 males) had unmethylated MGMT promotor.

The median age was 54 (26 to 72) and 47 (18 to 65)

The Karnofsky performance index was equally distributed. Median KPI was 80 in both groups.

We created a swimmer plot showing life span per patient from operation till death or analysis to evaluate the results.

We followed the tumour biology in a non-invasive way to adapt the treatment during the treatment. (Circulating cancer cells with chemo sensitivity tests and Liquid biopsies)

The PSF in both groups was significantly different (p 0.0097) 27 respectively 11 month, the difference of OS was again significantly different (p 0.0153) 38 respectively 22 month.

## Conclusion

Single institution real-world data show in a retrospective analysis of first line treatment a feasibility as ambulant treatment without additive toxicity.

The data of this analysis have a distinct scientific and clinical value with high relevance for the patients, in our opinion the paradigm of clinical research for GBM has to change.

GBM tumours are dynamic biologic processes which require treatment adaptations instead of fixed treatment protocols.

Liquid biopsies might become an instrument for monitoring.

# Tumor – Metastasen | Tumour – Metastases

## V231

### Zytoreduktion der Resttumorlast ist ausschlaggebend für ein längeres Überleben bei Patienten mit rezidivierenden Hirnmetastasen - Retrospektive Analyse von 219 Patienten

***Cytoreduction of residual tumor burden is decisive for prolonged survival in patients with recurrent brain metastases – Retrospective analysis of 219 patients***

J. Lin[1], Y. Kaiser[1], B. Wiestler[2], D. Bernhardt[3,4], S. E. Combs[3,4,5], C. Delbridge[6], B. Meyer[1], J. Gempt[1,7], A. K. Aftahy[1]

[1]Department of Neurosurgery, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[2]Department of Neuroradiology, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[3]Department of Radiation Oncology, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[4]German Cancer Consortium (DKTK), München, Deutschland
[5]Department of Radiation Sciences (DRS) Helmholtz Zentrum Munich, Institute of Innovative Radiotherapy (iRT), München, Deutschland
[6]Klinikum rechts der Isar, Technische Universität München, Institut für Pathologie, München, Deutschland
[7]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland

#### Objective

Despite advances in treatment for brain metastases (BMs), the prognosis for recurrent BMs remains poor and requires further research to advance clinical management and improve patient outcomes. Particularly, data addressing the impact of tumor volume and surgical resection with regards to survival remain scarce.

#### Methods

Adult patients with recurrent BMs between 12/2007-12/2022 were analyzed. A distinction was made between operated and non-operated patients and the residual tumor burden (RTB) was determined by (postoperative) MRI. Survival analysis was performed and RTB cut-off values were calculated using maximally selected log rank statistics. In addition, further analyses on systemic tumor progression and (postoperative) tumor therapy were conducted.

#### Results

219 patients were included in the analysis. Median age at was 60 years (IQR 52-69). Median preoperative tumor burden was 2.4 cm³ (IQR 0.8-8.3), and postoperative tumor burden was 0.5 cm³ (IQR 0.0-2.9). 95 patients (43.4%) underwent surgery and complete cytoreduction was achieved in 55 (25.1%) patients. Median overall survival was 6 months (IQR 2-10). Cutoff RTB in all patients was 0.12 cm³, showing significant difference (p = 0.00029) in overall survival (OS). Multivariate analysis has shown preoperative KPSS (HR 0.983, 95% CI, 0.967-0.997, p = 0.015), postoperative tumor burden (HR 1.03, 95% CI 1.008-1.053, p = 0.007) and complete vs. incomplete resection (HR 0.629, 95% CI 0.420-0.941, p = 0.024) as significant. Longer survival was significantly associated with surgery for recurrent BMs (p = 0.00097) and additional analysis demonstrated the significant effect of complete resection on survival (p = 0.0027). In the subgroup of patients with systemic progression, a cutoff RTB of 0.97 cm³ (p = 0.00068) was found; patients who had received surgery also showed prolonged OS (p = 0.036). Single systemic therapy (p = 0.048) and the combination of radiotherapy and systemic therapy had significant influence on survival (p = 0.036).

#### Conclusion

RTB is a strong prognostic factor for survival in patients with recurrent BMs. Operated patients with recurrent BMs showed longer survival independent of systemic progression. Maximal cytoreduction should be targeted to achieve better long-term outcomes.

# V232

## Leistungsfähigkeit von auf künstlicher Intelligenz basierten Analysen von stimulierter Raman Histologie für den intraoperativen diagnostischen Einsatz bei Rezidiv-Hirntumoren

***Performance of artificial intelligence-based analyses of label-free stimulated raman histology for intraoperative diagnostic use in recurrent brain tumors***

G. Fürtjes[1], D. Reinecke[1], A. K. Meissner[1], N. Müller[1], N. von Spreckelsen[1], D. Rueß[2], M. I. Ruge[2], T. Blau[3], T. Stehle[4], F. Khalid[5], R. Goldbrunner[1], V. Neuschmelting[1]

[1]Universitätsklinikum Köln, Klinik für Allgemeine Neurochirurgie, Köln, Deutschland
[2]Universitätsklinikum Köln, Klinik für Stereotaxie und funktionelle Neurochirurgie, Köln, Deutschland
[3]Universitätsklinikum Essen, Institut für Neuropathologie, Essen, Deutschland
[4]Universitätsklinikum Köln, Institut für Neuropathologie, Köln, Deutschland
[5]Invenio Imaging Inc., Santa Clara, CA, Vereinigte Staaten

### Objective

Stimulated Raman histology (SRH) and convolutional neuronal networks (CNN) based analyses have gained increasing attention for serving intraoperative tissue diagnostics. However, those CNN for tissue analysis have predominantly been trained on primary tumor tissues (Hollon TC et al., Nat Med 2020; Reinecke D, ANC, 2022). The validity of applying the techniques on recurrent disease remains yet unclear as radiotherapy, chemotherapy, previous surgical resections or tumor recurrence often lead to significant tissue alterations. This study aims to evaluate the performance of CNN-based analyses of SRH images for intraoperative diagnostics in brain tumors suspected for recurrence.

### Methods

In a prospective observational clinical study, small unlabeled tumor samples (1-3 mm3) were squashed flat onto a slide, SRH images were acquired on random areas (2x2 mm) under the same conditions by a dual wavelength laser (790nm and 1020nm) for excitation. By combining two Raman shift wavenumbers and by image calculation a virtual hematoxylin-eosin (HE) like image is created. The established CNNs (1,2) for tumor detection and classification were applied for further image analysis and diagnostic prediction was compared to the final histopathological diagnosis. Sensitivity and specificity were calculated as area under the ROC-curve (ROC-AUC).

### Results

We analyzed the CNN results of 115 SRH images out of 58 patients with suspected intracranial recurrent tumors that underwent resection or stereotactic biopsy at our center. In the final histopathological results 8 patients showed a radiogenic necrosis or gliosis. 91.3% of the recurrences were diagnosed correctly as tumor tissue by the CNN with a ROC-AUC of 0.833 (95% CI, 0.723-0.944). Regarding the sensitivity and specificity, the ROC-AUC of the CNN for meningioma recurrence prediction was outstanding with 0.901 (95% CI, 0.832-0970) and excellent for recurrent metastases with 0.885 (95% CI, 0.827-0.944) and still fair for recurrent malignant glioma (0.752; 95% CI, 0.615-0.889).

### Conclusion

Our data validate that recurrent tumors can be differentiated by the SRH based CNN algorithms within a few minutes. However, accuracy in diagnostic predictions may be further optimized in the future with training sets incorporating the heterogeneity of recurrent disease and rare primaries.

# Tumor – Metastasen | Tumour – Metastases

## V233

### Bildgestützte Biopsie der Makrometastasen-Hirnparenchym-Grenzfläche (Metinfilt-Studie)
*Imaging–guided biopsy of the macro metastasis–brain parenchyma interface (Metinfilt study)*

T. Araceli[1], C. Doenitz[1], K. M. Schebesch[2], K. Evert[3], C. Wendl[4], M. Riemenschneider[5], T. Pukrop[6], R. Blazquez[6], N. O. Schmidt[1], M. Proescholdt[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland
[2]Paracelsus Medizinische Privatuniversität (PMU), Neurochirurgie, Nürnberg, Deutschland
[3]Universitätsklinikum Regensburg, Pathologie, Regensburg, Deutschland
[4]Universitätsklinikum Regensburg, Neuroradiologie, Regensburg, Deutschland
[5]Universitätsklinikum Regensburg, Neuropathologie, Regensburg, Deutschland
[6]Universitätsklinikum Regensburg, Innere Medizin III, Regensburg, Deutschland

#### Objective

Recent studies have demonstrated that brain metastases (BM) can infiltrate the adjacent brain at the so-called macro-metastasis / brain parenchyma interface (MMPI). However, imaging-based data regarding the frequency, the specific pattern, and the clinical impact of BM infiltration at the MMPI are lacking. We conducted a prospective clinical trial, termed the Metinfilt study, in which we applied an imaging-based protocol to specifically acquire tissue samples from the MMPI, allowing histological and molecular analyses as well as the clinical impact of the different MMPI patterns in the brain.

#### Methods

We recruited 50 patients (21 female, 29 male, median age 62.2 years) undergoing microsurgical resection of a lesion suspicious for a BM. The most frequent primary tumor was lung cancer (n = 23; 46%). Based on the previous trials, the Metinfilt protocol consisted of 4 elements: A. The determination of target areas on the preoperative MRI scan, which appeared suspicious for tumor cell infiltration B. Identification of these target areas using the neuronavigation system C. Employment of fluorescein sodium (FL) as a tracer to detect tumor borders and D. Use of laser confocal endomicroscopy for direct visualization of the MMPI intraoperatively. A minimum of at least 70% successful MMPI-specific tissue acquisition was determined as a primary endpoint.

#### Results

We excluded six patients from the MMPI analysis because no tumor cells, but solely post-therapeutic changes were detected within the lesion. In the remaining 44 patients, we successfully acquired tissue representing the MMPI in 40 patients (90.1%); therefore, the study met its primary endpoint. Significant tumor cell infiltration was found in 29/40 (72.5%) of the analyzed MMPI samples. Infiltrative MMPIs correlated with significantly worse overall survival (HR: 4.61; p = 0.0001). We could not detect any differences between infiltrative and displacing tumors regarding tumor volume, primary tumor, or the age of the patients. Notably, no additional morbidity or prolongation of operative time was induced by the study protocol.

#### Conclusion

Our results demonstrate that the protocol was feasible and confirmed the clinical impact of infiltration at the MMPI. In addition, this highlights the potential importance of supramarginal resection in infiltrative BM.

Abb. 1

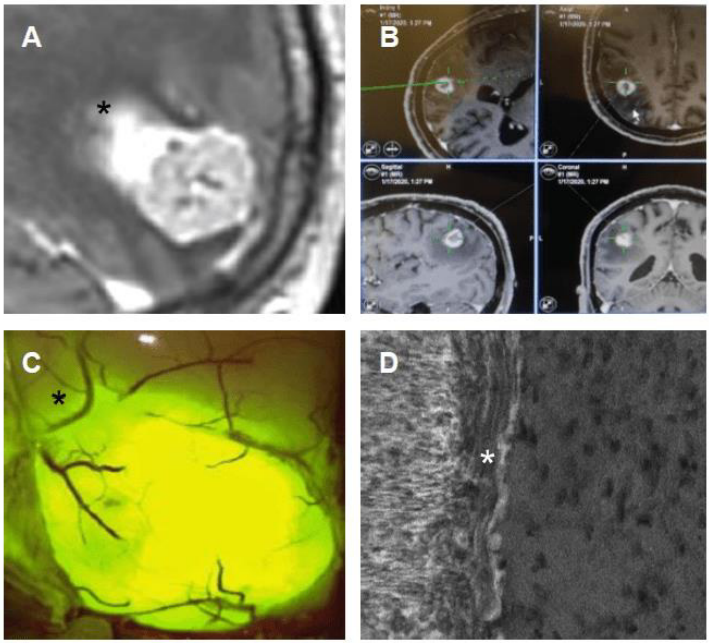

A
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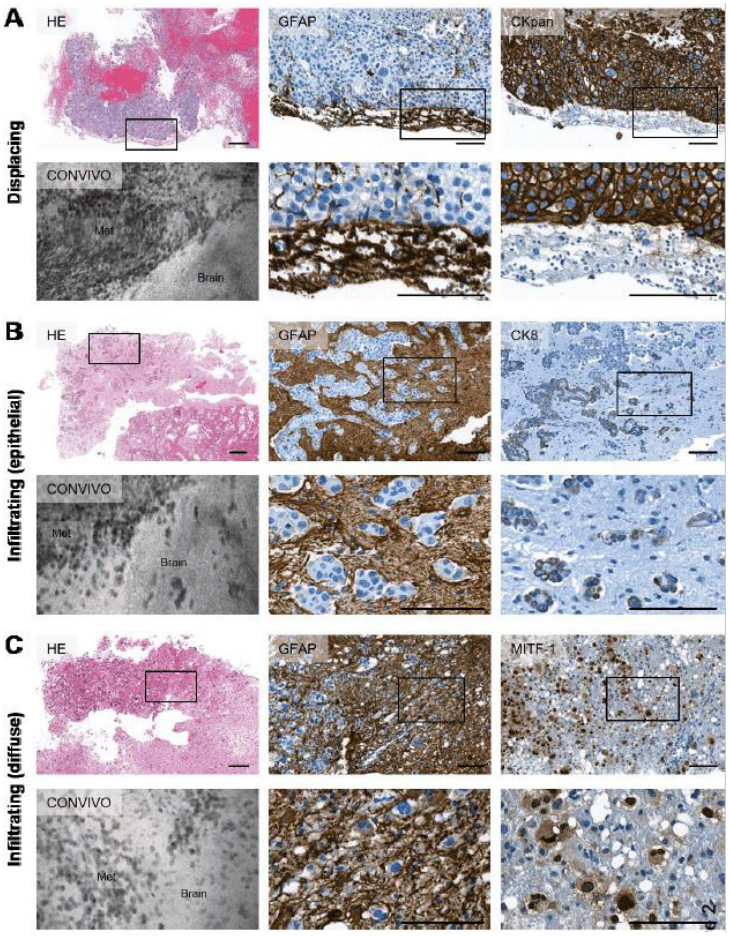
Abb. 2


A
HE
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C
HE
GFAP
MITF-1
Infiltrating (diffuse)
CONVIVO
Met
Brain

# V234

## Management postoperativer Ergebnisse bei Patienten mit Hirnmetastasen: eine Überarbeitung des ursprünglichen Graded Prognostic Assessment.

***Navigating post-operative outcomes: A comprehensive reframing of an original graded prognostic assessment in patients with brain metastases***

M. Goldberg[1,2], M. G. Mondragon-Soto[3], L. Dieringer[3], G. Altawalbeh[1], P. Pöser[4], L. Baumgart[5], B. Wiestler[6], J. Gempt[5], B. Meyer[1], A. K. Aftahy[1]

[1]Department of Neurosurgery, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[2]Institute of Innovative Radiotherapy (iRT), Department of Radiation Sciences (DRS), Helmholtz Zentrum Munich, München, Deutschland
[3]National Institute of Neurology and Neurosurgery, Department of Neurosurgery, Mexico City, Mexiko
[4]Department of Neurosurgery, Charite–Universitätsmedizin Berlin, Corporate Member of Freie Universität Berlin, Humboldt-Universität zu Berlin, and Berlin Institute of Health, Berlin, Deutschland
[5]Department of Neurosurgery, University Medical Center Hamburg-Eppendorf, Hamburg, Deutschland
[6]Department of Neuroradiology, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland

### Objective

Graded Prognostic Assessment (GPA) has been proposed for various brain metastases (BM) tailored to primary histology and molecular profiles. The residual tumor burden (RTB) is a strong predictor of overall survival. We validated the GPA score and introduced "volumetric GPA" in the largest cohort of operated patients and further explored the role of RTB as an additional prognostic factor.

### Methods

A total of 630 patients with BM between 2007 and 2020 were included. The four GPA components were analyzed. The validity of the original score was assessed using Cox regression and a modified index incorporating RTB was developed by comparing the accuracy, sensitivity, specificity, F1-score, and AUC parameters.

### Results

GPA categories showed an association with survival: age ($p < 0.001$, hazard ratio (HR) 2.9, 95% confidence interval (CI) 2.5–3.3), Karnofsky performance status (KPS) ($p < 0.001$, HR 1.3, 95% CI 1.2–1.5), number of BM ($p = 0.019$, HR 1.4, 95% CI 1.1–1.8), and presence of extracranial manifestation ($p < 0.001$, HR 3, 95% CI 1.6–2.5). The median survival for GPA 0–1 was 4 months, GPA 1.5–2 12 months, GPA 2.5–3 21 months, and GPA 3.5–4 38 months ($p < 0.001$). RTB was identified as an independent prognostic factor. A cut-off of 2 cm3 was used for further analysis, which showed a median survival of 6 months (95% CI 4–8) vs 13 months (95% CI 11–14, $p < 0.001$) for patients with RTB >2 cm3 and <2 cm3 respectively. RTB was added as an additional component for a modified volumetric GPA score. Survival rates of the modified GPA score were: GPA 0–1 4 months, GPA 1.5–2 7 months, GPA 2.5–3 18 months, and GPA 3.5–4 34 months. Both scores showed good stratification, with the new score showed a trend towards better discrimination in patients with more favorable prognoses.

### Conclusion

The prognostic value of the original GPA was confirmed in our cohort of patients who underwent surgery for BM. The RTB was identified as a parameter of high prognostic significance and was incorporated into an updated "volumetric GPA".This score provides a novel tool for prognosis and clinical decision-making in patients undergoing surgery. This method may be useful for stratification and patient selection in future clinical trials.

Abb. 1

| | 0 | 0.5 | 1 |
|---|---|---|---|
| **Age** | ≥ 70 | < 70 | NA |
| **KPS** | < 70 | 70-80 | 90-100 |
| **ECM** | no | NA | yes |
| **N of BM** | >3 | 2-3 | 1 |
| **Rest tumor volume** | ≥ 2 | < 2 | NA |

(KPS) Karnofsky performance scale, (ECM) extracranial manifestation, (BM) brain metastases, (NA) not applicable.

# V235

## Sarkopenie ist ein Indikator für das Gesamtüberleben von Patienten mit Hirnmetastasen bei nicht-kleinzelligem Lungenkarzinom

***The impact of sarcopenia on overall survival after resection of cerebral metastasis in patients with non-small cell lung cancer***

L. Schmidt[1], A. Schmitz[1], A. Dauth[1], D. Jankovic[1], H. Krenzlin[1], F. Ringel[1], N. Keric[1]

[1]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgische Klinik und Poliklinik, Mainz, Deutschland

### Objective

Frailty is an established predictor of response to therapy and survival in patients with brain metastasis and can be measured using temporal muscle volumetry (TMV) as a surrogate parameter. However, the role of frailty in patients undergoing surgical resection is still largely unknown. The aim of this study is to determine the impact of sarcopenia on survival after resection of brain metastasis in non-small cell lung cancer (NSCLC).

### Methods

We performed a single-center retrospective study including patients undergoing resection of supratentorial NSCLC metastasis. Patients were included from 2011 to 2020. Demographic data, Karnofsky Performance Score (KPS), Charlson Comorbidity Index (CCI) and Clinical Frailty Score (CFS) were compiled before surgery. Temporal muscle volumetry as surrogate for sarcopenia was performed using T1 MRI images using brainlab elements v4.0.0.108 (Brainlab Munich).

### Results

179 consecutive patients with a median age of 63 (56-69) years were included in this study (64/ 35.8% were female); while 64 (35.8%) patients had a single lesion. Median follow-up after surgery was 11 (0-120) months. PFS was 8 (3-23) and OS 11 (8-34) months. The median KPS before surgery was 80 (70-90), CCI 9 (8-10) and CFS 3 (3-4), classifying 37 (20.6%) as frail. Median temporal muscle volume (TMV) was 20.8 (14.2-26.7) cm3. (All median, IQR)Frailty as assessed by CFS correlated with age (r=0.361 p>0.001), CCI (r=0.229 p=0.014), pre- and postoperative KPS (r=-0.809 p>0.001; r=-0.715 p>0.001).TMV correlated with frailty (r=-0.222 p=0.018) and postoperative KPS (r=0.195 p=0.038). However, frailty according to CFS (PFS: 24 vs 20 months, p=0.455; OS: 34 vs 29 months, p=0.278) and median TMV (PFS: 32 vs. 21 months, p=0.9; OS: 29 vs. 25 months, p=0.94) alone did not predict differences in survival. A ROC analysis to define a cut-off for TMV and frailty showed an optimal discrimination for 1-year survival at 15.5(±9,5) cm3. The comparison of patients above and below this cut-off revealed a significant difference in OS of 34.5 vs 10.3 months (Chi2=16.953 p>0.001) but not in PFS (27.7 vs 16.3 months; Chi2=0.858 p=0.354). In the multivariate analysis sex, sarcopenia, radiation- and immunotherapy predicted a longer PFS and OS.

### Conclusion

In the presented cohort, sarcopenia is an independent predictor of OS after surgeryof cerebral metastasis in NSCLC in addition to radiotherapy. Consideration ofsarcopenia in surgical decision-making can improve patient selection for different treatment modalities.

# V236

## Chirurgische Behandlung von multiplen Hirnmetastasen bei Mammacarcinom: klinische Merkmale und Faktoren, die das postoperative Überleben beeinflussen

***Surgical treatment of multiple breast cancer brain metastases: Clinical characteristics and factors impacting postoperative survival***

A. Michel[1], M. Gümüs[1], T. F. Dinger[1], Y. Ahmadipour[1], M. Darkwah Oppong[1], P. Dammann[1], K. H. Wrede[2], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland
[2]Universitätsklinikum Essen, Klinik für Neurochirurgie, Essen, Deutschland

### Objective

Breast cancer (BC) is one of the most common primary tumor entities developing brain metastases (BM) in the course of disease. Multiple BM are associated with poorer prognosis, but different surgical, radio- and systemic therapy concepts improved survival. We aimed to analyze the baseline patterns of patients with single vs multiple BCBM and to compare their prognosis after BM surgery.

### Methods

All metachronous metastasized female patients with resected (singular and multiple) BCBM in our institution between 2008 and 2019 were included. We compared various clinical, radiologic, and histopathologic parameters of BC patients with multiple and singular BM. Postoperative survival was analyzed using univariate and multivariate Cox regression models.

### Results

We included 93 patients (median age of 60.0 years at BM diagnosis), where 30 patients presented with multiple (median age of 58.5 years) and 63 patients with singular BM (median age of 60.3 years). BC individuals with multiple BM were more frequently treated for infratentorial BM (aOR 3.35, 95% CI 1.03-10.83, p=0.044), showed positive HER2 receptor status of BC (aOR 3.93, 95% CI 1.23-12.53, p=0.021) and the presence of hepatic metastases (aOR 5.86, 95% CI 1.34-25.61, p=0.019) than the counterparts with single BM. There was no significant difference in postoperative survival between individuals with multiple (median: 12.5 months) and singular BM (17.0 months, p=0.186). Moreover, the adjuvant radiotherapy improved survival after BM resection, showing more prominent effect in cases of multiple BM (HR 0.09, 95% CI 0.02-0.50, p=0.006).

### Conclusion

BC patients with multiple BM show remarkable postoperative survival, particularly if combined with adjuvant radiotherapy. Our data justify the surgical treatment of multiple BCBM in patients with appropriate clinical condition and feasable location of BM.

# Pädiatrische Neurochirurgie – Tumor | Paediatric neurosurgery - Tumour

## V237

### Erlaubt ein intraoperatives Erkennen der Tumorursprungszone bei Medulloblastomen Rückschlüsse auf die Tumorsubgruppe und somit Adaptierung der chirurgischen Strategie? Erfahrungen aus einem Zentrum und Vorstellung einer prospektiven, multizentrischen Studie.

***Does the intraoperative assessment of site of origin of medulloblastoma allow for a tailoring of the neurosurgical strategy? Data from a retrospective single-center assessment and proposal of a prospective multicenter study***

O. Ciobanu-Caraus[1], T. Czech[1], A. Peyrl[2], C. Haberler[3], G. Kasprian[4], J. Furtner[4], M. Kool[5,6,7], M. Sill[5,6], J. Frischer[1], A. Cho[1], I. Slavc[2], K. Rössler[1], J. Gojo[2], C. Dorfer[1]

[1]Medical University of Vienna, Department of Neurosurgery, Wien, Österreich
[2]Medical University of Vienna, Department of Pediatrics and Adolescent Medicine, Wien, Österreich
[3]Medical University of Vienna, Division of Neuropathology and Neurochemistry, Department of Neurology, Wien, Österreich
[4]Medical University of Vienna, Department of Radiology, Wien, Österreich
[5]Hopp CHildren's Cancer Center, Heidelberg, Deutschland
[6]German Cancer Research Center (DKFZ), Department of Pediatric Neurooncology, Heidelberg, Deutschland
[7]Princess Maxima Center for Pediatric Oncology, Utrecht, Niederlande

#### Objective

Developmental gene expression data from medulloblastoma (MB) suggest that WNT-MB originate from the region of the embryonic lower rhombic lip (LRL), whereas SHH-MB and non-WNT/non-SHH MB arise from cerebellar precursor matrix regions. This study aims to analyze detailed intraoperative data with regard to the site of origin (STO) and compare these findings with the hypothesized regions of origin associated with the molecular group.

#### Methods

A review of the institutional database identified 58 out of 72 pediatric patients who were operated on a MB at our department between 1996 and 2020 that had a detailed operative report, surgical video as well as clinical and genetic classification data available for analysis. The STO was assessed based on intraoperative findings.

#### Results

Using the intraoperatively defined STO, "correct" prediction of molecular groups was feasible in 20% of WNT-MB, 60% of SHH-MB and 71% of non-WNT/non-SHH MB. The positive predictive values of the neurosurgical inspection to detect the molecular group were 0.21 (95% CI 0.08–0.48) for WNT-MB, 0.86 (95% CI 0.49–0.97) for SHH-MB and 0.73 (95% CI 0.57–0.85) for non-WNT/non-SHH MB.

#### Conclusion

In our series of 58 well-documented cases, the intraoperative assessment of the STO could not reliably predict the molecular group. Thus, the current evidence does still not allow for intraoperative group-specific risk stratification that would enable tailoring the neurosurgical strategy to the prognostic and predictive profile of the patient. Prospective multicenter assessments are necessary to systematically evaluate the growth pattern and site of origin of medulloblastoma. Accordingly, a study protocol of an international cohort study will be presented.

# Pädiatrische Neurochirurgie – Tumor | Paediatric neurosurgery - Tumour

## V238

### Umfassende Charakterisierung der B7H3-Expression in erwachsenen und pädiatrischen Hirntumor-Entitäten mit besonderem Fokus auf das Medulloblastom als hoch B7H3-exprimierenden Tumor

***Comprehensive characterization of B7H3 expression in adult and pediatric brain tumor entities, highlighting medulloblastoma as a highly B7H3-Expressing tumor***

V. Cibulkova[1], D. Hieber[2], J. Allgaier[3], J. Schobel[2], R. Pryss[3], A. F. Keßler[1], A. Cattaneo[1], T. Schulz[1], M. Breun[1], F. Liesche-Starnecker[4], C. Hagemann[1], R. I. Ernestus[1], M. Löhr[1], C. Monoranu[5], V. Nickl[1]

[1]Universität Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Hochschule Neu-Ulm, Institute DigiHealth, Neu-Ulm, Deutschland
[3]Universität Würzburg, Institut für Klinische Epidemiologie und Biometrie, Würzburg, Deutschland
[4]Universität Augsburg, Institut für Pathologie und Molekulare Diagnostik, Augsburg, Deutschland
[5]Universität Würzburg, Pathologisches Institut, Abteilung für Neuropathologie, Würzburg, Deutschland

#### Objective

Chimeric antigen receptor (CAR) T-cell therapy holds promise as a cancer immunotherapy, necessitating the selection of appropriate tumor-associated antigens (TAAs). The immune checkpoint protein B7H3 is a TAA under evaluation in eight CAR T-cell clinical trials, primarily targeting glioblastoma (GBM). This study assesses B7H3 expression in a diverse spectrum of brain tumors in relation to survival and safety considerations.

#### Methods

Formalin-fixed paraffin-embedded tumor samples from adult (n=199) and pediatric (n=25) patients were subjected to immunohistochemical staining for B7H3. Tumor types included GBM (n=146), astrocytoma WHO grade 1-4 (n=31), oligodendroglioma WHO grade 2 and 3 (n=22), medulloblastoma (n=5), pediatric-type diffuse high-grade glioma (n=5), ependymal tumor (n = 9), circumscribed astrocytic tumor (n = 4), and pediatric astrocytoma (n=2). Staining intensity was quantified with QuantCenter, assigning an H-score (range 0-300) to each sample. Survival analysis for GBM patients was performed using Kaplan-Meier curves and Cox regression, considering relevant clinical factors. B7H3 safety as a target was evaluated in healthy tissue microarrays approved by the FDA.

#### Results

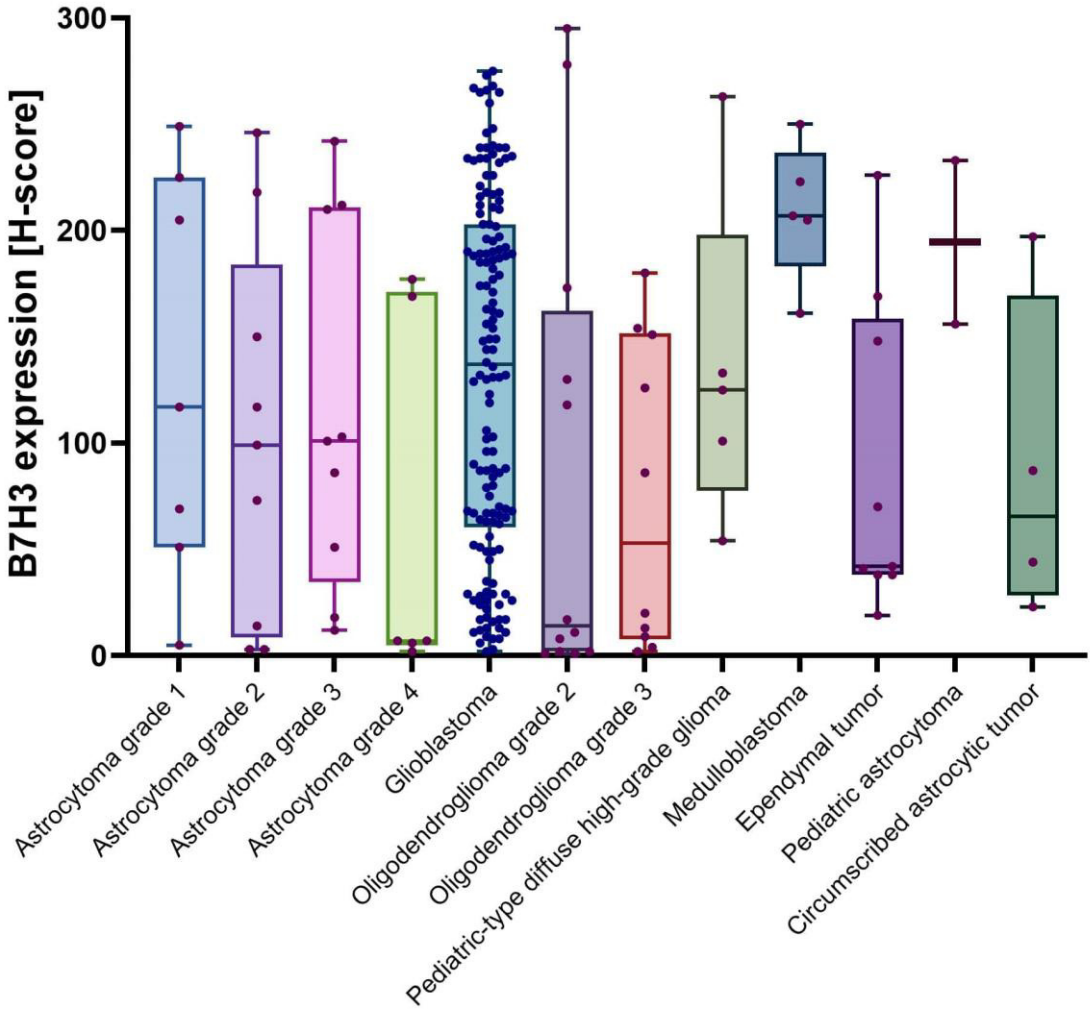
Medulloblastoma exhibited the highest and uniform B7H3 expression (median H-score 209), presenting a valuable prerequisite for CAR T-cell immunotherapy in this predominantly pediatric tumor. In contrast, other pediatric entities displayed significant heterogeneity in B7H3 expression. Among adult tumors, GBM demonstrated the highest B7H3 expression (median H-score 137), followed by astrocytoma grade 1, 3, and 2. Survival analysis revealed significantly longer overall survival for high B7H3 expressors in GBM (log rank p = 0.049). Healthy liver, lung, and colon exhibited moderate B7H3 levels, providing insights into potential on-target off-tumor toxicity.

#### Conclusion

This study comprehensively characterized B7H3 expression in diverse adult and pediatric brain tumor entities. The identified high and uniform B7H3 expression in medulloblastoma underscores its potential as a precise target for CAR T-cell immunotherapy, particularly in pediatric cancers. The observation of higher B7H3 expression correlated with longer overall survival in adult GBM patients has implications for prognostication and clinical practice. Insights into B7H3 expression in healthy tissues contribute to the assessment of potential on-target off-tumor toxicity in therapeutic interventions.

Abb. 1

**Figure 1. B7H3 expression across adult and pediatric brain tumor entities.**
The intensity of immunohistochemical staining was quantified into an H-score, representing antigen expression level. H-score can be considered as low (0 - 100), medium (101 - 200), and high (201 - 300).



V239

## Eine vergleichende Analyse epidemiologischer, klinischer Merkmale und Langzeitergebnisse zwischen pädiatrischen und erwachsenen Meningeomen. Klinisch: Eine SEER-Datenbankstudie

***A comparative analysis of epidemiologic, clinical characteristics and long-term outcomes between pediatric and adult meningiomas clinical: A SEER database study***

L. Hua[1], L. Ren[1], Y. Gong[1]

[1]Huashan Hospital, Fudan University, Neurosurgery, Shanghai, China, Volksrepublik

### Objective

Meningioma represents the most common intracranial tumor among adults. However, it is rara in pediatric patients. We are aimed to compare the clinical characteristics and long-term outcome of pediatric meningiomas (PMs) and adult meningiomas (AMs).

### Methods

We enrolled 211682 patients with PMs in the Surveillance, Epidemiology, and End Result (SEER) datasets from 2000 to 2020. Clinical characteristics, overall survival (OS) and disease specific survival (DSS) were compared between PMs and AMs. Univariate and multivariate Cox analysis were employed to evaluate the predictive values of clinical characteristics.

### Results

901 PM and 210781 AM patients were identified in the SEER datasets. The age-adjusted incidence rate of PMs ranged from 0.1 to 0.2 per 100,000 population. PMs accounted for 0.4-0.5% of all meningiomas from 2004 to 2020. The mean age of PM patients was 13.6±4.96 years. In comparison to AMs, PMs showed a notable male predominance ($p<0.001$), multiple system number ($p<0.001$), a predilection for spinal locations ($p<0.001$), malignant behaviors ($p<0.001$), and high WHO grade ($p<0.001$). Regarding treatment modalities, a significantly larger proportion of PM patients underwent surgery ($p<0.001$), postoperative radiotherapy ($p<0.001$), and systemic therapy ($p<0.001$). The mortality rate of PM patients was 6.55%, with a disease-specific mortality of 2.89%. Propensity score matching (PSM) was conducted between PM and AM cohorts. The survival analysis showed PMs had a significantly better OS ($p<0.001$) and DSS ($p<0.001$) when compared to the matched AM cohort. System number ($p<0.001$), tumor behavior ($p=0.001$), and systemic therapy ($p=0.006$) were determined as independent factors for the OS of PM patients. A nomogram with excellent accuracy was constructed based on the results of the multivariate Cox analysis.

### Conclusion

PMs are extremely rare and show distinct clinical characteristics and outcomes when compared to AMs. They are characterized by male predominance, spinal location, multiple system diseases, malignant behavior and favorable OS.

# Pädiatrische Neurochirurgie – Tumor | Paediatric neurosurgery - Tumour

## V240

### Präoperatives Mapping der Sprachfunktion bei Kindern - eine systematische Übersichtsarbeit
***Preoperative language mapping in children – A systematic review***

T. Link[1], T. Rosenstock[1,2], T. Picht[1,3], U. W. Thomale[1], P. Vajkoczy[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, BIH Charité Junior Clinician Scientist Program, Berlin, Deutschland
[3]Humboldt-Universität zu Berlin, Cluster of Excellence Matters of Activity, Image Space Material, Berlin, Deutschland

#### Objective

In pediatric brain tumor/epilepsy surgery, preserving eloquent areas is essential beside sufficient resection margins. Electrical stimulation mapping (ESM) and the Wada-procedure are accepted as gold standarts for the assessment of language function. However, both methods are invasive with varying degrees of feasibility. The aim of this review was to summarize preoperative language mapping data in children for identification of hemipsheric language dominance (HD) or localization of language-eloquent regions, highlighting the feasibility, strengths and limitations of invasive methods and noninvasive alternatives.

#### Methods

A systematic review was conducted using PubMed and registered in PROSPERO. The following keywords were used to identify articles eligible for review: *children, brain mapping, children".*

#### Results

38 articles examining invasive (ESM, Wada, electrocorticography (ECOG)) and noninvasive methods (task-based and resting-state fMRI, repetitive navigated TMS (rnTMS), magnetoencephalography and tractography) were included. Most studies (n=23) were feasibility analyses, whereas 16 validation studies were identified. Invasive methods require extensive compliance resulting in success rates of 19% (3/19) for children below 10 years, and seizures in up to 35% (43/122) of patients undergoing ESM. Non-invasive alternatives proved to be safe and could be integrated into clinical routine, with MEG and tb-fMRI mostly utilized for determination of HD and rnTMS and tractography analyzed for identification of language-eloquent areas. For determination of HD, tb-fMRI and MEG displayed concordance rates with invasive mapping from 0.29-0.89. rnTMS and tractography identified eloquent areas with sensitivities between 0.20-0.97. Postoperative outcomes were reported in 13 studies (174/1075 patients) whereby language outcome predicition was aimed only in two cohorts (ECOG and tractography). Resection of ECOG hotspots was not assciated with (worse) postoperative language outcome. In contrast, injury of subcortical language tracts significantly correlated with postoperative language deficit ($R=0.7$, $p<0.001$).

#### Conclusion

The challenges in pediatric neurosurgery are mirrored in the limited literature where postoperative outcomes are rarely reported. However, there are suitable alternatives to invasive methods, each with specific strenghts and weaknesses for determining HD or location analysis of language areas. Prospective, multicenter studies should be initiated to further validate these methods.

# Pädiatrische Neurochirurgie – Tumor | Paediatric neurosurgery - Tumour

## V241

### Langfristiges Outcome nach dringender und notfallmäßiger Operation bei Kindern mit tumor-assoziierten intrakraniellen Hypertension und zerebralen Herniation: eine monozentrische Studie

***Long-term outcome following urgent and emergent surgery in children with tumor-related intracranial hypertension and cerebral herniation: A monocentric study***

D. Emmanouilidis[1], C. Zinke[2], R. Knöfler[2], J. Schallner[3], S. Brenner[4], M. von der Hagen[5], M. Smitka[5], T. Juratli[1], G. Schackert[1], I. Y. Eyüpoglu[1], S. B. Sobottka[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Pädiatrische Onkologie, Dresden, Deutschland
[3]Universitätsklinikum Carl Gustav Carus Dresden, Integriertes Sozialpädiatrisches Zentrum, Dresden, Deutschland
[4]Universitätsklinikum Carl Gustav Carus Dresden, Pädiatrische Intensivmedizin, Dresden, Deutschland
[5]Universitätsklinikum Carl Gustav Carus Dresden, Neuropädiatrie, Dresden, Deutschland

#### Objective

Brain tumors, whether supratentorial or infratentorial, can induce life-threatening cerebral herniation necessitating urgent or emergent surgery to normalize intracranial pressure. While survival is the primary surgical goal, the quality of life in children is also of paramount importance.

#### Methods

We conducted a retrospective analysis of 29 pediatric patients with tumor-associated brain herniation (subfalcine, transtentorial and tonsillar) who underwent surgery from 2014 to 2023 at our center.

#### Results

Of the 29 patients (19 males, median age 4.3 years) 79.3% had infratentorial tumors. Emergent surgeries were performed in 31%, while urgent surgeries within 12 hours took place in 6.9% and within 24 hours in 62%. Histopathological analysis identified medulloblastoma in 37.9%, pilocytic astrocytoma in 31%, anaplastic ependymoma in 10.3%, diffuse high-grade glioma in 6.9%, ATRT in 6.9%, and anaplastic astrocytoma, ETMR and sarcoid tumor in 3.4% respectively. Preoperatively, intracranial pressure symptoms had 89.6%, focal cerebellar symptoms 37.9%, papilledema 31%, reduced alertness 20.7%, cranial nerve disorder 10.3% and focal cerebral symptoms 3.4%. Gross total resection was achieved in 75.9%, near-total in 17.3% and subtotal in 6.8%. Preoperative hydrocephalus was diagnosed in 82.8%, more common in infratentorial tumors (91.3%). External ventricular drain was used in 37.9%, with only 16.7% requiring postoperative shunt placement. In long-term follow-up (median 48.5 months) clinical improvement was observed in 72.4% (73.9% of infratentorial and 66.7% of supratentorial tumors). Tumors in cerebellar hemispheres showed the least clinical improvement (55.6%, p=0.03). Long-term symptoms included cerebellar symptoms in 88.5%, cranial nerve disorder in 23.1% and focal cerebral symptoms in 11.5%. Gross total resection correlated with clinical improvement in 77.3%. 10.3% were asymptomatic in long-term follow-up. Four patients died due to tumor progression (median survival 23.1 months). 14.3% of the children were unable to attend school and 32.1% required special support schools. 50% of the patients participated in sports.

#### Conclusion

Various factors influence the long-term outcome in children undergoing urgent or emergent tumor surgery. This single-center study underscores the potential for a positive outcome postoperatively. These findings could contribute to managing crucial discussions with caregivers of children facing life-threatening brain tumors regarding clinical outcome postoperatively.

# Pädiatrische Neurochirurgie – Tumor | Paediatric neurosurgery - Tumour

## V242

### Klinische Symptomatik und chirurgische Ergebnisse nach operativer Versorgung von Kolloidzysten des dritten Ventrikels: eine multizentrische Kohortenstudie

*Clinical symptoms and surgical outcome of colloid cysts of the third ventricle: A multicenter retrospective study*

V. M. Butenschön[1], A. Quiring[1], N. Lange[1], L. Mikhina[2], J. Gempt[2], M. Shah[3], J. Beck[3], P. Evangelou[4], V. Rhode[4], D. Jankovic[5], F. Ringel[5], I. Janssen[6], K. Schaller[6], C. Freyschlag[7], C. Thomé[7], S. Maurer[8], M. Czabanka[8], P. Leissa[9], P. Vajkoczy[10], B. Meyer[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Hamburg, Deutschland
[3]University Medical Center Freiburg, Freiburg i. Br., Deutschland
[4]Universitätsklinikum Göttingen, Göttingen, Deutschland
[5]Universitätsklinikum Mainz, Mainz, Deutschland
[6]HUC, Genf, Schweiz
[7]Universitätsklinikum Innsbruck, Innsbruck, Österreich
[8]University Hospital Frankfurt a.M., Department of Neurosurgery, Frankfurt a. M., Deutschland
[9]Charité – Universitätsmedizin Berlin, Berlin, Deutschland
[10]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland

#### Objective

Colloid cysts of the third ventricle are rare benign brain lesions that can lead to potentially life-threatening hydrocephalus. Surgical removal is the primary treatment option, involving minimally invasive endoscopic or microsurgical techniques.

#### Methods

We performed a multicenter retrospective cohort study including all patients suffering from colloid cysts of the third ventricle operated upon in eight tertiary care neurosurgical departments from Germany, Austria, and Switzerland. Data assessment included preoperative symptoms focusing on the presence of chronic or acute hydrocephalus, pre-and postoperative imaging for the colloid cyst risk score, surgical technique, and long-term clinical outcome and shunt-dependency.

#### Results

We collected data on 192 patients operated upon between 2006 and 2022. The mean age was 46 years; 56% of the patients were male. Symptoms were present in 91.2% of the patients, including headache, vertigo, and memory loss. Acute hydrocephalus was diagnosed in 27.5% and chronic hydrocephalus in 38.7% of the patients. The mean cyst diameter was 12.7 mm, and most patients had a colloid cyst risk score of four out of five points. A microsurgical transcortical approach was chosen in 94% of the cases, and 23.4% opted for an intraoperative rescue EVD. Shunt dependency was observed in only 5% of the cases, all linked to postoperative ventriculitis. Long-term follow-up revealed a satisfying clinical status after a median of 10 months.

#### Conclusion

In our large cohort, most patients benefited from microsurgical approaches. The low rate of postoperative shunt dependency, primarily associated with ventriculitis, underscores the effectiveness of surgical management. Our findings support the favorable long-term clinical outcome, emphasizing the role of surgical treatment in alleviating symptoms and preventing complications in this rare condition.

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## V243

### Airway Pressure Release Ventilation ist sicher bei Patienten mit intrakraniellen Pathologien
*Airway pressure release ventilation is safe to use in patients with intracranial pathologies*

L. Schmidt[1], D. Kalasauskas[1], M. Kosterhon[1], F. Ringel[1], T. Kerz[1]

[1]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgische Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Airway Pressure Release Ventilation (APRV) is an alternate mode of ventilation in Acute Respiratory Distress Syndrome (ARDS), but there are inconsistent data to support its use over other modes of ventilation. Because of increased intrathoracic pressure for most of the respiratory cycle, a negative impact of APRV on intracranial pressure (ICP) has been hypothesized. We evaluated the impact on APRV on Horovitz index, ICP, Cerebral Perfusion Pressure (CPP), Mean Arterial Pressure (MAP), and Therapy Intensity Level (TIL).

#### Methods

Retrospective single-center analysis from January 2021 to March 2023 of neurosurgical ICU patients with ICP probes inserted. APRV was used as a rescue mode at the physician"s discretion when the Horovitz index fell below 150 despite optimized conventional ventilation.

#### Results

This study enrolled 28 patients undergoing 31 episodes of APRV. Median age was 56 (IQR 44-62) years, 12 (38.7%) were female. The main diagnosis was intracerebral hemorrhage (n=11, 35.5%), subarachnoid hemorrhage (n=7, 22.6%), traumatic brain injury (n=4, 2.9%) and other (n=9, 29%). The median time between ICU admission and the first episode of APRV was 8 (IQR 4-13) days. Before conversion to APRV, compliance was 38 (IQR 23-55) ml/cmH2O, Horovitz index 144 (IQR 136-160) mmHg, ICP 12 (IQR 5-17.5) mmHg, cerebral CPP 78 (IQR 62-84) mmHg (all median). The TIL was 0 in 5 (16.1%), 1 in 12 (38.7%), 2 in 11 (35.5%) and 3 in 3 (9.7%) cases. Following conversion to APRV, there was a rise in the median Horovitz index (60min: 201,44|120min: 208,61 mmHg), indicating enhanced oxygenation. Additionally, there was a tendency towards a lower ICP (60min: 9,5|120min: 11 mmHg) with an increase in CPP (60min: 80|120min: 77 mmHg, all median). Differences, apart from CPP after 45 minutes (p=0.011), did not attain statistical significance. One-hour post-transition, TIL significantly decreased (Z=-2.464, p=0.008); yet there were no differences after two hours. No critical increases in ICP (>20 mmHg) were observed. ICP, MAP, CPP values and Horovitz Quotient are displayed in Figure 1. No instances of pneumothorax, acute renal failure or myocardial injury was observed.

#### Conclusion

APRV did not increase intracranial pressure ICP or decrease CPP. TIL decreased in the first hour. APRV was safe regarding effects on ICP, MAP, and CPP. The Horovitz index showed an increase after the use of APRV. APRV appears to be a possible ventilatory strategy in this patient population.

Abb. 1

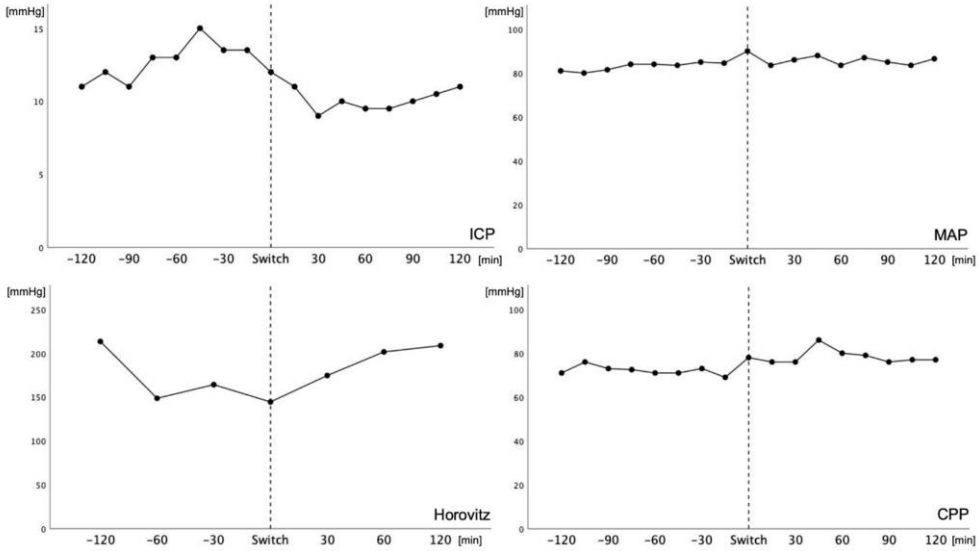



Figure 1- ICP, MAP, Horovitz-Quotient and CPP before and after transition to APRV.

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## V244

### Serum Procalcitonin in der Diagnose einer Pneumonie auf der neurochirurgischen Intensivstation
*Serum procalcitonin in the diagnosis of pneumonia in the neurosurgical intensive care unit*

M. Overstijns[1], P. Scheffler[1], J. Beck[1], A. El Rahal[1]

[1]Universitätsklinikum Freiburg, Neurozentrum, Freiburg i. Br., Deutschland

#### Objective

Procalcitonin (PCT) is an inflammatory blood marker associated with lower respiratory tract infections. An optimal cutoff value and its validity in the diagnosis of Hospital-Acquired Pneumonia (HAP) is controversial. This study aims to investigate the utility of PCT in supporting the diagnosis of HAP in a neurosurgical intensive care unit (NICU).

#### Methods

In this single-center retrospective study, we evaluated patients with clinical suspicion of HAP in our NICU from 01.01.2020 until 31.12.2022. A confirmed HAP diagnosis was based on a combination of clinical, biochemical, microbiological and radiological data. Inclusion criteria were serum PCT measurements taken for suspected HAP cases. Exclusions were patients whose PCT levels were measured >48 hours after HAP onset or for reasons unrelated to HAP. The optimal PCT cutoff value for confirmed HAP was calculated using the Youden Index. The relationship between PCT levels above this threshold, chest imaging results, and sputum culture findings with confirmed HAP was analyzed using chi-square tests.

#### Results

Among 2363 patients, 193 met inclusion and exclusion criteria, 45 (23.3%) of whom met our predefined criteria for confirmed HAP. The optimal cutoff procalcitonin value was 0.095ng/ml, and is highly significantly associated with confirmed HAP ($p<0.001$), with a sensitivity of 89.2% and specificity of 93.3% yielding a positive likelihood ratio of 13.3 and a negative likelihood ratio of 0.116. No significant association was found between confirmed HAP and signs of pneumonia on imaging or positive microbiological cultures.

#### Conclusion

Contrary to previous studies, this research highlights the beneficial role of PCT in confirming HAP among patients with clinical suspicion in the NICU, establishing a cutoff value of 0.095ng/ml. Prompt and accurate identification of HAP could expedite antibiotic treatment, enhancing patient care in the NICU. Further prospective studies are needed to validate these results.

Abb. 1

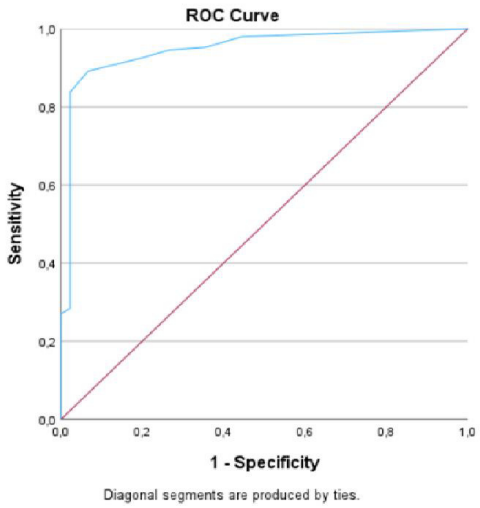
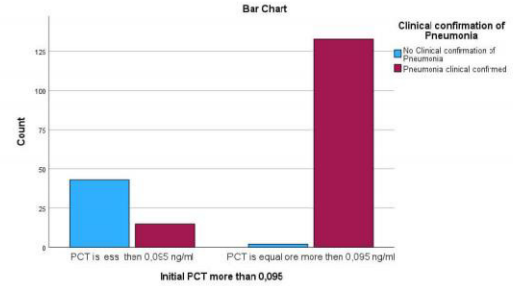
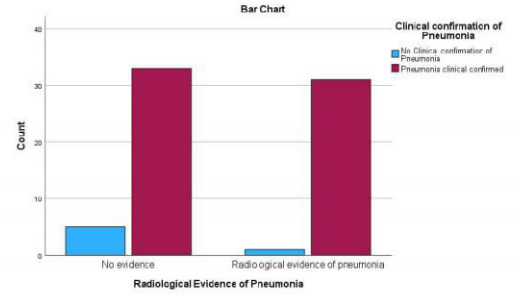



*Figure 1:* Receiver operating characteristic curve showing the specificity and sensitivity of Procalcitonin in diagnosing bacterial Pneumonia.

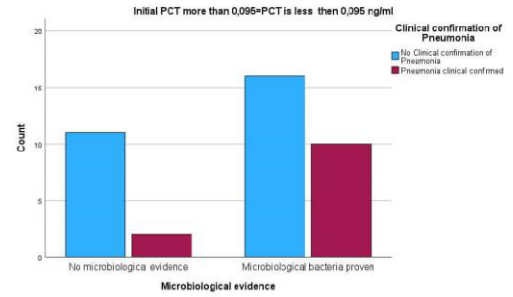
Abb. 2




a)




b)




c)

*Figure 2: a)* Cutoff PCT value of 0.095ng/ml has the optimal sensitivity and specificity ($p<0.001$) for HAP diagnosis. *b)* Chest imaging has a relatively high specificity but low sensitivity in HAP diagnosis ($p>0.05$). *c)* Microbiological evidence of bacteria in sputum has a relatively high sensitivity but low specificity in HAP diagnosis ($p>0.05$)

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## V245

### Die Rolle des Intensivstations-Flüssigkeitmanagements bei Patienten mit aneurysmatischer Subarachnoidalblutun

*The role of ICU fluid control in patients with aneurysmal subarachnoid hemorrhage*

J. Rodemerk[1], M. Gümüs[1], T. F. Dinger[1], C. Rieß[1], M. Darkwah Oppong[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

Rupture of intracranial aneurysm is associated with several complex primary and secondary complications where the proper intensive care unit (ICU) treatment plays an essential role. Herewith, fluid management is of eminent importance to balance between sufficient cerebral perfusion and avoiding brain swelling. This study aims to identify the significance of fluid balancing in ICU and elucidate its role as a predictor for outcome after subarachnoid hemorrhage (SAH).

#### Methods

All consecutive cases with aneurysmal SAH treated at our institution between 01/2003 and 06/2016 were eligible for this study. Fluid balance in ICU care was analyzed in univariate and multivariate analyses. The association between positive and negative fluid balance and primary study endpoints (risk of cerebral infarction, in-hospital mortality, and unfavorable outcome at six months defined as modified Rankin scale>3) was analyzed.

#### Results

The final cohort (n = 904) comprised patients between 19 and 90 years old, with an in-hospital mortality rate of 17.4%. Nearly 42% had an unfavorable outcome at six months, and 48.1% had an ischemic insult. ICU fluid control ranged between -9.7 and +28.5 l in all patients. The risk of an unfavorable functional outcome increased as the fluid balance increased (OR: 1.03, CI: 1.02-1.04, p: <0.0001). Moreover, higher-balanced patients showed a higher chance of developing an ischemic insult (OR: 1.02; CI: 1.01-1.03, p: <0.0001). Further, in-hospital mortality was positively linked to higher balanced patients (OR: 1.01, CI: 1.01-1.02, p: 0.0007).

#### Conclusion

The intricate balance between ensuring enough blood flow to the brain and preventing swelling highlights the importance of meticulous fluid management in the ICU. Higher balanced patients were consistently linked with higher risks of unfavorable functional outcomes at six months, ischemic insults, and in-hospital mortality. Fluid management is a critical aspect of care that significantly impacts patient outcomes and requires ongoing research for better protocols and improved results in SAH treatment.

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## V246

### Die fibrinolytische subdurale Spülung ist eine wirksame minimal-invasive Technik für die Behandlung akuter subduraler Hämatome, die nicht sofort evakuiert werden müssen

***Fibrinolytic subdural irrigation as an effective minimally invasive technique for acute subdural hematomas not requiring immediate evacuation***

M. Bissolo[1], R. Doria-Medina[1], T. Loidl[1], J. Beck[1], R. Roelz[1]

[1]Universitätsklinikum Freiburg, Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Acute subdural hematoma (aSDH) ranks among the most prevalent conditions in neurosurgery. While craniotomy remains the gold standard for aSDH removal, its association with high perioperative complications mandates the exploration of minimally invasive techniques, particularly in non-immediate intervention cases. Here, we present a novel approach to effectively remove aSDH in patients who do not require urgent evacuation, by percutaneous subdural fibrinolytic irrigation.

#### Methods

10 aSDH patients admitted between June to December 2023 were selected for a novel minimally invasive fibrinolytic irrigation approach. We selected patients with a GCS of 13-15, hematoma thickness of >7mm, but no need for immediate evacuation. A catheter for pressure-controlled irrigation was inserted into the aSDH via a 3.5mm twist drill burr hole under local anesthesia. Fibrinolytic irrigation was preformed using electrolyte solution containing 200,000 IU/L Urokinase at a rate of 100ml/h until radiological clearance was obtained (ca. 3-5 days). We compared perioperative complications, and neurological outcome at three-month (modified Rankin scale) with matching cases admitted before implementation of the novel approach (2020-06/2023).

#### Results

Near-complete hematoma resolution was attained in 9/10 cases (90%). One patient (10%) showed a decrease in the level of consciousness and was converted to an open craniotomy. There was one recurrence of a chronic subdural hematoma which resolved without sequelae after a 2nd twist drill craniostomy. No other perioperative complications or neurological deficits were observed. 8/10 patients (80%) had regained independence (mRS 0-3) at 3 months. Hematoma evacuation via craniotomy was performed in 30 matching cases (GCS 13-15, hematoma thickness of >7mm) in the preceding 2,5 years. Perioperative complications occurred in 16/30 patients (53%). We observed aphasia in 3 (10%), hemiparesis in 4 (13%), epilepsy in 8 (27%), re-hemorrhage in 2 (7%), meningitis in 1 (3%) and mortality in 2 (7%) patients. 17/30 patients (57%) had regained independence (mRS 0-3) at 3 months.

#### Conclusion

Our first experience indicates that minimally invasive fibrinolytic irrigation of aSDH may represent a safe and effective alternative to open surgery in selected patients who do not require immediate evacuation.

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## V247

### Prospektive, randomisierte Studie zur Vergleich von minimalinvasiver Hohlschraubentrapanation und erweitertem Bohrloch zur Therapie chronischer Subduralhämatome

***Prospective, randomized study comparing minimal invasive burr hole craniotomy to drill hole craniotomy for the management of chronic subdural hematomas***

V. M. Eisenkolb[1], L. Hönikl[1], N. Schwendinger[2], T. Obermüller[1], N. Buchmann[1], A. Wagner[1], S. Krieg[3,1], B. Meyer[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[2]Universitätsspital Zürich, Neurochirurgie, München, Deutschland
[3]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland

#### Objective

The chronic subdural hematoma (cSDH) is a frequently treated entity for neurosurgeons worldwide. Since the occurrence of this pathology is particularly common in elderly and multimorbid patients, the demographic shift is increasing the pressure on our healthcare systems, which are already facing major economic challenges. The high number of recurrences leads to an even greater importance of standardization of the medical approach. However, a wide spectrum of various surgical procedures is still employed.

#### Methods

In our study, we compared bedside evacuation of the cSDH using hollow screws (HS) under local anesthesia with the commonly used evacuation via enlarged burr holes (BH) under general anesthesia in a randomized, prospective, unicentric trial. 140 patients were enrolled in the period from 2015 to 2020, 9 patients had to be excluded during the course of the study. Mean age was 77.

#### Results

HS trephination is not inferior to BH in terms of recurrence rate (BH 31.2% vs. HS 47.8%; p>0,05) or clinical outcome (p>0,05). Yet, this less invasive surgical approach is associated with a significantly shorter operation duration (p<0,05) and a shorter hospital stay (median BH 4.3 days vs HS 3.0 days; p<0,005).

#### Conclusion

In the treatment of chronic subdural hematoma (cSDH), HS trephination should be considered as a reasonable alternative to BH trepanation, especially considering the demographic changes in modern society.

# Trauma und Neurointensiv – Verschiedenes 4 | Trauma and Neurointensive – Various 4

## BO-07

### *Microvascular perfusion in patients with aneurysmal subarachnoid hemorrhage*

A. Kyrylova[1], N. Terpolilli[2], C. Brem[3], T. Liebig[3], N. Plesnila[4]

[1]LMU Klinikum, München, Deutschland
[2]LMU Klinikum, Neurochirurgie, München, Deutschland
[3]LMU Klinikum, Neuroradiologie, München, Deutschland
[4]Institut für Schlaganfall- und Demenzforschung, München, Deutschland

#### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) may lead to both micro- and macrovascular spasms, resulting in impaired cerebral perfusion and, ultimately, in delayed cerebral ischemia (DCI). While spasm of larger cerebral arteries can be detected by perfusion computed tomography (CTP) or digital subtraction angiography (DSA), perfusion changes of the cerebral microcirculation, which is suggested to be significantly affected after SAH, are not part of routine clinical assessments.

Aim of study: Developing an algorithm to assess and quantify the perfusion of the cerebral microcirculation in datasets obtained from standard 2D-DSA.

#### Methods

DSA datasets obtained from aSAH patients (n=8; WFNS: 5) and age-matched healthy controls (n=8) admitted to LMU Klinikum from January 1st, 2010, to February 15th, 2023 with a mean age of 54,3 years were analyzed. Time density curves of the contrast agent bolus in ROIs (regions-of-interest) located over the extra- and intracranial segments of the internal carotid artery, the sigmoid sinus in both anterior-posterior (A) and sagittal (B) plane; three ROIs over the M2 branches of the middle cerebral artery and six areas of the cerebral cortex with no visible larger vessels in the B plane vs. two ROIs over the middle cerebral artery as well as two regions-of-interest over the anterior cerebral artery and four peripheral cortex areas in the A plane were analyzed using a custom MATLAB algorithm to calculate peak density, TTP (time-to-peak), rTTP A & rTTP B (relative TTP in A or B plane), AUC (area under the curve), FWHM (full width at half maximum), and MS (maximal slope).

#### Results

Aneurysms were located at the ICA (n=2), the MCA (n=2), the ACoA (n=2), and in the posterior cerebral circulation (n=2). FWHM and MS were statistically different between the aSAH and the control group.

#### Conclusion

The currently developed analysis allows to assess microcirculatory flow, i.e. tissue perfusion, using DSA datasets obtained during routine clinical workups. FWHM and MS seem to be promising angiographic markers to quantify cerebral microcirculatory flow following SAH and may thus help to detect microcirculatory dysfunction early after the onset of SAH. Further analyses are ongoing to validate these findings in a large, international multi-center cohort of SAH patients.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC001

### Klinisches Outcome und Komplikationen nach endovaskulärer Vasospasmolyse bei Patienten mit aneurysmatischer Subarachnoidalblutung

***Clinical outcome and complications after endovascular vasospasmolysis in patients with aneurysmal subarachnoid hemorrhage***

C. Albrecht[1], R. Liang[1], M. Wostrack[1], T. Boekh-Behrens[2], B. Meyer[1], T. Dominik[2], I. Hostettler[1], A. Wagner[1], Z. Claus[2], L. Charlotte[3], J. Schwarting[2]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Neuroradiologie, München, Deutschland
[3]Klinikum rechts der Isar, Technische Universität München, Anästhesiologie, München, Deutschland

#### Objective

The present study aimed to investigate whether endovascular therapy of large-artery vasospasms in delayed cerebral injury after aneurysmal subarachnoid haemorrhage (aSAH) results in a better outcome than in those who do not receive vasospasmolysis. Secondarily, predicting factors for CVS and complications following vasospasmolysis were examined.

#### Methods

Patients who were treated with aSAH between March 2006 and March 2020 in our department were retrospectively analyzed regarding general health data, aneurysm treatment strategies and development of CVS, symptomatic and/or measured using TCD, respectively. Severe vasospasm was defined by TCD mean velocities of >200 cm/sec or occurrence of new neurological deficits

#### Results

Overall, 853 Patients with acute aneurysmal SAH were treated. 310 (36%) suffered from severe vasospasm. Conservative treatment including induced hypertension was performed in all these patients. 92 patients (30%) underwent endovascular vasospasmolysis (eSL) due to persistent symptoms despite conservative therapy. Among endovascularly treated patients 79 patients (86%) improved in terms of angiographic results, 71% (n=44) improved clinically. Clinical worsening occurred in 11% of cases (n=7). In 30 (33%) unconscious or sedated patients of all 92 patients no obvious clinical improvement could be accessed immediately after eSL. Therefore, we evaluated the rates of secondary infarcts on CCT scans at discharge, TCD outcome and mortality among this subgroup.

#### Conclusion

Endovascular vasospasmolysis appears to be a valuable and favorable therapeutic option for patients with persistent cerebral vasospasm despite conservative measures. The procedure demonstrates promising clinical and radiological outcomes with low rates of periprocedural risks. Careful evaluation and continuous advancements in spasmolysis techniques are crucial in addressing cases of clinical deterioration after vasospasmolysis and further optimizing patient outcomes. Unconscious and sedated patients do not show a clinical or radiological improvement following eSL, evaluated by secondary infarct rates on CCT.

Abb. 1

**Table 3 – Results of endovascular Spasmolysis**

| | | n = 92 | % |
|---|---|---|---|
| **Type of Intervention** | **Local Nimodipine** | 63 | 68 |
| | **Local Nimodipine + PTA** | 19 | 21 |
| | **PTA** | 10 | 11 |
| | | | |
| **Affected Vessel** | **Unilateral Anterior Circulation** | 25 | 27 |
| | **Bilateral Anterior Circulation** | 25 | 27 |
| | **Posterior Circulation** | 4 | 4 |
| | **Generalized** | 38 | 41 |
| | | | |
| **Interventions / patient** | **Median** | 1 | |
| | **Minimum** | 1 | |
| | **Maximum** | 14 | |
| | | | |
| **Total number of interventions** | | 241 | |
| | | | |
| **Angiographic Result** | **Improvement** | 79 | 86 |
| | **No Improvement** | 13 | 14 |
| | | | |
| | | | |
| **Complications** | **Dissection Intracranial** | 2 | 0.8 |
| | **Dissection Extracranial** | 1 | 0.4 |
| | **Groin complication** | 1 | 0.4 |

*Note. — GCS = Glasgow coma scale.*

Abb. 2

**Table 1 – Results of Endovascular Spasmolysis in symptomatic conscious patients**

| | | n = 62 | % |
|---|---|---|---|
| **H&H distribition** | **I** | 9 | 15 |
| | **II** | 24 | 39 |
| | **III** | 15 | 24 |
| | **IV** | 10 | 16 |
| | **V** | 4 | 6 |
| | | | |
| **Overall clinical status** | **Improvement** | 44 | 71 |
| | **Stable** | 11 | 18 |
| | **Worse** | 7 | 11 |
| | | | |
| **CCT on discarge** | **Secondary infarct** | 21 | 33 |
| | **No infarct** | 41 | 77 |
| | | | |
| **Death** | **Yes** | 4 | 6 |
| | **No** | 58 | 94 |

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC002

### Blutmenge im 4. Ventrikel nach aneurysmatische Subarachnoidalblutung: prognostische Bedeutung und Einfluss der aktiven Blut clearance.

***Blood load in the 4th ventricle after aneurysmal subarachnoid hemorrhage: prognostic significance and impact of active blood clearance.***

M. Overstijns[1], J. Beck[1], A. El Rahal[1], R. Rölz[1]

[1]Universitätsklinikum Freiburg, Neurozentrum, Freiburg i. Br., Deutschland

#### Objective

Blood in the fourth ventricle is associated with particularly poor outcomes after aneurysmal subarachnoid hemorrhage (aSAH). We investigate a) the prognostic significance of 4th-ventricular hemorrhage severity, and, b) the influence of active blood clearance on outcome in patients with 4th ventricular hemorrhage.

#### Methods

A retrospective review of our aSAH database was performed, and 817 patients with aSAH admitted between 01.01.2009 and 31.12.2022 were included. Blood clearance by cisternal fibrinolysis was introduced in 10.2015 and the data set was split in two cohorts with 473 patients BEFORE availability of active blood clearance and 344 patients AFTER introduction of active blood clearance, which was performed in 111 (32.3%) patients. 4th ventricular hemorrhage was classed into 4 categories: grade 1 (no or minimal blood), grade 2 (partly filled), grade 3 (completely filled/ cast), grade 4 (ballooning due to hemorrhage). Neurological outcome was assessed using the modified Rankin Scale after 6 months by an independent rater.

#### Results

4th-ventricular hemorrhage was present in 39.7% of patients. Ruptured aneurysms in the posterior circulation were associated with a higher risk for a high-grade (3-4) 4th-ventricular hemorrhage (p=0.008). In the BEFORE cohort, patients with grade 3 and 4 hemorrhages had poor outcome in 75.6% and 92.7%, respectively. In the AFTER cohort, active blood clearance was performed in 24.7% (grade 3) and 31.7% (grade 4) of patients, and poor-outcome was reduced to 57.5% and 75.6% (p=0.043, p=0.017), respectively. Grade 4 hemorrhage was the most powerful predictor for poor-outcome (OR:**19.2**, p<0.001) without active blood clearance. This association, however, was reduced after implementation of active blood clearance (OR:**2.45**, p=0.075).

#### Conclusion

Ballooned 4th ventricular hemorrhage represents a very powerful predictor of poor outcome after aSAH. Implementation of active blood clearance significantly improved outcomes in high-grade 4th ventricular hemorrhage patients.

Abb. 1

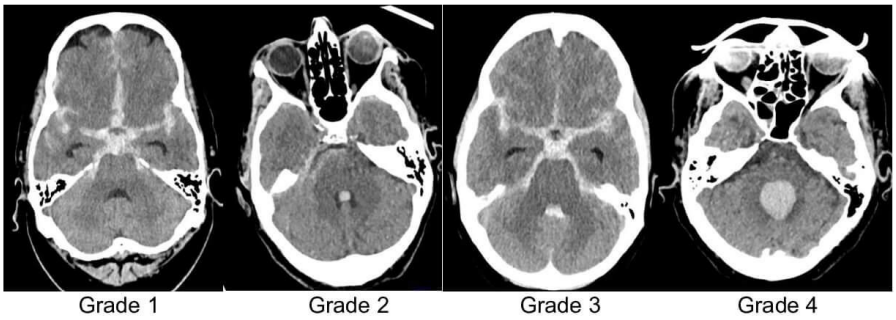



Figure 1: Images show from left to right grade 1-4 ,4th ventricular hemorrhage, which were defined as: No or minimal blood (1), partly filled(2), fully filled (cast)(3) and ballooned (4).

Abb. 2

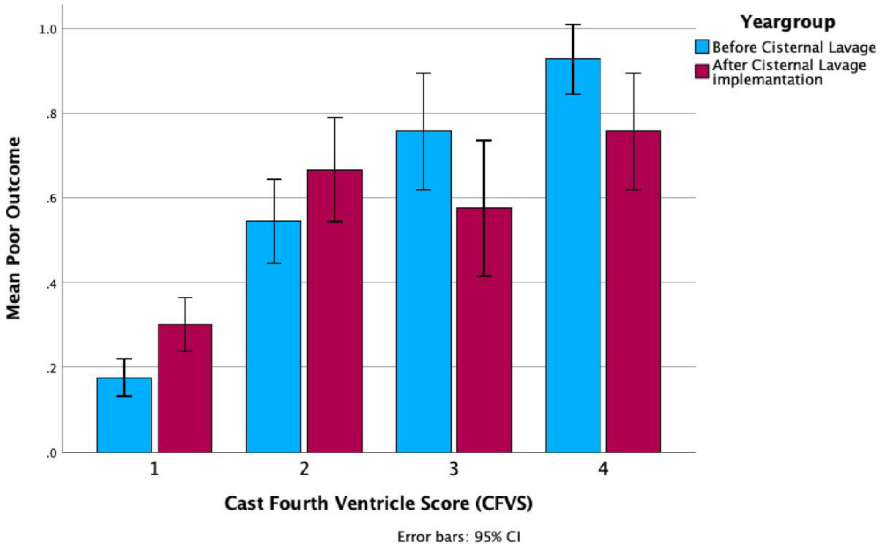



Figure 2: Proportion of poor outcome per degree of 4th ventricular blood. A higher rate of poor outcome occurred in patients with grade 3 or 4 hemorrhages in the cohort BEFORE active blood clearance, compared to AFTER.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC003

***Angewandtes Machine Learning und serielle Troponin Messungen in Patienten mit aneurysmatischer Subarachnoidalblutung können Vasospasmen angemessen hervorsagen.***
***Machine learning applied to cardiac troponin dynamics may sufficiently predict cerebral vasospasm in patients with subarachnoid hemorrhage (aSAH)***

P. Shalchian-Tehran[1], A. E. Hartmann[1], K. Frank[1], M. Manu[1], M. Nakamura[1]

[1]Krankenhaus Köln-Merheim, Klinik für Neurochirurgie, Köln, Deutschland

### Objective

The outcome of patients (pts) with aSAH is highly dependent on the occurrence of vasospasms (vs) and cerebral ischemia (DCI) within the first weeks after the ictus.2 As of today, there are no reliable serum parameters that can predict the occurrence of vs in pts with aSAH. Serum cardiac Troponin (cTrop) in aSAH is associated with an increased risk of DCI, poor outcome and death after 3 and 12 months.1 The area of machine learning (ML) is rising and studies in pts with aSAH and applied ML algorithms are lacking. The purpose of this study was to determine whether ML algorithms can predict the occurrence of vasospasms in pts with aSAH by using serial measurements of cTrop.

### Methods

90 pts with daily measurements of cTrop within the first 10 days after ictus and vs on digital subtraction angiography (DSA) were retrospectively considered. Using custom written routines in Python, we first extracted parametric and non-parametric statistical features from the normalized cTrop measurements (mean, variance, Sen"s slope, Mann-Kendall trend test). Next, we used these extracted features to train 80% of the data and test 20% on 3 supervised ML models, namely logistic regression, random forest, and multi-layer perceptron to predict vs on DSA.

### Results

Of 90 pts, 25 % (n=23) had demonstrated vasospasms on DSA. Significant difference in the mean and variance of the normalized cTrop values (p=0.0015 and p=0.0014 respectively, Mann-Whitney test) were seen, but no significant difference in trending (Mann-Kendall test: p-value 0.5588). The logistic regression classifier showed the best performance in predicting vs with ROC AUC of 0.86, accuracy of 0.73 and precision of 0.8.

### Conclusion

Our results show that applying ML algorithms on cTrop in pts with aSAH can sufficiently predict vs on DSA. The discriminative ability of these ML models requires validation in external cohorts to establish generalizability to show accurately pts at risk and improve pt"s outcome.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC004

### Mikrochirurgisches Evakuationsausmaß bei spontanen intrazerebralen Blutungen in Abhängigkeit der Art der gerinnungshemmenden Medikation

***Microsurgical evacuation performance of spontaneous intracerebral hemorrhage depending on the type of antithrombotic therapy***

K. Ferdowssian[1], J. H. Raff[1], S. König[2], L. Wessels[1], A. Aigner[3], P. Vajkoczy[1], N. Hecht[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Universitätsmedizin Göttingen, Klinik für Anästhesiologie, Göttingen, Deutschland
[3]Charité – Universitätsmedizin Berlin, Institut für Biometrie und Klinische Epidemiologie, Berlin, Deutschland

#### Objective

Evidence regarding the specific impact of different antithrombotic agents on the microsurgical evacuation performance of spontaneous intracerebral hemorrhage (ICH) is limited. Here, we investigated the effect of different antithrombotic therapies on the radiographic outcome of patients undergoing surgery for spontaneous supra- and infratentorial ICH.

#### Methods

In this retrospective cohort study, we identified all consecutive patients who underwent microsurgical hematoma evacuation for spontaneous supra- and infratentorial ICH in our department between 2008-2022. Patient characteristics and antithrombotic reversal strategies were reviewed. Neuroimaging analysis included semi-automated segmentation of pre- and postoperative ICH volumes. Preoperative use of vitamin K antagonists (VKA), direct oral anticoagulants (DOAC), antiplatelet therapy (AP), and combined anticoagulant/antiplatelet therapy (comb) were compared to no history of antithrombotic medication. We analyzed the association between type of antithrombotic therapy and both the absolute preoperative and relative postoperative hematoma volume, using multivariable regression models adjusting for patient characteristics.

#### Results

Overall, we included 245 patients with supratentorial (AP: 58, VKA: 31, DOAC: 14, comb: 18) and 91 patients with infratentorial ICH (AP: 20, VKA: 18, DOAC: 8, comb: 4). In supratentorial ICH, patients with any type of antithrombotic therapy presented with larger preoperative hematoma volume than patients with no history of antithrombotic medication. In infratentorial ICH, only patients under VKA therapy presented with larger preoperative hematoma volume. Combined anticoagulant/antiplatelet therapy affected preoperative ICH volume in supratentorial ICH to the greatest extent (Volume increase: 17.8 $cm^3$; 95% CI 4.2-31.5). For AP therapy, postoperative ICH volume was increased 1.4-fold (95% CI 0.93-2.01) for supratentorial and 1.5-fold (95% CI 0.55-4.23) for infratentorial location. For combined anticoagulant/antiplatelet therapy, postoperative ICH volume was increased 1.9-fold (95% CI 0.99-3.49) for supratentorial and 5.4-fold (95 % CI 0.88-33.07) for infratentorial location.

#### Conclusion

Despite preoperative emergency reversal, antithrombotic therapy contributed to poorer microsurgical evacuation performance in spontaneous ICH. Particularly, for patients under AP therapy, our findings underline the importance of optimization of antithrombotic reversal strategies.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC005

### Clipping ist weiterhin wichtig nach aneurysmatischer Subarachnoidalblutung: Eine Re-Analyse der Earlydrain-Studie

***Clipping is still a valid option after aneurysmal subarachnoid hemorrhage: Secondary results from the earlydrain trial***

S. Wolf[1], R. Mertens[1], P. Vajkoczy[1]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland

#### Objective

A recent US national cohort study comprising of more than 100.000 patients showed still a preference for clipping over coiling in patients with aneurysmal subarachnoid hemorrhage (1). As such databases lack a granular level of clinical data, features associated with each method in contemporary practice are unknown.

#### Methods

We performed a secondary analysis of the Earlydrain trial, which investigated the use of an additional lumbar drain in patients with aneurysmal subarachnoid hemorrhage (2). Deidentified patient data is freely available on the internet. Aneurysm treatment choice was at the discretion of the local physicians and not mandated by the study protocol.

#### Results

Earlydrain recruited 287 patients with aneurysmal subarachnoid hemorrhage of all severity grades in 19 centers in Germany, Switzerland, and Canada from 2011 to 2016. Overall, 140 patients (49%) received clipping and 147 patients (51%) coiling. Age and clinical severity based on Hunt-Hess / WFNS grades and radiological criteria were similar. Clipping was more used for aneurysms in the anterior circulation (55%), while most posterior circulation aneurysms were coiled (86%, $p< 0.001$).

Infarction on postoperative imaging was seen in 16% of clipped vs 8% of coiled patients ($p=0.03$). Postprocedural hemorrhages had a higher frequency after coiling (7% vs 10%). 60% of clipped vs 42% of coiled patients showed signs of elevated TCD criteria ($p < 0.005$), which was reflected in the rates of angiographic vasospasm (51% vs 38%, $p= 0.03$). The rates of severe angiographic vasospasm (10% vs 11%) and the use of endovascular rescue techniques (9% vs 8%) were similar.

In high-volume recruiting centers, 56% of patients were treated with clipping, compared to 38% in all others. No trend in preference of clipping or coiling was notable during the six year of study duration. In contrast to the Earlydrain main results establishing the superiority of the use of a lumbar drain additional to standard of care, outcome rates after clipping and coiling measured by secondary infarctions, mortality and the modified Rankin score at six months were without statistically significant difference.

#### Conclusion

In clinical practice, aneurysm clipping is still a required and frequently used method. Further development of periprocedural clipping techniques is warranted.

#### References:

1. Shah VA, et al: Front Neurol 2022; 16:13:908609
2. Wolf S, et al: JAMA Neurol 2023; 80(8):833-842

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC006

### Vergleichen der extraduralen radikulären Gefäßligatur mit dem intraduralen Gefäßverschluss bei der Behandlung SDAVF. Erfahrung mit 18 Eingriffen.

***Comparison of extradural radicular vessel ligation versus intradural vascular occlusion in the treatment of SDAVF. Experiences with 18 procedures***

A. Prajsnar-Borak[1], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

The goal of SDAVF treatment is a permanent fistula interruption. Simply microsurgical intradural occlusion of the proximal arterialized draining vein has become a well-accepted treatment option. Other technique modifications with extradural fistula occlusion at the level of accompanying nerve root are lacking in the literature. This report discusses the experiences with the surgical treatment of SDAVF, focusing on comparing the effectiveness of intradural and extradural radicular vessel ligation.

#### Methods

A retrospective analysis of all patients undergoing microsurgical occlusion of SDAVF from 05/2011 – 05/2022 in the author"s department was performed. Clinical, radiological, and intraoperative data were evaluated. All patients with SDAVF treated surgically were analyzed. Special attention has been given to providing insights into surgical technique, and comparison of effectiveness of intra- and extradural SDAVF occlusion.

#### Results

In total, 18 microsurgical SDAVF occlusions were performed in 14 patients (three female and eleven male patients, mean age 62,14 years, age range 28-83 years). Most commonly, the SDAVF was localized in the thoracal region (72.2%). Progressive motor deficits and gait ataxia were the most common clinical manifestations (71.4%). Simply microsurgical intradural SDAVF interruption was considered in 10 procedures (55.5%), and extradural radicular vessel ligation with intradural fistula occlusion in 7 procedures (38.8%). In one case, an extradural radicular vessel occlusion was solely performed. There were no intraoperative complications. There were no differences in the clinical outcome directly postoperatively. However, a significantly better outcome was observed for gait ataxia in SDAVF patients treated with concomitant intra- and extradural radicular vessel ligation in 6 months follow-up, ( p= 0,0441). Successful surgical occlusion of SDAVF was achieved in 94.4%. The mean follow-up period was 13.23 months (range, 1–57 months).

#### Conclusion

Microsurgical occlusion of SDAVF is an effective, and low complication rate first-line treatment option for SDAVF. A concomitant extradural radicular vessel ligation, close to the fistula point, offers proximal fistula disconnection, minimizes the risk of incomplete fistula occlusion, and avoids the formation of new arteriovenous shunt vessel recruitment. Intradural inspection adds to a high occlusion rate. Satisfactory outcomes of selected neurologic deficits can be achieved.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC007

### Vorschlag zweier verschiedener hämodynamischer Mechanismen der Aneurysmagenese basierend auf der Trägergefäß-Bifurkationsgeometrie bei MCA-Aneurysmen

***Proposal of two different hemodynamic mechanisms involved in the aneurysm genesis based on the parent vessel bifurcation geometry in MCA aneurysms***

D. Deuter[1], A. Haj[1], T. Mederer[1], K. Rosengarth[1], A. Brawanski[1], N. O. Schmidt[1], C. Doenitz[1]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland

#### Objective

Hemodynamic mechanisms for the initiation of intracranial aneurysms are not completely understood yet. Computational Fluid Dynamics (CFD) provides a powerful tool to investigate hemodynamic features of aneurysms and parent vessel geometries underlying aneurysm initiation, growth and rupture.

#### Methods

We investigated 22 aneurysm-bearing MCA bifurcations and 26 aneurysm-free MCA bifurcations from 42 patients from our institute's database. Based on 3D-DSA imaging, aneurysms were digitally removed from the bifurcation to reconstruct the aneurysm-free parent vessel geometry based on a previously described workflow (Ford et al. 2009). After 3D reconstruction of geometries using AMIRA (FEI Visualization Sciences, France) and definition of boundary conditions, CFD calculations were performed using ANSYS CFX (Ansys Inc., USA). Rigid walls and pulsatile flow conditions were assumed. Blood was modeled as a non-Newtonian fluid with a shear-dependent dynamic viscosity following a Power Law model. Bifurcations were grouped based on geometric features and bifurcation angles into three groups (Type 1 – 3). To assess rupture risks and the probability of these bifurcation types to bear an aneurysm, additional CTA-imaging leading to a total of 99 MCA bifurcations from 72 patients was analyzed as well as clinical data.

#### Results

We found two different hemodynamic mechanisms based on the geometry of the parent vessel bifurcation. Depending on the bifurcation geometry, one mechanism might be represented by a dislocated flow impingement point due to an asymmetry of the aneurysm bearing bifurcation (Type 1 bifurcations), another by a rotatory flow component (Type 2 bifurcations). Including the CTA-group, different types of bifurcations showed different probabilities to bear an aneurysm. Aneurysms showed different rupture risks depending on the bifurcation type.

#### Conclusion

We propose three types of MCA-bifurcations based on the parent vessel bifurcation geometry leading to two different hemodynamic patterns in aneurysm-bearing bifurcations. These data might help to better understand hemodynamic mechanisms underlying the formation and growth of MCA aneurysms. Further prospective CFD studies are needed to assess the reproducibility of these findings.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC008

### Konzentrische Kontrastmittelaufnahme der Gefäßwände bei Moyamoya Erkrankung als Risikofaktor perioperativer Schlaganfälle bei revaskularisierenden Eingriffen

***Concentric vessel wall contrast enhancement in Moyamoya disease as a risk factor for perioperative strokes during revascularization procedures***

P. Haas[1,2], T. K. Hauser[3], M. Tatagiba[1], N. Khan[2,4], C. Roder[1,2]

[1]Universitätsklinikum Tübingen, Klinik für Neurochirurgie, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Zentrum für Moyamoya und cerebrale Revaskularisation, Tübingen, Deutschland
[3]Universitätsklinikum Tübingen, Department Radiologie, Diagnostische und Interventionelle Neuroradiologie, Tübingen, Deutschland
[4]Universitätskinderspital Zürich, Moyamoya Center, Zürich, Schweiz

#### Objective

Concentric vessel-wall contrast enhancement (VW-CE) of the terminal carotid artery and its proximal branches is linked to disease activity and progression in Moyamoya angiopathy (MMA). In this study, the incidence of perioperative stroke during revascularization procedures was evaluated and correlated with the occurrence of concomitant VW-CE.

#### Methods

All previously untreated MMA patients with indicated bypass surgery who had preoperative MR imaging with contrast-enhanced T1 vessel-wall sequences to visualize a possible VW-CE were included. A perioperative stroke was detected by CT angiography and/or diffusion-weighted MRI sequences <48h postoperatively.

#### Results

Of the 110 patients included (female-to-male ratio 2.7:1, median age 45.1 (16.6-69.2); n=157 (64.9%) direct EC-IC bypasses), a priori VW-CE was present in 67.3% of cases (mean time interval MRI to first surgery 86 days ±82). A perioperative stroke occurred in 5 patients in the primary revascularization procedure (stroke rate per bypass 2.1%), all of whom had a preoperative pathological VW-CE in the vascular segment corresponding to the stroke area (likelihood ratio: $chi^2$=4.1, p=.0434; OR 5.8). 3 of these 5 patients (60%) suffered strokes in a vascular territory other than the revascularized one, also showing VW-CE as sign of disease activity. No other perioperative strokes occurred during subsequent revascularizations in the case of multistage procedures (n=38), such as ACA or PCA revascularization as second step.

#### Conclusion

Patients with preoperative VW-CE are at a higher risk of perioperative stroke at the time of first revascularization. This specifically applies to the vascular territory that is supplied by the vascular segment affected by VW-CE. To achieve an optimal outcome, vessel wall imaging must be performed when planning surgical revascularizations in Moyamoya patients. If VW-CE is found, strict perioperative monitoring of these high-risk patients must be performed to achieve the best results possible.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC009

### Die Mikrochirurgie als primäre Behandlungsmethode von kranialen duralen arteriovenösen Fisteln - Rückblick auf 30 Jahre Erfahrung

***The role of microsurgery in the management of cranial dural arteriovenous fistulas – A 30-year experience including 72 cases***

B. Kranawetter[1], T. Abboud[1], D. Mielke[1], V. Rohde[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland

#### Objective

Cranial dural arteriovenous fistulas (dAVFs) are rare vascular lesions and an increasing number are treated with endovascular embolization. However, due to the rarity and heterogeneity of dAVFs the generation of high-level evidence is challenging, and the best treatment option is still unclear. Over the past decades, only a few retrospective series have evaluated microsurgery as a primary treatment option, and it might be underrepresented in the literature. To further evaluate the role of microsurgery without prior embolization in the treatment of dAVFs we present our 30-year experience.

#### Methods

Medical records, imaging studies, and surgical reports of 72 patients diagnosed with a dAVF and treated with microsurgery between 1990 and 2022 were reviewed. 42 patients were treated before 2010 (prior to the use of liquid embolic agents i.e. premodern era) and 30 between 2010 and 2022 (after the introduction of liquid embolic agents i.e. modern era). We evaluated presenting symptoms, location, surgical strategy, surgical complications, occlusion status of the dAVF, and neurological outcome.

#### Results

No difference in patient characteristics was demonstrated between patients treated in the premodern and modern area. Overall, 46% (33/72) of patients developed neurological symptoms due to cerebral hemorrhage. 24% (17/30) of fistulas were classified as Borden type II and 76% (55/76) as Borden type III. In the combined patient cohort, a permanent surgery-associated morbidity of 6% (4/72) and an overall occlusion rate of 97% (70/72) was demonstrated. None of the patients died due to the surgery or as a consequence of the initial bleeding.

#### Conclusion

The presented surgical series shows that the operative morbidity is low and the dAVF occlusion rate is high in both non-sinus and sinustype fistulas. We therefore propose that microsurgery should be considered early in the treatment of both types of aggressive dAVFs.

Abb. 1

Table 1.

| | Pre-modern era (n=42) | Modern era (n=30) | All (n=72) |
|---|---|---|---|
| **Age (mean)** | 58.4 | 63.4 | 60.8 |
| Min | 35 | 39 | 35 |
| Max | 72 | 82 | 82 |
| Sex (m:f) | 9:33 | 16:14 | 25:47 |
| **Location** | | | |
| Tentorial | 9 (20) | 14 (47) | 23 (32) |
| Anterior fossa | 7 (17) | 4 (13) | 11 (15) |
| TSS | 7 (17) | 4 (13) | 11 (15) |
| Foramen magnum | 4 (10) | 3 (10) | 7 (10) |
| Convexity | 7 (17) | - | 7 (10) |
| SSS | 1 (2) | 4 (13) | 5 (7) |
| CS | 4 (10) | 1 (4) | 5 (7) |
| Temporal | 3 (7) | - | 3 (4) |
| **Borden** | | | |
| II (Sinus-type) | 12 (29) | 5 (17) | 17 (24) |
| III (Non-sinus-type) | 30 (71) | 25 (83) | 55 (76) |
| **Hemorrhage** | | | |
| Yes | 16 (38) | 17 (57) | 33 (46) |
| No | 26 (62) | 13 (43) | 39 (54) |
| **Surgical technique** | | | |
| Packing | 12 (29) | 5 (17) | 17 (24) |
| Selective disconnection | 30 (71) | 25 (83) | 55 (76) |
| **Complete occlusion** | | | |
| Yes | 41 (98) | 29 (97) | 70 (97) |
| No | 1 (2) | 1 (3) | 2 (3) |

Abb. 2

| Patient ID | Location | Hemorrhage | Approach | Technique | additional treatment | Occlusion |
|---|---|---|---|---|---|---|
| 1 | ethmoidal | yes | interhemispheric | SD | - | CO |
| 2 | ethmoidal | no | interhemispheric | SD | - | CO |
| 3 | ethmoidal | yes | interhemispheric | SD | microsurgery | CO |
| 4 | ethmoidal | yes | interhemispheric | SD | microsurgery | CO |
| 5 | Foramen magnum | no | suboccipital FME | SD | - | CO |
| 6 | Foramen magnum | yes | suboccipital FME | SD | - | CO |
| 7 | Foramen magnum | yes | suboccipital FME | SD | - | CO |
| 8 | CCF | no | pterional | SP | microsurgery | CO |
| 9 | SSS | no | parietal | SD | microsurgery | residual |
| 10 | SSS | yes | parietal | SD | - | CO |
| 11 | SSS | yes | parietal | SD | - | CO |
| 12 | SSS | no | occipital | SP | - | CO |
| 13 | TSS | yes | occipital-suboccipital | SP | - | CO |
| 14 | TSS | yes | suboccipital | SP | - | CO |
| 15 | TSS | yes | occipital-suboccipital | SP | microsurgery | CO |
| 16 | TSS | yes | suboccipital | SD | - | CO |
| 17 | tentorial | yes | suboccipital | SD | - | CO |
| 18 | tentorial | no | occipital | SD | - | CO |
| 19 | tentorial | no | occipital-suboccipital | SD | - | CO |
| 20 | tentorial | yes | occipital | SD | - | CO |
| 21 | tentorial | no | retrosigmoid | SD | - | CO |
| 22 | tentorial | yes | occipital-suboccipital | SD | - | CO |
| 23 | tentorial | no | occipital-suboccipital | SD | microsurgery & embolization | CO |
| 24 | tentorial | no | suboccipital | SD | - | CO |
| 25 | tentorial | no | suboccipital | SD | - | CO |
| 26 | tentorial | yes | suboccipital | SD | - | CO |
| 27 | tentorial | no | retrosigmoid | SD | - | CO |
| 28 | tentorial | yes | retrosigmoid | SD | - | CO |
| 29 | tentorial | yes | suboccipital | SD | - | CO |
| 30 | tentorial | no | retrosigmoid | SD | - | CO |

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC010

### Wandkalzifikation in Unrupturierten Intrakraniellen Aneurysmen: Analyse der Assoziation mit Aneurysmamorphologie und klinischen Risikofaktoren

***Wall calcification in Unruptured Intracranial Aneurysms: analysis of association with Aneurysm morphology and clinical risk factors***

L. Costa[1], M. J. Kamphuis[2,3], O. Akanji[1], I. van der Schaaf[2], L. T. van der Kamp[3], M. Vergouwen[3], N. Etminan[1], G. Rinkel[1,3]

[1]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland
[2]University Medical Center Utrecht, Radiologie, Utrecht, Niederlande
[3]University Medical Center Utrecht, Neurologie und Neurochirurgie, Utrecht, Niederlande

#### Objective

Calcification in the wall of Unruptured Intracranial Aneurysms (UIAs) increases the risk of neurosurgical aneurysm treatment. Since UIAs are often detected with MR-imaging and further evaluated by conventional angiography, calcification may go unnoticed pre-operatively. We studied patient and aneurysm risk factors for the presence of wall calcifications with the aim to identify patients who should undergo CT-imaging to detect UIA calcifications in the pre-operative work-up.

#### Methods

We studied 316 UIAs from 2 institutions and assessed aneurysm location, diameter and morphology on MR or DSA, and presence of aneurysm wall calcifications on CT. At-risk morphology was defined as either aspect ratio > 1.6 or size ratio > 3, or irregular aneurysm configuration. Information on clinical risk factors was retrieved from the medical records. Univariate and multivariate analysis was performed using logistic regression and $\chi^2$ tests. Risk distribution for aneurysm calcification was assessed in each institution's cohort according to size and morphology.

#### Results

OR for presence of aneurysm wall calcification were in univariate analysis for UIA size 1.20 [95%: 1.13-1.26], for at-risk morphology 2.99 [95%: 1.67-5.33], for arterial hypertension 1.73 [95%: 0.90-3.33], and for current vs. never smokers 1.27 [95%: 0.53-3.07]. In multivariate analysis of association with aneurysm calcification, UIA size showed an OR 1.18 [95%: 1.12-1.25], while at-risk morphology showed an OR 1.78 [95%: 0.92-3.42]. Both cohorts showed a similar risk distribution for wall calcifications, with a high risk in UIA with a diameter of 8mm and larger, especially when at-risk morphology was also present. Furthermore, UIA smaller than 8mm displayed a negative predictive value for the presence of wall calcification of 98.8%.

#### Conclusion

Size of Unruptured Intracranial Aneurysms is associated with aneurysm wall calcifications. We recommend CT-imaging in patients with a UIA of ≥8mm in diameter, in particular when at-risk morphology is present, to assess aneurysm wall calcifications.

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC011

### Wetterbedingungen in Zusammenhang mit dem Schweregrad einer aneurysmatischen Subarachnoidalblutung: eine Beobachtungsstudie

***Weather conditions associated with severity of aneurysmal subarachnoid hemorrhage: A single-center observational study***

C. Albrecht[1], M. Wostrack[1], B. Meyer[1], K. Graw[2], V. Kehl[3], A. Matzarakis[2]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[2]Deutscher Wetterdienst, Zentrum für Medizin-Meteorologische Forschung, Freiburg i. Br., Deutschland
[3]Institut für KI und Informatik in der Medizin, München, Deutschland

#### Objective

Controversy exists regarding the potential seasonal variations in the incidence of spontaneous intracranial aneurysm rupture leading to subarachnoid hemorrhage (SAH). Bio-synop weather classes categorize weather conditions affecting human health positively as well as negatively. They are recognized for their relevance to acute illnesses and acute exacerbation of chronic conditions by influencing biological processes. This study aims to explore the connection between bio-synop weather classes and SAH occurrence and severity, utilizing data derived from a large retrospective cohort at our high-volume neurovascular center.

#### Methods

The analysis involved patients with aneurysmal SAH treated between March 2006 and March 2020 at our department. In collaboration with the German Meteorological Service, we compared SAH incidence and severity, graded according to the Hunt&Hess score (H&H), to bio-synop weather classes. The Kruskal-Wallis was employed to address the question of whether the occurrence of SAH is more frequent and/or the severity of SAH grades is increased in the presence of specific bio-synop weather classes. Additionally, we assessed whether SAH exhibits any seasonal dependence, a factor frequently suggested in previous studies.

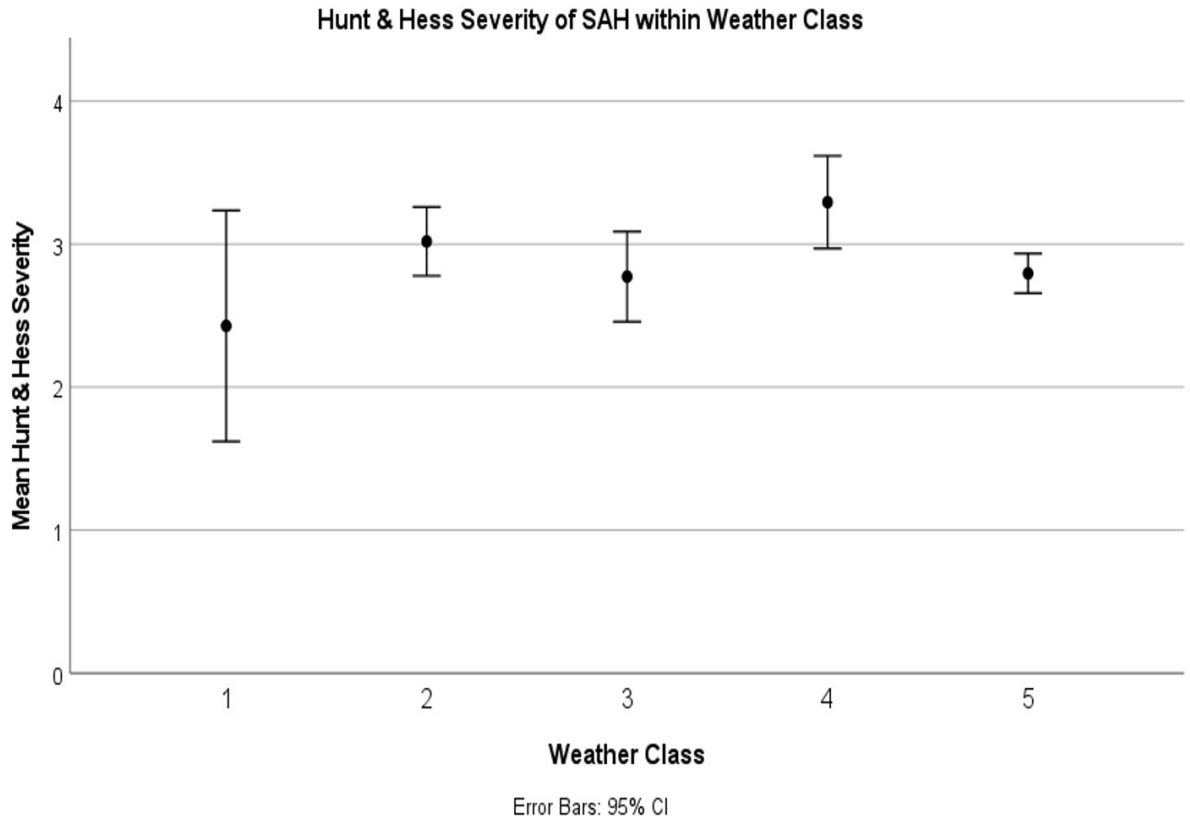
#### Results

Overall, data of 982 patients with acute SAH was analyzed. In our study, we found no statistically significant difference between the incidence of SAH under specific bio-synop weather classes ($p=0.168$). In terms of seasonality, a notable reduction in SAH occurrences in June each year was observed in sub-tests for specific months, though the overall Kruskal-Wallis test did not show statistical significance ($p=0.157$). Regarding the severity of cases, our data unveil a notable increase of H&H grades during class 4 ("rear side of low-pressure system with cold air advection") weather conditions, previously identified as a determinant for a range of adverse health outcomes in prior research ($p=0.022$).

#### Conclusion

Our results suggest that while SAH incidence may not be directly influenced by specific weather conditions, a notable connection exists between certain bio-synop weather classes and severity at admission. The observed June decrease tentatively implies a possible seasonal pattern. Further research on potential underlying mechanisms is warranted for better understanding.

Abb. 1


Hunt & Hess Severity of SAH within Weather Class
Mean Hunt & Hess Severity
0
1
2
3
4
1
2
3
4
5
Weather Class
Error Bars: 95% CI

# Rapid communication – Vaskuläre Neurochirurgie | Rapid communication – Vascular Neurosurgery

## RC012

### Kontinuierliche intraarterielle Nimodipin-Therapie in Patienten mit Subarachnoidalblutungen mit refraktären sekundären zerebralen Ischämien - Risikofaktoren für ein schlechtes Outcome

***Continuous intraarterial nimodipine therapy in SAH patients with refractory DCI – Risk factors for unfavorable outcome***

E. Kurz[1], C. Brockmann[2], D. Kalasauskas[1], F. Ringel[1], A. Neulen[1]

[1]Universitätsmedizin Mainz, Neurochirurgie, Mainz, Deutschland
[2]Universitätsmedizin Mainz, Neuroradiologie, Mainz, Deutschland

#### Objective

Continuous intraarterial nimodipine infusion (CIAN) is a rescue therapy in subarachnoid hemorrhage (SAH) patients with refractory delayed cerebral ischemia (DCI). However, the benefit of this therapy is variable and complications have to be taken into account. The objective of this study was to evaluate risk factors for complications and identify predictors for outcome.

#### Methods

Retrospective single center study, including all SAH patients treated from 2016 - 2023 who received CIAN. CIAN was indicated in patients with DCI refractory to induced hypertension, and ended based on improvement of clinical symptoms, and resolving vasospasms and normalizing perfusion. For CIAN, microcatheters were placed in the internal carotid (ICA) or vertebral arteries, Nimodipine was administered continuously. Demographic data, aneurysm location, WFNS and Fisher score, need for a CSF-drain, radiological response to CIAN, CIAN-associated complications, DCI-related infarctions as well as outcome after 6 months(mRS) were evaluated.

#### Results

36 patients (27 female, 9 male) with a mean age of 53.1 years (SD=12.2) were included. 11 patients had a complication related to CIAN. The most frequent complication was formation of a thrombus blocking the catheter (n=5). The Fisher and WFNS scores of CIAN patients were 3.6 (SD=0.6) and 3.1(SD=1.6), respectively. Mean mRS after 6 months was 3.2 (SD=2.1), good outcome (mRS 0-3) was found in 15 patients, unfavorable (mRS 4-6) in 21. DCI-associated infarctions were found in 21 patients. 16 cases showed an excellent response with resolving vasospasms. In 20 patients CIAN was not able to completely resolve vasospasm. Incompletely resolving vasospasm was associated with high WFNS (p=0.03, OR=1.7; multivariate analysis), multiple aneurysms (p=0.03, OR=5.3) and the need for CIAN in both ICA (p=0.05, OR=2.6), and was a risk factor for unfavorable 6 months outcome (p=0.028; OR=5.0), additionally to a high Fisher score (p=0.028; OR=4.7) and the need for an EVD (p=0.019; OR=8.3). Complications related to the procedure had no influence on outcome (p=0.5) or development of infarctions (p=0.6).

#### Conclusion

CIAN is a promising method for treating SAH patients with refractory DCI, with excellent response in many cases (44% in our cohort). We found no evidence that CIAN-related complications affected outcome. Based on the risk factors for unfavorable outcome identified here, more studies are warranted to determine which subgroups of SAH patients benefit most from CIAN

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC013

### Klinische Ergebnisse einer schnell wirkenden Sub-Perzeptionstherapie bei chronischen Schmerzen: eine europäische Beobachtungsstudie

***Clinical outcomes using a fast-acting sub-perception therapy for chronic pain: A european observational study***

S. Bayerl[1], J. Paz-Solis[2], D. Tkatschenko[1], G. Matis[3], J. W. Kallewaard[4], P. Rigoard[5], J. Vesper[6], J. E. Llopis[7], G. Edward[8]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]University Hospital La Paz, Neurosurgery, Madrid, Spanien
[3]University Hospital of Cologne, Stereotaxy and Functional Neurosurgery, Köln, Deutschland
[4]Rijnstate Hospital, Anesthesiology and Pain Management, Arnhem, Niederlande
[5]University Hospital La Milétrie, Neurosurgery, Poitiers, Frankreich
[6]Universitätsklinikum Düsseldorf, Klinik für Neurochirurgie, Sektion Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland
[7]Hospital de la Ribera, Pain Management, Valencia, Spanien
[8]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

#### Objective

Traditional Spinal Cord Stimulation (SCS) modalities that achieve sub-perception analgesia require patients to often wait hours or even days until pain relief is fully realized. The objective of the study was to assess the magnitude and quality of pain relief in patients using a new sub-threshold-based SCS modality called Fast-Acting Sub-Perception Therapy (FAST) for chronic pain in a European-based, multicenter, observational study.

#### Methods

This is an international, multicenter, observational case-series of patients permanently implanted with a FAST enabled SCS system (Boston Scientific, Marlborough, MA USA) to treat chronic pain as part of an ongoing assessment of real-world outcomes of SCS for chronic pain based on retrospective chart review (Clinicaltrials.gov identifier: NCT01550575). All analyzed patients are programmed using novel FAST (i.e., biphasic-symmetric waveform at 90 Hz; pulse width: 160- 260 µs). To minimize potential bias, data collection from patients is being performed directly by clinical site personnel without any sponsor involvement. Demographic information, pain location, surgical history, medical history are being collected for all subjects. In addition, Numeric Rating Scale (NRS) scores and Percent Pain relief (PPR) are being collected as part of the chart review. Mean, median, and standard deviations will be calculated for demographic data and NRS scores.

#### Results

To date, 143 patients have been assessed out to a mean follow-up duration of 531±450 days. Baseline mean NRS pain score inthis current cohort was determined to be 7.9±1.2.

A 5.1 ± 2.4-point improvement ($p<0.0001$) in overall pain was reported at mean last follow-up (n=143). A 5.0-point (n=76, $p<0.0001$) and 5.8-point (n=40, $p<0.0001$) decrease in overall NRS pain score was noted in patients who reached their 1-year and 2-year visits respectively, compared to baseline. Assessment of quality of life (EQ-5D-5L) and Disability (Oswestry Disability Index) demonstrated substantial improvement compared to baseline measurements. Based on patients who reported PPR at last follow-up, responder rate (PPR>50%) was 88.8% (n=79/89).

#### Conclusion

A methodology that allows for near immediate pain relief following activation of neurostimulative treatment therefore represents an advancement that may further improve the outcomes and experience of patients who desire to use sub-perception-based SCS for relief of their chronic pain.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC014

### Die Komplexität der Fraktalmuster in der sensorimotorischen kortikalen Oszillationsaktivität im Rattenmodell der Parkinsonerkrankung

*Complexity of fractal patterns in motor cortical oscillatory activity in rodent models of Parkinson disease*

A. Abdulbaki[1], M. Alam[1], A. Armstrong[1], D. Milakara[2], J. K. Krauss[1], K. Schwabe[1]

[1]Hannover Medical School, Department of Neurosurgery, Hannover, Deutschland
[2]Charité – Universitätsmedizin Berlin, Institute of Health, Berlin, Deutschland

#### Objective

Previous studies demonstrated enhanced beta-band activity in rat models (haloperidol (HALO), and 6-hydroxydopamin (6-OHDA)) of Parkinson disease (PD), which was reduced after administration of the dopamine-receptor agonist apomorphine (APO) or deep brain stimulation (DBS) of the subthalamic nucleus (STN), respectively. Fractal dimension (FD) analysis is a nonlinear approach that quantifies the complexity of neuronal activity. Little is known about nonlinear analytic approaches, such as FD analysis, to characterize pathological network activity in PD. This study aims to investigate whether motor cortical oscillation changes in fractal patterns are associated with a change in the FD in the HALO and the 6-OHDA rat model of PD.

#### Methods

In the acute HALO rat model of PD, an ECoG array was placed subdurally above the MCtx area in male Sprague-Dawley rats. Thereafter, ECoG was recorded in the free moving rat in three conditions: (1) basal activity, (2) after injection of HALO (0.5 mg/kg), and (3) with additional injection of APO (1mg/kg). In the chronic model, 6-OHDA was unilaterally injected into the medial forebrain bundle, sham-lesioned control rats received vehicle. A stimulation electrode was then implanted in the ipsilateral STN, and an ECoG array placed subdurally above the MCtx area. Thereafter, ECoG was recorded in the free moving rat with two conditions: (1) during basal activity, and (2) during STN DBS. The ECoG signals were band-pass filtered between 1–100 Hz and sampled at 1 kHz. Furthermore, the raw data were down-sampled at 250 Hz and Higuchi's FD algorithm was applied for analysis of the raw ECoG data.

#### Results

In the MCtx area, the average FD values were higher in both the HALO and the 6-OHDA rat model as compared to basal activity and sham-lesioned control rats. Further, injection of APO or STN DBS decreased the average FD values in both models ($P<0.001$).

#### Conclusion

In PD rat models, the neural dynamics can also be characterized by FD. The non-linear analysis of FD allows to detect oscillation-based pattern changes achieving robust temporal resolution. This analytic approach may be integrated into future research concerning therapeutic algorithms for PD, such as adaptive closed loop stimulation, thus providing an alternative and possibly efficient biomarker of pathological network activity in PD.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC015

### Kosteneffektivität verschiedener Impulsgeneratoren zur tiefen Hirnstimulation - wiederaufladbar versus nicht-wiederaufladbar

***Cost effectiveness of different pulse generators for deep brain stimulation – Rechargeable versus non-rechargeable***

N. M. Ratiu[1], M. Synowitz[1], S. Paschen[1], A. K. Helmers[1]

[1]Universitätsklinikum Campus Kiel, Neurochirurgie, Kiel, Deutschland

#### Objective

The treatment of some specific neurological diseases has undergone a significant evolution through deep brain stimulation (DBS), yet limitations persist regarding the lifespan of non-rechargeable impulse generator (non-RC-IPG) batteries. When these batteries are getting discharged, patients require replacement surgeries, entailing associated risks. A relatively new approach involves the implantation of rechargeable generators (RC-IPG), although at a higher initial cost, offering a potential reduction in operation frequency and perioperative complications.

#### Methods

Our research was conducted within our department, analysing medical records of patients who underwent DBS between 2010 and 2022. Encompassing an initial pool of 520 patients, we narrowed down our analysis to 414 patients based on specific criteria. Among these, 165 patients received a RC-IPG while the remaining 249 were implanted with a non-RC-IPG. With a minimum one-year postoperative follow-up, we tracked the annualized total costs of stimulation and subsequent follow-up expenses. Furthermore, we examined the incidence and nature of complications associated with each type of IPG.

#### Results

What we could objectify is that with non-RC-IPGs, the costs resulting after implantation are obviously higher compared to RC ones, mostly because new operations must be performed for IPGs replacement that comes with associated risks. Following a 12-year period of stimulation, the average cost post-implantation amounts to 1172,92 euros for the cohort utilizing RC-IPGs and 16436,26 euros for the non-RC-IPG group.The rate of complications was 14.85% in patients with non-RC-IPG and 5.45% for those with RC-IPG. In both cohorts, the most common complication observed was wound healing issues. In non-RC-IPGs, surgical revisions followed as the second most prevalent complication, then cable tension and infections. RC-IPGs saw IPG failure as the second most frequent issue, followed by surgical revisions, with no reported infections.

#### Conclusion

Our analysis shows a distinct financial advantage in choosing RC-IPG implantation, leading to significantly lower subsequent costs compared to non-RC-IPG. Moreover, this option correlates with about a threefold decrease in complication occurrence during the stimulation period. Notably, among complications associated with RC-IPGs, infections were absent. This absence notably reduces hospitalizations and surgical revisions, resulting in automatic cost reductions of subsequent follow-up expenses.

# RC016

## Tiefe Hirnstimulation in der Behandlung von Patienten mit therapie-refraktärer OCD: Real-life Erfahrungen aus einer prospektiven single-center Kohorte

***Deep Brain Stimulation in the treatment of therapy-refractory OCD: Real-life experiences from a prospective single-center cohort***

D. Deuter[1], T. Mederer[1], V. Lang-Hambauer[2], B. Langguth[2], K. Rosengarth[1], N. O. Schmidt[1], J. Schlaier[1], M. Abdelnaim[2]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Regensburg, Klinik und Poliklinik für Psychiatrie und Psychotherapie, Regensburg, Deutschland

### Objective

Over the last years, Deep Brain Stimulation (DBS) has evolved towards a standard treatment option in movement disorders like Essential tremor, Parkinson's disease and dystonia. In history, a variety of focal ablative procedures had been described also in psychiatric diseases as well as the application of DBS more recently. As in nowadays, standard medical treatment leads only to an incomplete symptom release in many patients and some patients even remain treatment-resistant, DBS is currently more and more discussed in relation to these psychiatric diseases like Obsessive Compulsive Disorder (OCD). Within this study, we present a prospective cohort of patients with therapy-refractory OCD having received bilateral DBS with electrodes in the bed nucleus of stria terminalis (BNST) at our center.

### Methods

This prospective cohort consisted of 10 patients suffering from therapy-refractory OCD. Patients underwent surgery at our center between 2020 and 2022. MR imaging was performed with patients under general anesthesia on a 3T scanner for planning of the stereotactic target. Electrodes were bilaterally implanted in the BNST with patients asleep. Electrode locations were postoperatively controlled by CT scans with 1mm slice thickness. Pre- and postoperatively, standardized assessments using the YBOCS, MADRS, GAF, CGI, and WHOQOL-BREF scores were performed by specialized psychiatric experts.

### Results

In 6 of 10 patients (60%), DBS evoked a good clinical response indicated by a significant reduction of the YBOCS score. In 3 further patients (30%), a non-significant improvement was observed. WHOQOL scores were higher in the follow-up, representing a higher quality of life after DBS surgery. 40% (4/10) of patients, which were previously unemployed or received disability pension, were able to start working again after DBS surgery.

### Conclusion

In literature, about 10% of OCD patients remain treatment-resistant to standard medical treatment. In our cohort consisting of 10 patients with therapy-refractory OCD, BNST-DBS lead to a relevant improvement of OCD symptoms culminating in an improved quality of life of treated patients, objectively measurable in the follow-up examinations. Additional studies for adequate selection criteria for DBS in patients suffering from psychiatric diseases are needed to further optimize patients' outcomes after DBS surgery.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC017

### Bevorzugte Wellenformen und Ergebnisse der Rückenmarkstimulation bei CRPS-Patienten: eine multizentrische Beobachtungsstudie unter realen Bedingungen.

***Preferred waveforms and outcomes of spinal cord stimulation in CRPS patients: A multicenter real-world observational study***

A. Gulve[1], G. Kyriakopoulos[2], G. Edward[3]

[1]The James Cook University Hospital, Pain Medicine, Middle, Vereinigtes Königreich
[2]St. Marien Hospital Hamm, Orthopaedics and Traumatology, Hamm, Deutschland
[3]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

#### Objective

Spinal cord stimulation (SCS) is an established therapeutic option for patients with Complex Regional Pain Syndrome (CRPS) suffering from severe chronic pain. Recent SCS devices are versatile and offer multiple waveforms options with distinct mechanisms of action. One of them is a recently-developed fast-acting sub-perception therapy which acts on the surround inhibition mechanism and could be a valuable option for CRPS patients[1,2.]

1. Loss of Surround Inhibition and After Sensation as Diagnostic Parameters of Complex Regional Pain Syndrome. Marie Wojcik Wolanin, Robert J. Schwartzman, Guillermo Alexander, John Grothusen. Neuroscience & Medicine, 2012, 3, 344-353
2. Schwartzman R. Deconstructing Complex Regional Pain Syndrome. Pract Pain Manag. 2010;10(2)

#### Methods

This is a consecutive, observational, multicenter case-series based an on-going, real-world evaluation of SCS outcomes for chronic pain (Clinicaltrials.gov: NCT01550575). All evaluated patients were implanted with an SCS device and documented data from their medical records were used to assess their condition at baseline and post-implant follow-up visits. Data collection includes diagnosis and medical history, pain scores, and preferred SCS settings. All data were collected by site personnel, as per standard practice and without sponsor involvement

#### Results

To date, the review of over 80 CRPS cases implanted with SCS has been performed. Patients had a baseline pain score of 8.0, and the average follow-up after SCS implant is 3.2 years. Over 60% of the patients preferring fast-acting sub-perception therapy had a profound response and reported 76% reduction in overall pain NRS score, from 8.3 to 2.0 at last follow-up (-6.3 point, average follow-up 313 days).

#### Conclusion

Spinal cord stimulation is diverse and offers the possibility to use waveforms with different mechanisms of action, which may help personalize SCS therapy to specific pain conditions.

Our results show a significant efficacy of various SCS waveforms in CRPS patients, with a profound pain relief in most patients using fast-acting sub-perception therapy. These outcomes suggest that this new modality may act on a specific mechanism (loss of surround inhibition) that plays a role in CRPS condition.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC018

### Post traumatische Schwannzellen vom Neurom behalten einen einzigartigen molekularen Fußabdruck im Vergleich zu Schwannzellen des Suralis in vitro und in vivo

***Post traumatic Schwann cells of neuroma retain a unique molecular signature compared to Schwann cells of sural nerve in vitro and in vivo***

S. Deininger[1], J. Schumacher[2], M. Pedro[1], B. Knöll[2], S. Meyer zu Reckendorf[2]

[1]BKH Günzburg der Universität Ulm, Neurochirurgie, Günzburg, Deutschland
[2]Universität Ulm, Institut für Neurobiochemie, Ulm, Deutschland

#### Objective

Traumatic peripheral nerve injury (PNI) induces neuroma formation at the severed nerve stump resulting in impaired nerve regeneration and functional recovery in patients. So far, molecular mechanisms and cell types present in the neuroma millieu impeding on regeneration have only sparsely been analyzed.

#### Methods

In this study we compare resected human neuroma tissue with intact donor nerves from the same patient. Neuroma tissues from several post-injury timepoints (1-10 months) were included, thereby allowing for temporal correlation with molecular and cellular processes in vitro and in vivo.

#### Results

We observed reduced axonal area and percentage of differentiated myelin producing Schwann cells (SCs). However, total SC numbers were comparable between neuroma and intact nerves. Notably, markers for SCs in a repair mode including (c-JUN and SHH) and SC proliferation (pH3) were upregulated in neuroma, suggesting presence of SCs in repair rather than differentiated status. In agreement, in neuroma tissue, pro-regenerative markers (pCREB, GAP43, ATF3 and SCG10) were upregulated. Neuroma tissue was infiltrated by both proinflammatory M1 and anti-inflammatory M2 macrophages, with M1 macrophages declining with increasing neuroma age. Finally, SC cultures derived from neuroma and control nerve were morphologically indistinguishable. However in vitro, cultured neuroma SCs remain a different molecular signature from control SCs including increased inflammation but reduced differentiation markers such as myelin genes.

#### Conclusion

In summary, human neuroma tissue consists of SCs with a persistent repair status and a unique molecular signature. However, repair SCs most likely fail to support axonal regeneration due to extrinsic factors including an inflammatory environment and deposition of fibrotic material.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC019

### Stereotaktische Laserbasierte interstitielle thermische Therapie (LITT) und präklinisches, Tumororganoid-basiertes Medikamentenscreening bei rezidivierenden hochgradigen Gliomen. Erste Erfahrungen aus der Hi-SMILE Studie.

***Stereotactic Laser Interstitial Thermal Therapy (LITT) and preclinical tumororganoid-based drug screening in recurrent high-grade glioma. First experiences from the Hi-SMILE study***

M. Jakobs[1], C. Herold-Mende[2], S. Krieg[3]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Sektion stereotaktische Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Sektion neurochirurgische Forschung, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

#### Objective

Recurrent high-grade glioma require innovative locoregional and systemic treatment options. Laser Interstitital thermal therapy (LITT) is a stereotactic, minimally invasive surgical approach to target small and difficult to resect tumors under MR-thermometric guidance. Tumororganoids are representative tumor avatars that enable ex-vivo drug testing even from small tissue samples provided by stereotactic biopsies. The Hi-SMILE study is an ongoing trial to evaluate safety and efficacy of LITT and feasibility of preclinical tumororganoid-based drug screening in n=30 patients with recurrent high-grade glioma.

#### Methods

Patients are prospectively enrolled in a registry. For LITT, tumor volume and ablation coverage andaccuracy of laser catheter placement are assessed. OR time, length of hospital stay and surgical complications are documented. Stereotactic frame-based biospsy and laser catheter placement are performed before laser ablation is carried out in an intraoperative MRI setting.Biopsy samples taken during LITT surgery are used for tumororganoid formation. After tumororganoid formation, ex-vivo high-throughput drug testing of up to 9 selected drugs is performed. Responses are classified as sensitive, intermediate or resistant.

#### Results

So far, n=9 patients (4 females, 5 males; mean age 51.8 years) have been enrolled. Final histological diagnoses was glioblastoma (n=6), astrocytoma WHO 4° (n=2) and radiation necrosis (n=1). N=4 patients required 2 laser catheters to cover the desired mean tumor volume of 4.2 (+/- 3.2) ml. Mean operative time was 194min (+/- 38) of which a mean 103min (+/- 24) were spent in the intraoperative MRI scanner. Ablation coverage was on average 138% and took on avergae 14min 30s per catheter. Laser catheters could be placed with a Euclidian distance of 1.1 mm (+/- 0.85) and a mean radial error of 0.8 mm (+/- 0.7). Mean postoperative hospital stay was 2.1 days. One epileptic seizure occurred after surgery. It was always possible to test at leat 5 drugs. Most tumors revealed a high level of driug resistance with only 1 case revealing drug sensivitivy more than 1 drug.

#### Conclusion

In the first patients surgical accuracy an ablation coverage was high. LITT seems to be a safe and well-tolerated procedure. Progression free and overall survival need to be evaluated at the end of the trial. Tumororganoid-based drug screening is feasible with tissue from stereotactic biopsies, however its impact on clinical decision-making is yet unclear.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC020

### Die Bedeutung der selektiven dorsalen Rhizotomie (SDR) im Behandlungskontext der spastischen Cerebralparese: Erfahrungsbericht eines interdisziplinären Behandlungsteams über 115 Patienten

***The significance of selective dorsal rhizotomy (SDR) in the treatment of patients with spastic cerebral palsy (CP): Case series of 115 patients at a single institution***

M. Abel[1], M. Kudernatsch[1], M. Hoesl[1], S. Persits[1], S. Berweck[1], H. Haberl[1]

[1]Schon Klinik Vogtareuth, Neurochirurgie, Vogtareuth, Deutschland

#### Objective

Selective dorsal rhizotomy (SDR) is a functional intervention to significantly reduce spasticity in children with cerebral palsy (CP). Up to date, there is a lack of international consensus regarding criteria for patient selection as well as adapted treatment strategies in patients with spastic CP (Grunt et al., 2014).

#### Methods

To optimize patient selection for SDR and subsequent treatment strategies in patients with spastic CP, we set up a multidisciplinary consultation, consisting of pediatric neurosurgeons, neuropediatricians and pediatric orthopedic surgeons since 2019. Candidates for SDR received a detailed neurological examination to assess the extent of spasticity and a routine 3-D gait analysis (3DGA) to quantify the extent of movement abnormalities before surgery and 6-12, as well 24 months after surgery to evaluate the functional outcome. The MobQues47 Questionnaire was conducted to quantify caregiver-reported daily mobility.

#### Results

Based on multidisciplinary consensus, SDR was performed in 115 patients (Gross Motor Function Classification System (GMFCS) I-V) with spastic CP at our institution since 2021. Using a monosegmental laminoplasty close to the conus medullaris as developed by TS Park (Park and Johnston, 2006) and modified by H Haberl (Funk and Haberl, 2016), a partial deafferentation of 50-80% of each sensory nerve root (from L1-S2) was performed, assisted by intraoperative neuromonitoring (IONM). There was no permanent surgery-related complication or morbidity. Out of 115 patients, 3DGA was performed in 43 functional children before surgery and 6-12 months after surgery (7.4±1.8 months) up to now. In this cohort, Ashworth-Scores reduced significantly after surgery, mobility increased (figure 1) and Gait Profile Scores (GPS: summary measures for deviation of 3D lower limb joint angles from those of typically developing controls while walking), reduced (figure2).

#### Conclusion

SDR effects a significant reduction of spasticity, functional improvement according to the initial GMFCS level, and an enhancement of mobility in daily life across all GMFCS levels in the selected patients. To meet the challenge of an adapted further treatment, significance, indication and techniques of traditional conservative treatment options have to be redefined to meet the fundamentally altered demands of CP patients after surgical elimination of spasticity.

Abb. 1

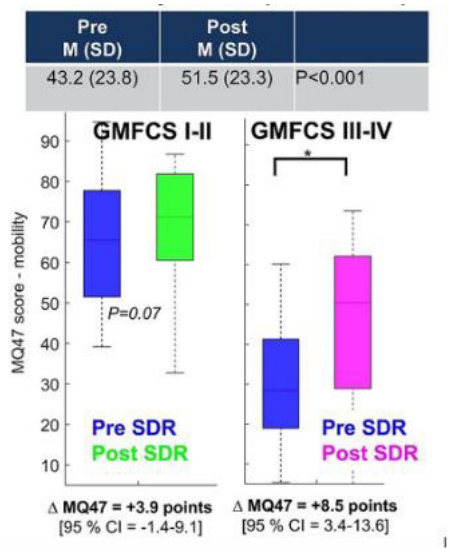
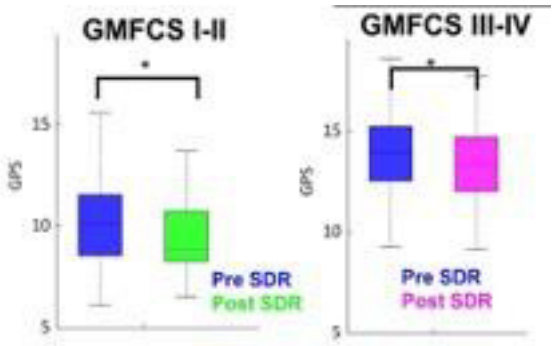

Pre
M (SD)
Post
M (SD)
43.2 (23.8)
51.5 (23.3)
P<0.001
GMFCS I-II
GMFCS III-IV
MQ47 score - mobility
90
80
70
60
50
40
30
20
10
P=0.07
*
Pre SDR
Post SDR
Pre SDR
Post SDR
Δ MQ47 = +3.9 points
[95 % CI = -1.4-9.1]
Δ MQ47 = +8.5 points
[95 % CI = 3.4-13.6]

Abb. 2


GMFCS I-II
GMFCS III-IV
GPS
15
10
5
*
*
Pre SDR
Post SDR
Pre SDR
Post SDR

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC021

### Der Zusammenhang zwischen zervikaler Foraminalstenose und adhäsiver Kapsulitis: Eine bildgebende Fall-Kontroll-Studie

***The association between cervical foraminal stenosis and adhesive capsulitis: An imaging-based case-control study***

S. G. Thavarajasingam[1,2], D. S. C. Ramsay[2], R. Vardanyan[2], A. Sharma[3], K. D. Riew[4,5], F. Ringel[1], S. Russo[3]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich
[3]Imperial College NHS Healthcare Trust, Department of Neurosurgery, London, Vereinigtes Königreich
[4]Weill Cornell Medical Center, Department of Neurological Surgery, New York, NY, Vereinigte Staaten
[5]Daniel and Jane Och Spine Hospital, Columbia University Medical Center, of Orthopedic Surgery, New York, NY, Vereinigte Staaten

#### Objective

Patients investigated for cervical spondylosis often present with shoulder symptoms. Cervical radiculopathies, particularly C5, can present with severe shoulder pain and reduced shoulder mobility, therefore mimicking glenohumeral adhesive capsulitis or frozen shoulder (FS), one of the most common shoulder conditions. No prior studies have explored the link between adhesive capsulitis and cervical radiculopathy. This study aimed to evaluate the potential correlation between these conditions and the clinical implications.

#### Methods

We reviewed 438 patients who underwent glenohumeral hydrodistension between 2012 and 2019 at a tertiary care center. Included were individuals with unilateral FS who were further evaluated using ultrasound and had a cervical spine MRI for cervical spondylosis. Foraminal stenosis at C3/4, C4/5, C5/6 and C6/7 was graded in axial T2 MRI ipsilateral and contralateral to adhesive capsulitis. The presence or absence of foraminal stenosis ipsilateral to the FS (cases) was compared with the contralateral side (control). McNemar"s exact test was used to assess the strength of a correlation.

#### Results

Out of 438 reviewed patients, 107 (24.5%) reported FS and neck pain. Of these, 48 matched the study criteria. MRI assessment revealed a significant association between ipsilateral FS and C4/5 foraminal stenosis ($p = 0.00000008636$). Ipsilateral foraminal stenosis was observed in 57.3% of these cases, with bilateral stenosis in 29.1%. Additionally, 78% had neck pain on the same side as their FS, and 44% had pain radiating to the shoulder. Of the surgical and root injection therapy, 48% targeted the nerve root; 44% of these specifically addressed the C5 nerve.

#### Conclusion

A substantial link between C5 foraminal stenosis and ipsilateral FS was found. C5 radiculopathy could be a risk factor for "neurogenic frozen shoulder". Those diagnosing FS and cervicobrachialgia should recognize that FS and C5 radiculopathy may coexist. A multidisciplinary approach involving both shoulder and spine specialists is recommended for a definitive diagnosis.

Abb. 1

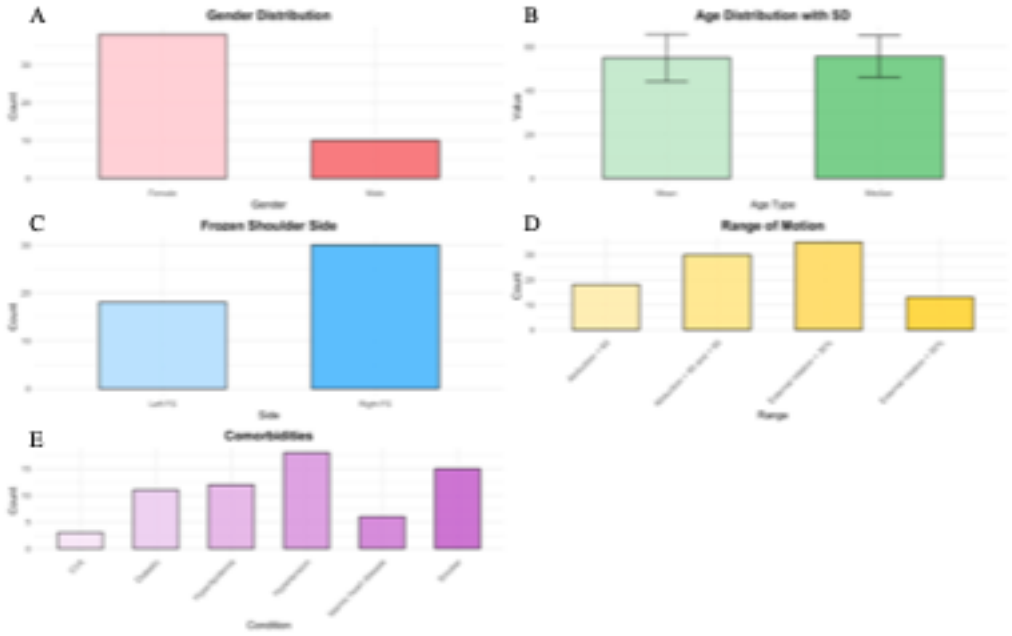
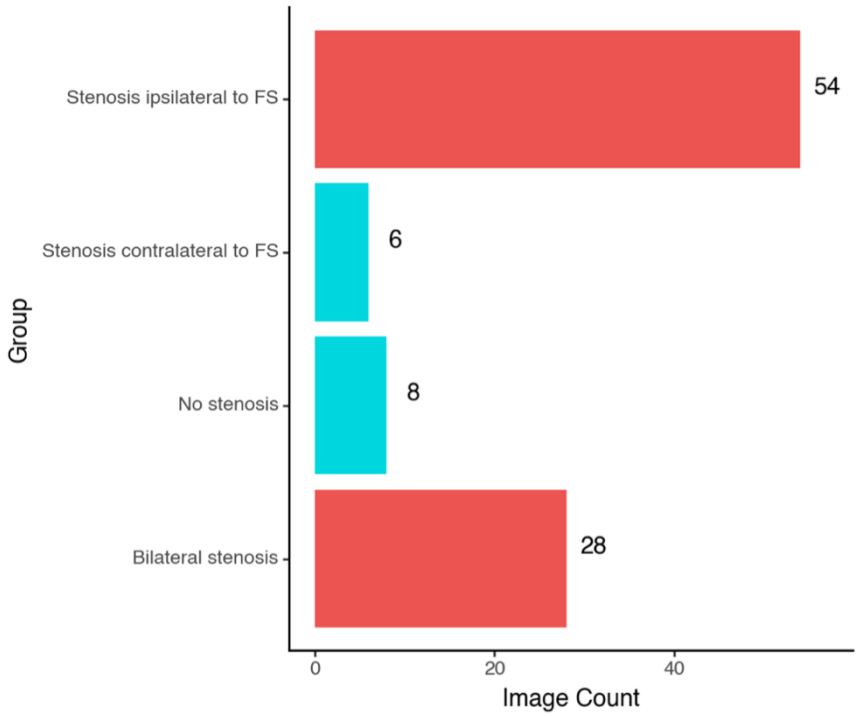

A
Gender Distribution
B
Age Distribution with SD
C
Frozen Shoulder Side
D
Range of Motion
E
Comorbidities

Abb. 2


Stenosis ipsilateral to FS
54
Stenosis contralateral to FS
6
No stenosis
8
Bilateral stenosis
28
Group
0
20
40
Image Count

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC022

### Anschlussfrakturen nach Kyphoplastie in Bezug auf Hounsfield Units
***Adjacent segment fractures in kyphoplasty in relation to Hounsfield units***

N. Aboud[1], C. Senft[1], F. Schwarz[1]

[1]Universitätsklinikum Jena, Klinik mit Poliklinik für Neurochirurgie, Jena, Deutschland

#### Objective

Adjacent segment fractures (ASF) after kyphoplasty for osteoporotic vertebral fractures represent a significant complication of treatment. Recently, bone density assessment using Hounsfield units (HU) in computed tomography (CT) has gained importance to predict fracture risk. In this study, we investigated whether there was an association between the measured HU values in the treated vertebral body region and the occurrence of ASF after kyphoplasty

#### Methods

We performed a retrospective analysis of patient data who underwent one level-kyphoplasty on thoracolumbar vertebral bodies in our institution between 2012 and 2020. HU values were collected from CT scans in vertebrae above and below the treated vertebral body. Patients were divided into two groups: a group with ASF and a group without ASF. The group with ASF was further divided according to the location of the ASF: ASF above, ASF below, and ASF both above and below the kyphoplasty. HU values were statistically analyzed to determine a possible association

#### Results

A total of 93 patients were examined, including 64 women and 29 men. 24 patients (43%) developed ASF after kyphoplasty (10 above, 9 below, and 5 both above and below the index vertebra, including 17 women and 7 men ($p = 1$)). Mean age was 77 years in the group without ASF and 75 years in the group with ASF ($p = 0.4$). The mean HU value above the index vertebra was 78 HU in the group without ASF and 59 HU in the group with ASF ($p=0.01$). The mean HU values below the index vertebra were 67 HU in the group without ASF and 58 HU in the group with ASF ($p = 0.96$)

#### Conclusion

Our study suggests that low HU values on CT above the treated vertebral body could be a potential risk factor for the occurrence of adjacent segment fractures after kyphoplasty. Therefore, preoperative bone density assessment using Hounsfield units should be considered to improve patient selection and success rate of this treatment. Our study failed to find any association between ASF below the index vertebra and HU values. Further prospective studies are needed to confirm these results and to verify their clinical applicability

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC023

### Einfluss von lumbaler Dekompression oder Instrumentation auf die Outcomeparameter von Patienten mit intrathekaler Morphintherapie bei Persistent Spinal Pain Syndrome Type 2 (PSPS-T2)

***Lumbar spinal decompression or fusion surgery and its influence on outcome parameters in patients with intrathecal morphine treatment for Persistent Spinal Pain Syndrome Type 2 (PSPS-T2)***

F. P. Schwarm[1], R. Rehman[2], J. Nagl[1], H. Gött[1], E. Uhl[1], M. A. Kolodziej[3]

[1]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[2]Klinikum Darmstadt, Klinik für Neurochirurgie, Darmstadt, Deutschland
[3]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland

#### Objective

Intrathecal morphine pump (ITMP) infusion therapy as part of pain management concepts is efficient in managing chronic pain refractory to standard treatment. This study evaluates pain relief and improvement of quality of life in chronic pain patients after intrathecal morphine pump implantation for treatment of persistent pain after lumbar spinal fusion surgery or lumbar spinal decompression only.

#### Methods

Between 2009 and 2019 43 chronic pain patients that received an intrathecal morphine pump at our department were retrospectively analyzed divided into 2 cohorts (lumbar spinal fusion surgery and lumbar spinal decompression only). Pain intensity (NRS), quality of life (EQ-5D-3L), mental health (BDI-V), and Pain Catastrophizing Scale (PCS) were assessed. Morphine dosage was assessed over time. Data was collected preoperatively, 6 and 24 months postoperatively. Statistical analysis was performed using Friedman"s analysis of variance to evaluate the development of NRS, PCS, BDI and EQ-5D-3L over time and Mann-Whitney-U-test for the differences between these parameters in the different cohorts. A two-sided *P* -value < 0.05 was considered statistically significant.

#### Results

Median age was 64 years (IQR25–75 56-71 years). NRS, EQ-5D-3L, BDI-V, and PCS showed a significant overall improvement after 6 and 24 months compared to baseline data ($p<0.001$). No statistically significant differences between patients with lumbar spinal fusion and lumbar spinal decompression only were seen in the whole follow-up. Furthermore, no statistically significant differences for age and gender were seen. The initially administered median morphine dosage was significantly higher in the spinal-fusion group 3.0 mg/day (IQR25-75 1.5-4.2 mg/day) compared to the decompression-alone group 1.5 mg/day (IQR25-75 1.0-2.6 mg/day); ($p=0.027$).

#### Conclusion

ITMP has a major long-term impact on pain relief, improvement of quality of life, reduction of psychological distress, as well as pain catastrophizing in patients with chronic pain following lumbar spinal surgery independent of the previous surgical procedure. After ITMP implantation median morphine dosage seems to be significantly higher after spinal-fusion- compared to decompressive surgeries alone.

# Rapid communication – Funktionelle Neurochirurgie | Rapid communication – Functional Neurosurgery

## RC024

### Umgang mit osteoporotischen Wirbelkörperfrakturen in Klinik und Praxis: Eine Analyse der Behandlungspraktiken und Anwendung der OF-Klassifikation im deutschsprachigen Raum

***Management of osteoporotic vertebral fractures in clinic and practice: An analysis of treatment practices and application of the OF-classification in German-speaking countries***

T. Miron[1], I. Moritz[2], Y. M. Ryang[2]

[1]Universitätsklinikum, Erfurt, Deutschland
[2]Helios Klinikum Berlin-Buch, Nerochirurgie, Berlin, Deutschland

#### Objective

Vertebral fractures as a result of untreated osteoporosis are steadily increasing due to demographic change. The OF-classification and score for osteoporotic vertebral fractures provides a standardised basis for determining therapeutic indications. We have collected information on the application and other treatment practices in German-speaking countries.

#### Methods

An anonymous electronic questionnaire with 36 questions was sent to all members of the German Spine Society (DWG), the Austrian Society for Spine Surgery (spine.at) and clinics in Switzerland in October 2023. The responses were stratified according to speciality, level of training and other factors and compared using Fisher's exact test or T-test.

#### Results

A total of 2981 physicians received the questionnaire, and 300 (10.06% response rate; 18.67% F, 79.33% M, 2% diverse) aged 35-54±10 years, 40.3% from neurosurgery, 36.3% orthopaedics, 22.3% trauma surgery, 1% others completed the survey. With regard to the treatment decision, imaging was decisive for 90.7%, the clinic for 95.0%, the general condition of the patient for 78.7% and the OF score for 44%. Overall, 70.3% of respondents reported using the OF classification as standard (neurosurgery: 67.8%, orthopaedics: 75.2%, trauma surgery: 70.2%). Among general practitioners, standard use was significantly more common at 81.4%, compared to 65.5% of senior consultants ($p = 0.013$) and 67.6% of chief physicians. There was also a significant difference between practices and clinics: only 30% of practices compared to 75.5% of university clinics used the OF classification as standard ($p<0.05$). 60.7% of respondents regularly examined bone density, most frequently by DEXA scan (58%) followed by HU on CT (19%) and QCT (14.7%). Antiosteoporotic therapy was regularly prescribed by 26%, with only 17.3% regularly checking bone density during therapy.

#### Conclusion

The results of the survey provide valuable insights into the current management of osteoporotic vertebral fractures in hospitals and practices. They show that the OF classification is already widely used in clinics, whereas the OF score still plays a less important role in clinical decision-making with regard to other parameters such as clinical findings, imaging and general condition. In long-term care there is a deficit in the form of a lack of follow-up and inadequate outpatient care. Further research is needed to identify specific needs in order to optimise treatment strategies.

# Rapid communication – Tumor 1 | Rapid communication – Tumour 1

## RC025

### ElectroGenOmics: Integrierte räumlich aufgelöste Elektrophysiologie und Transkriptomics zur Exploration von Tumor-Host Kommunikation bei Glioblastomen

***ElectroGenOmics: Integrated spatially resolved electrophysiology and transcriptomics to explore tumor-host communication in glioblastoma***

E. Grabis[1], J. Ort[2], J. Zhang[1], G. Villa[3], Y. A Jabo[3], N. Neidert[1], J. Beck[1], D. Delev[3], H. Heiland[3]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[2]RWTH Aachen University, Klinik für Neurochirurgie, Aachen, Deutschland
[3]Universitätsklinikum Erlangen, Klinik für Neurochirurgie, Erlangen, Deutschland

#### Objective

Cancer neuroscience is emerging, emphasizing the interaction of cancer cells with their neuronal environment. Recent insights have redefined glioblastoma, transitioning from an isolated system to a bidirectional consortium integrated into neural circuits. However, technical obstacles have made integrating electrophysiology and transcriptomic data challenging. Here, we present ElectroGenOmics, a solution for spatially-integrated, multi-omic analysis merging array-based electrophysiology and transcriptomics.

#### Methods

Using patient-derived tumor cultures introduced into human cortical slices, we employed a multi-channel electrode array system. After recording for 2 hours, which involved electrical and pharmacological stimulation, the sections underwent PFA fixation and paraffin embedding followed by HE staining and spatial transcriptomic profiling using the 10X Visium kit. Data postprocessing was performed by space-ranger and a novel developed package "SPATAElectro", an R-based toolbox built upon the SPATA framework.

#### Results

Quality checks on human cortical slices post-electrophysiological recordings showed high RNA integrity in 84% of the samples, with a DV>200 exceeding 45%. Image co-registration post-paraffin embedding demonstrated high accuracy for the multi-modal integration, enabling effective data overlay. we identified highly correlative transcriptomic modules that are associated with high tumor network activity and a high firing rate. These modules were linked to enriched genes, providing new insights into the molecular underpinnings of glioblastoma activity. By examining the spatial context, we explored the directionality of information transport in different zones of the tumor and adjacent brain tissue. Looking into the composition of the microenvironment in active malignant nodes, revealed how these areas interact with and influence their surroundings.

#### Conclusion

ElectroGenOmics overcomes previous multi-omic data integration challenges, offering a comprehensive view of the transcriptional context in relation to glioblastoma electrophysiological communication patterns.

# RC027

## Eine erhöhte GD2-Expression in Oligodendrogliomen bietet eine grundlegende Voraussetzung für die Immuntherapie mit CAR T-Zellen

***First-time characterization of high GD2 expression in oligodendroglioma: A pre-requisite for CAR T-Cell immunotherapy***

V. Cibulkova[1], D. Hieber[2], J. Allgaier[3], J. Schobel[2], R. Pryss[3], A. F. Keßler[1], A. Cattaneo[1], T. Schulz[1], J. Hübner[4], T. Nerreter[4], M. Breun[1], F. Liesche-Starnecker[5], C. Hagemann[1], R. I. Ernestus[1], M. Löhr[1], V. Nickl[6]

[1]Universität Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Hochschule Neu-Ulm, Institute DigiHealth, Neu-Ulm, Deutschland
[3]Universität Würzburg, Institut für Klinische Epidemiologie und Biometrie, Würzburg, Deutschland
[4]Universität Würzburg, Medizinische Klinik, Würzburg, Deutschland
[5]Universität Augsburg, Institut für Pathologie und Molekulare Diagnostik, Augsburg, Deutschland
[6]Universität Würzburg, Pathologisches Institut, Abteilung für Neuropathologie, Würzburg, Deutschland

### Objective

Gliomas, the most prevalent malignant brain tumors, present with limited treatment options and often dismal prognoses. Chimeric antigen receptor (CAR) T-cell therapy is a promising immunotherapeutic approach that requires a careful selection of tumor-associated antigens (TAAs). GD2, a well-explored TAA in neuroblastoma, is currently under investigation in four clinical CAR T-cell trials for gliomas. This study aims to assess GD2 expression in glioma entities, correlating findings with survival outcomes and target safety.

### Methods

A retrospective cohort of 198 adult glioblastoma (GBM) (n=145), astrocytoma WHO grade 1-4 (n=31), oligodendroglioma WHO grade 2 (n=12) and 3 (n=10), and 5 pediatric-type diffuse high grade glioma patients was included. Formalin-fixed paraffin-embedded tumor samples underwent immunohistochemical staining for GD2. Staining intensity of each sample was quantified into an H-score (range 0-300) using QuantCenter. Analysis of overall (OS) and progression-free survival (PFS) of GBM patients was analyzed with Kaplan-Meier curves and Cox regression, considering clinical data. GD2 safety as a target was evaluated in healthy FDA-approved tissue microarrays.

### Results

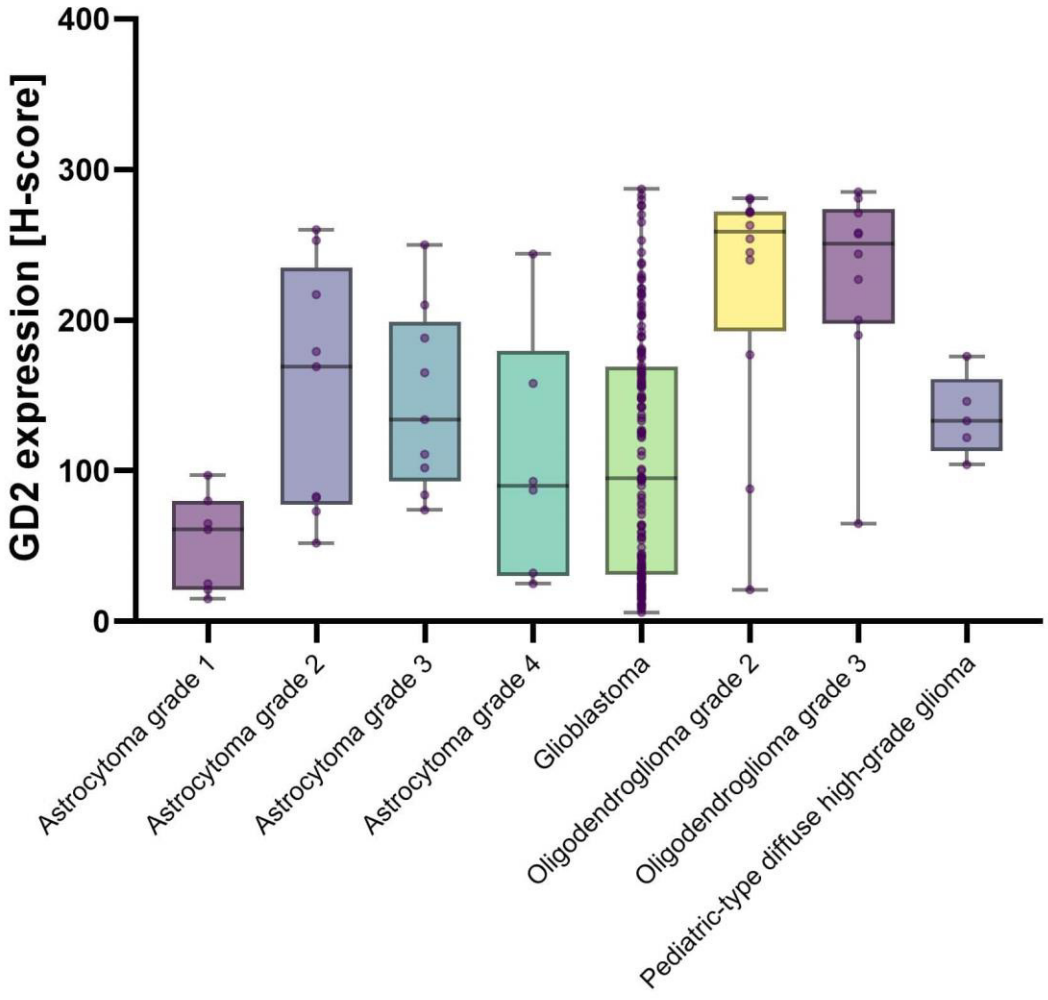
High GD2 expression was detected in 10 of 12 oligodendroglioma WHO grade 2 (median H-score 259) and 9 of 10 WHO grade 3 patients (median H-score 250.5) with a narrow interquartile range. GBM and astrocytoma WHO grade 1, 2, 3, or 4 displayed moderate to weak GD2 expression (median H-score of 95, 61, 169, 134, 90, respectively). All pediatric-type diffuse high-grade gliomas moderately expressed GD2. Survival analysis revealed that GD2 high GBM patients had shorter OS (log rank p=0.057) and PFS (log rank p=0.073). Multivariate analysis identified GD2 as a significant negative prognostic factor for PFS (HR=1.004, 95% CI=1.000–1.008, p=0.008). Furthermore, we found elevated levels of GD2 in healthy colon, kidney, and liver.

### Conclusion

This study marks the inaugural characterization of GD2 expression in oligodendroglioma, unveiling elevated GD2 levels primarily affecting younger patients with an unfavorable outcome. Target expression analysis in healthy tissues provides valuable insights into potential on-target off-tumor toxicity, although such effects have not been observed in clinical trials. Further research and validation studies are warranted to confirm the clinical utility of GD2 as a prognostic marker and to explore its potential as a therapeutic target in gliomas.

Abb. 1

**Figure 1. GD2 expression across adult and pediatric glioma entities.**
The intensity of immunohistochemical staining was quantified into an H-score, representing antigen expression level. H-score can be considered as low (0 - 100), medium (101 - 200), and high (201 - 300).



# Rapid communication – Tumor 1 | Rapid communication – Tumour 1

## RC028

### Geschlechtsunterschiede im Glioblastom: Machen Mikroglia oder Makrophagen den Unterschied?
***Sex differences in glioma growth – Do microglia or macrophages make the difference?***

E. Motta[1], H. Kettenmann[1,2], S. Wolf[1], C. Flüh[3,1]

[1]Max Delbrück Center for Molecular Medicine in the Helmholtz Association, Cellular Neurosciences, Berlin, Deutschland
[2]Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, China, Volksrepublik
[3]Universitätsklinikum Schleswig-Holstein, Campus Kiel, Klinik für Neurochirurgie, Kiel, Deutschland

#### Objective

GBM is a highly malignant brain tumor with a devastating prognosis. Strikingly, men develop GBM more frequently and have a shorter survival than women. The reasons for this are currently unknown, and sex-specific treatment options are not available. Up to 40% of the tumor mass consist of glioma-associated microglia and macrophages (GAMs), which are known to foster glioma growth and invasiveness. Under physiologic conditions, microglia and macrophages harbor specific sex-dependent differences. In this study we aimed at evaluating whether there is a sex-specific influence of GAMs on glioma growth. We focused on circulation of sexual hormones, peripheral immune cells and the influence of sexual maturation on microglia.

#### Methods

We employed an *ex vivo* model of organotypic brain slices, using brains of P11- P14 mice pups, which were sectioned to 250µm coronal slices. Slices were transferred onto a semi-permeable membrane inserts with access to medium from the bottom. 72h after preparation, GL261-mCherry glioma cells were injected into each hemisphere. Tumor-inoculated OBS were cultivated for 5 day, fixated and analysed via confocal microscopy and the imaging analysis program IMARIS. Altering the model, estradiol was added to the culture medium, peripheral male or female monocytes were coinjected, and mature mice were chosen for slice generation. Statistical analysis was performed by using the Mann-Whitney test.

#### Results

In slices harbouring only microglia, tumor volumes did not differ when comparing male and female slices ($p=0,65$). Tumors injected into slices of adult mice or additional treatment with the female sexual hormaone estradiol also did not show sex-dependent differences in tumor volume ($p=0,9495$). Coinjection of sex-specific bone-marrow derived monocytes resulted in significantly bigger tumors in males ($p=0,0008$).

#### Conclusion

Only if peripheral monocytes **and** microglia are present, a sex-specicifity in GAM-associatiated fostering of tumor growth can be observed, but not if only microglia are present. Maturity of microglia and presencence of estradiol does not affect tumor growth in sex-dependent manner. Caution has to be taken while interpreting data on sex-dependent differences coming from *ex vivo* models.

# RC029

## Specific *ex vivo* expansion of NKG2C+/CD25+ "memory-like" natural killer cells from peripheral mononuclear blood cells for immunotherapy of glioblastoma

***Spezifische ex vivo Expansion von NKG2C+/CD25+ "memory-like" Natürlichen Killerzellen aus peripheren mononukleären Blutzellen zur Immuntherapie des Glioblastoms***

M. M. Remus[1], S. Michen[1], T. Tonn[2], I. Y. Eyüpoglu[3,4], A. Temme[1,4]

[1]TU Dresden, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Klinik und Poliklinik für Neurochirurgie, Experimentelle Neurochirurgie/Tumorimmunologie, Dresden, Deutschland
[2]DRK Bludspendedienst Nord-Ost gGmbH, Institut für Transfusionsmedizin Dresden, Dresden, Deutschland
[3]TU Dresden, Medizinische Fakultät und Universitätsklinikum Carl Gustav Carus, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[4]German Cancer Consortium (DKTK), Dresden, Deutschland

### Objective

This study focuses on NKG2C+ natural killer (NK) cells, a small NK cell subpopulation in the blood of human cytomegalovirus (HCMV) seropositive donors. Beside recognition of peptides derived from classical HLA alleles, these NKG2C+ NK cells are able to recognize a processed HLA-G signal peptide and processed peptides from HCMV-UL40 presented by HLA-E molecules on the surface of glioblastoma cells. Consequently, NKG2C+ NK cells have a higher intrinsic capability to kill specifically glioblastoma cells. In our study we investigated, the selective outgrowth of NK cells directly from peripheral mononuclear blood cells (PBMCs) when co-cultivated with a novel feeder cell line and without the need for tedious NK cell sorting in order to simplify translational efforts.

### Methods

PBMCs were isolated from the blood of HCMV-seropositive donors. Specific NKG2C+/CD25+ NK cell expansion was achieved by co-cultivation with a novel feeder cell line, modified with an HLA-E trimer presenting the HLA-G-derived VMAPRTLFL peptide. Considering clinical regulations, the feeder cells were irradiated and a CD3 depletion of the PBMCs was conducted. Over the course of two weeks, the NK cells activation and exhaustion markers were analyzed via flow cytometry. Subsequently, the cytotoxicity of the *ex vivo* expanded NKG2C+/CD25+ NK cells was evaluated by cytotoxicity assays employing allogeneic primary glioblastoma cells.

### Results

NK cell expansion from PBMCs with irradiated feeder cells showed a significantly higher growth of NKG2C single positive NK cells, compared to expansion with non-irradiated feeder cells (p=0.0056). Proliferation of CD3 positive natural killer T-cells (NKT cells) as a byproduct, made a CD3 depletion necessary, even though single donors achieved high NK cell purity from expansion of non-depleted PBMCs (median 58.9 %; range 10.4 % - 92.2 %). CD3 depletion showed significantly higher purity (p=0.0015; median 91.8 %; range 79.4 % - 99.3 %), whilst not significantly influencing growth as well as NKG2C expression (median 56.6 %; range 15.0 % - 83.4 %). Regarding cytotoxicity no significant difference between the depleted and non-depleted group could be found.

### Conclusion

Our results demonstrate selective outgrowth of NKG2C+/CD25+ NK cells when using GMP compliant protocols approved by regulatory bodies. They furthermore, demonstrate a promising strategy for achieving clinically relevant quantities of NKG2C single positive NK cells for treatment of glioblastoma.

# RC030

## Nutzung von aus Biopsien hergestellten Tumororganoiden für die personalisierte Medikamententestung von Rezidiv-Glioblastomen

***Use of biopsy-derived tumor organoids for personalized drug testing in recurrent glioblastoma***

A. Wöllner[1], R. Warta[1], J. Cao[1], A. Paul[1], M. Arquilla[1], G. Jungwirth[1], W. Wick[2], A. von Deimling[3], S. Krieg[1], A. Unterberg[1], M. Jakobs[1], C. Herold-Mende[1]

[1]Universitätsklinikum Heidelberg, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Heidelberg, Deutschland

### Objective

To date, there are no systemic treatment options for patients suffering from recurrent glioblastoma with a proven efficacy. Furthermore, often surgical resection is not any more possible and patient tumors have acquired an increased chemo- and radioresistance. Patient-derived tumor organoids (TOs) provide a new exciting tool to test individual treatment responses. Aim of this study was to develop a protocol and to test the feasibility to perform personalized TO-based drug testing using the rare material from stereotactic biopsies.

### Methods

Patient-derived TOs were prepared based on single cell suspensions from tumor material obtained either from open glioblastoma resections serving as a reference data set (n=37) or from stereotactic biopsies of 8 patients. Drug response curves (6-9 dose points) were performed for nine selected drugs including temozolomide, lomustine, etoposide and temsirolimus, which are commonly used in clinical practice. Viability and metabolic activity were measured using CellTiterGlo (Promega). Half-maximal inhibitory concentrations (IC50) were calculated by GraphPad Prism software. Medical records were reviewed for survival and routine molecular information such as the MGMT promoter methylation status.

### Results

Drug testing performed on TOs derived from open resections allowed to adjust the concentration test range for each drug, as well as to determine the range of drug vulnerability. Additionally, we found a significant association between increased temozolomide sensitivity of TOs and both, MGMT methylation and increased survival. However, in 59% of the cases, no high sensitivity to any of the drugs was observed, and only 17% were highly sensitive to more than one drug. Subsequent drug testing on TOs derived from biopsies of recurrent glioblastoma revealed sensitivity in 3/8 cases against one (n=2) or two (n=1) of the drugs. However, sensitivity against drugs varied substantially in a patient-individual manner.

### Conclusion

Taken together, we successfully developed a workflow to test drug sensitivity on glioblastoma-derived tumor organoids even from the low starting material obtained from stereotactic biopsies. Association of clinical outcome and MGMT methylation with temozolomide sensitivity corroborated the strength of this approach. Furthermore, patient-individual treatment responses strongly suggest for a future personalized drug testing.

# Rapid communication – Tumor 1 | Rapid communication – Tumour 1

## RC031

***Neurokognitive Auswirkungen von rechts- versus linkshemisphärischen T2/FLAIR-Läsionen des Tractus Arcuatus bei Patienten mit erstdiagnostiziertem Glioblastom***
***The effects of right- versus left-sided T2/FLAIR lesions of the arcuate fasciculus on neurocognitive abilities in patients with newly diagnosed glioblastoma***

M. Ferner[1], R. Loução[1], K. Rodrian[1,2], S. Kochs[1], M. Becker[1], C. Nettekoven[1], D. Wiewrodt[3], M. Löhr[4], C. Jungk[5], M. Kocher[1], R. Goldbrunner[1], N. 1. Studiengruppe[1,6,7,3,8,2,4,5,9,10,11,12,13,14,15], C. Weiß Lucas[1]

[1]Universitätsklinikum Köln, Zentrum für Neurochirurgie, Köln, Deutschland
[2]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[3]Uniklinik Münster, Neurochirurgische Klinik, Münster, Deutschland
[4]Universitätsklinikum Würzburg, Neurochirurgische Klinik, Würzburg, Deutschland
[5]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[6]Universität zu Köln, Department für Heilpädagogik und Rehabilitation, Köln, Deutschland
[7]Universitätsklinikum Regensburg, Neurochirurgische Klinik, Regensburg, Deutschland
[8]Universitätsklinikum Tübingen, Abteilung Neurologie mit interdisziplinärem Schwerpunkt Neuroonkologie, Tübingen, Deutschland
[9]Uniklinik Mainz, Neurochirurgische Klinik, Mainz, Deutschland
[10]Donau-Isar-Hospital, Neurochirurgische Klinik, Deggendorf, Deutschland
[11]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgische Klinik, Dresden, Deutschland
[12]Universitätsklinikum Schleswig-Holstein, Neurochirurgische Klinik, Lübeck, Deutschland
[13]Klinikum Chemnitz, Neurochirurgische Klinik, Chemnitz, Deutschland
[14]HELIOS Krankenhaus Schwerin, Neurochirurgische Klinik, Schwerin, Deutschland
[15]Universitätsklinikum Freiburg, Neurochirurgische Klinik, Freiburg i. Br., Deutschland

### Objective

There has been increasing evidence that not only the distinct segments of the dominant (usually left-hemispheric) arcuate fasciculus (AF), but also its right-hemispheric counterparts are crucial to communication functions, including the recognition of facial expressions. However, the non-dominant AF is rarely included in invidual surgical plannings for brain tumour resections. In this study, we set out to investigate the correlation between cognitive functions and tumour infiltration of bihemispheric AF segments.

### Methods

121 patients (79 males, 43 females, 116 right-handed, median age 62 years [36-83 years]) with a newly diagnosed unilateral glioblastoma underwent a preoperative cognitive assessment consisting of 11 subtests. Cognitive performance was expressed in percentile ranks (PR), normalised regarding age, gender and education. The PR and data-driven cluster analysis were used to build 7 different cluster scores, each describing a specific neurocognitive domain. Cranial FLAIR/T2-weighted MR images were acquired on a Phillips 3T scanner within 5 days. The respective tumour/oedema volumes were segmented using BrainLab Elements. A NatBrainLab atlas template was used to calculate the overlap of the lesion and the 3 segments of the AF in both hemispheres. Kendall-tau rank correlation coefficients between the cluster scores and the overlap were calculated in R and corrected for multiple comparisons.

### Results

Correlations were to be found between right-hemispheric lesions of the long AF segment and visuospatial judgment ( $\tau$= -0,17; p= 0,046), of the posterior segment and visuospatial memory ($\tau$= -0,18; p= 0,038) as well as visuospatial construction abilities ($\tau$= -0,21, p= 0,013). Lesions in all segments of the left AF correlated with working memory, albeit most pronounced in the long segment ($\tau$= -0,26; p= 0,004). Similarly, lesions in all left AF segments correlated with lexical fluency and verbal memory, especially regarding the long AF segment ($\tau$= -0,29; p= 0,001).

## Conclusion

Our findings confirm the strong involvement of the left AF and, particularly, its long segment, in cognitive language functions such as verbal fluency and working memory, but also emphasise the importance of the right AF for visuospatial functions, which are for instance involved in emotional communication aspects. This stimulates the discussion whether appropriate mapping and monitoring tasks should be integrated in the awake surgery setting and calls for further analysis of the patients" follow-up outcomes.

# RC033

## Bewertung des Potentials eines Machine Learning Models mit MGMT-Methylierung als Hauptvariable bei Glioblastoma-Patienten in einem limitierten Datenset

***Assessing the prognostic potential of MGMT methylation as the primary variable in a machine learning framework for glioblastoma patients, particularly in a limited dataset***

E. Maragno[1], S. Ricchizzi[1,2], M. Gallus[1,3], N. R. Winter[1,2], S. J. Hellwig[1], W. Stummer[1], T. Hahn[2], M. Holling[1]

[1]Uniklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Institut für Translationale Psychiatrie, Medical Machine Learning Lab, Münster, Deutschland
[3]University of California, Department of Neurological Surgery, San Francisco, CA, Vereinigte Staaten

### Objective

Machine learning is increasingly finding applications in glioblastoma (GBM) research, focusing on large datasets derived from genetic analysis and imaging for predictive modeling.

This study shifts attention to fundamental patient data, particularly exploring the impact of MGMT-Methylation on GBM patient prognosis. With this, we aim to assess the predictability of overall survival, using a machine learning framework.

### Methods

The patient cohort comprised retrospective data from 218 patients from a single-center study. Age, sex and MGMT methylation were used to predict overall survival of patients in months. The predictive performance was measured in mean absolute error (MAE), mean squared error (MSE), explained variance (EV), Pearson correlation and r-squared (r2) and evaluated within a 10x10 nested cross-validation framework. The machine learning pipeline comprised five regression estimators, including both linear and non-linear approaches. The variables were further evaluated based on their impact on the prognosis using feature importance analysis. Statistical significance was assessed using a permutation test procedure.

### Results

The machine learning pipeline achieved an MAE of 12.88 (SD=2.18) and an EV of 3% (SD=1.8%) when predicting survival duration in months. It marginally outperformed a baseline model that always predicts the mean survival of the training sample (MAE=13.66 months). Our analysis showed that the linear method of Support Vector Regression led to more accurate predictions compared to non-linear estimators. Feature importance testing indicated that age (permutation norm=0.897) and positive MGMT-Methylation (permutation norm=0.045) have the greatest influence on the model predictions.

### Conclusion

Our findings emphasize the efficacy of a linear machine learning approach on a limited dataset, with focus on MGMT-Methylation's impact on the prognosis of glioblastoma patients in terms of overall survival rated in months.

This method shows potential especially in accurately predicting long-term survival based on the tumor's genetic profile. Such predictive capabilities could significantly assist surgeons and oncologists in their routine decision-making.

Fig.1: Support Vector Regression performance - Light blue: training dataset performance; Dark blue: Validation on test model

Fig.2: Predictions in training and test set - True value on y-axis, predicted overall survival in months on x-axis. Left: Training set (90% data). Right: Test set (10% data)

Abb. 1

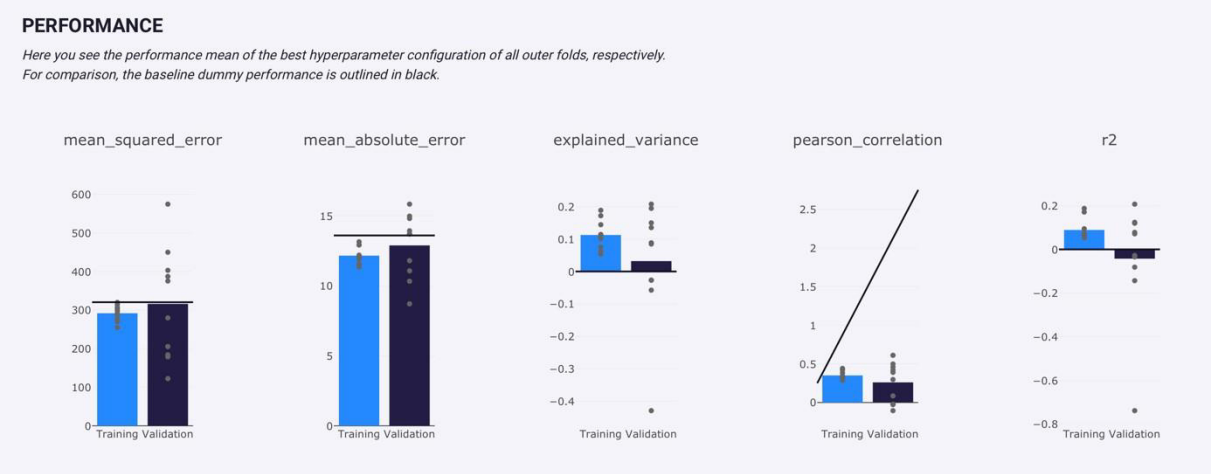



Abb. 2

# RC034

## Konfokale Laserendomikroskopie zur Differenzierung glialer Hirntumore
*Differentiating glial tumors via confocal laser endomicroscopy*

K. Radtke[1], W. Schulz-Schaeffer[2], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Universitätsklinikum des Saarlandes, Neuropathologie, Homburg a. d. Saar, Deutschland

### Objective

While the 5th version of the WHO classification of tumors incorporates more genetic markers to determine tumor subtypes, classical histomorphological analysis of glial tumors remains a crucial aspect of tumor grading. As demonstrated in our previous poster, confocal laser endomicroscopes can be used to intraoperatively visualize glial tissue and tissue characteristics such as cellularity, nuclear pleomorphism, glial matrix abnormalities, vascularization and necrosis without the need for processing in a lab or staining. We analyzed how those characteristics can be used to not only determine identify glial tumors, but how they might be used to differentiate low- versus high-grade as well as astrocytic versus oligodendroglial brain tumors.

### Methods

125 glioma biopsies were harvested and analyzed using a 670 nm confocal laser endomicroscope. They were then examined as hematoxylin and eosin stained frozen sections. All confocal images and frozen sections had previously been analyzed for their tissue characteristics and were now grouped into astroglial and oligodendroglial as well as high- and low-grade tumors. Differences in visualization of these tissue features in astroglial versusoligodendroglial tumors and low-grade versus high-grade tumors were calculated using Fisher"s exact test.

### Results

All 125 biopsies were examined successfully. 102 specimens were astroglial, 23 were oligodendoglial. The accuracy for detection of astro- versus oligodendroglial tumors was 90.2 % and 95.7 %, respectively. 42 specimens were low-grade gliomas, 83 specimens were high-grade gliomas. The accuracy for detection of low-grade and high-grade gliomas was 88.1 % and 92.8 %, respectively. Astrocytic tumors showed significantly more nuclear pleomorphism in confocal laser endomicroscopy than oligodendroglial tumors. Necrosis significantly helped in differentiation of low- and high-grade tumors (p

### Conclusion

Confocal laser endomicroscopy not only allows identification of glial tumor tissue, but might intraoperatively aid in the further differentiation of glial tumor subgroups. High nuclear pleomorphism is indicative of astrocytic tumors, while the visualization of necrosis points towards high-grade gliomas. All results have to be controlled in a blinded study in the next step.

# Rapid communication – Tumor 1 | Rapid communication – Tumour 1

## RC035

### Determinanten eines Langzeitüberlebens bei Patientinnen und Patienten mit IDH-mutierten Gliomen
***Determinants of long-term survival in patients with IDH-mutant gliomas***

S. Katzendobler[1], J. Weller[1], S. Niedermeyer[1], J. Blobner[1], C. Trumm[2], R. Egensperger[3], P. Harter[3], L. von Baumgarten[1], V. Stöcklein[1], J. Tonn[1], M. Weller[4], N. Thon[1]

[1]Klinikum der Ludwig-Maximilians-Universität München, Klinik für Neurochirurgie, München, Deutschland
[2]Klinikum der Ludwig-Maximilians-Universität München, Neuroradiologie, München, Deutschland
[3]Klinikum der Ludwig-Maximilians-Universität München, Zentrum für Neuropathologie und Prionforschung, München, Deutschland
[4]Universitätsspital Zürich, Klinik für Neurochirurgie, Zürich, Schweiz

#### Objective

Survival times of patients with IDH-mutant gliomas is variable and can extend to decades. Many studies only provide progression-free rather than overall survival times and prognostic factors remain ill-defined. Here we explored clinical disease characteristics of long-term survivors within a large cohort of patients with extended follow-up.

#### Methods

This single-center, retrospective analysis included 114 patients with IDH-mutant glioma that either died due to tumor-related causes or survived at least 15 years after first diagnosis. Patient characteristics, outcomes, and prognostic factors were stratified by short- (< 15 years) versus long-term (≥ 15 years) survival. Initial diagnosis was (re-)classified according to the WHO 2021 classification. Uni- and multivariate analyses were performed.

#### Results

Overall, 66 patients (58%) were diagnosed with astrocytoma and 48 patients (42%) were diagnosed with oligodendroglioma. Resection was performed in 65 patients (57%) and 49 patients (43%) received a biopsy. Median follow-up of the survivors was 16.6 years (range 15-28.9). Overall, 62 tumor-related deaths (54%) had been reported at database closure. Patients that died before reaching 15 years survival time had been diagnosed with astrocytoma in 41 (72%) and oligodendroglioma in 16 cases (28%). The long-term survivor cohort comprised 25 patients (44%) with astrocytoma and 32 patients (56%) with oligodendroglioma. Long-term survival was associated with grade 2 histology ($p < 0.01$), smaller tumor volumes ($p < 0.01$), and lack of contrast enhancement ($p = 0.02$). 41 long-term survivors (72%) were initially monitored by a wait-and-scan strategy as opposed to 16 patients (28%) in the cohort of short-term survival ($p<0.01$). In multivariate analyses, diagnosis of an astrocytoma and initiation of tumor-specific therapy were associated with shorter overall survival. Tumor resection (HR 0.43; 95% CI 0.22-0.86; $p = 0.02$) and wait-and-scan strategies (HR 0.34; 95% CI 0.14-0.79; $p = 0.01$) were associated with longer survival in patients with astrocytoma.

#### Conclusion

Tumor resection followed by a wait-and-scan strategy may yield excellent survival times, especially in patients with IDH-mutant grade 2 astrocytoma. Age appears not be an important predictor for survival in patients with IDH-mutant gliomas.

# RC036

## Die ungeplante und frühzeitige Krankenhauswiederaufnahme von Glioblastompatient:innen: Auswirkungen auf die Behandlungsqualität und Behandlungskosten

***Early unplanned readmission in glioblastoma patients: implications for quality of care and treatment costs***

J. Kasper[1], E. Güresir[1], V. D. Nikolaus[2]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland
[2]Universitätsklinikum Leipzig, Bereich 6 - Medizinmanagement, Leipzig, Deutschland

### Objective

Unplanned early hospital readmission (UER) was shown to be significantly associated with shortened survival, including patients suffering from glioblastoma (GBM). Moreover, international data proved UER to cause significant economic burden for healthcare systems. Several nations have hence implemented reforms to reduce UER rates, including financial penalties for hospitals with UER rates above average.

For Germany, there is no comprehensive data available concerning the economic role of UER. We therefore analyzed the GBM cohort of a neurosurgical university center with focus on quality of care (QoC) and treatment cost when UER occurred.

### Methods

All patients with newly diagnosed GBM between 2014 and 2020 were included. Exclusion criteria were age below 18 years and proof of IDH mutation. Clinical patient data as well as data concerning the diagnosis related group (DRG) were retrospectively assessed. UER was defined as unappointed hospital readmission within 30 days after discharge for primary treatment. Statistical analysis was carried our using SPSS.

### Results

275 patients newly diagnosed with GBM were included. UER occurred in 37 cases (13,5% of the entire cohort). Most frequent causes for UER were neurological deterioration, post-operative infections and epileptic seizures. Four cases were identified as avoidable hospital readmission.

Concerning QoC of primary treatment, there were no significant differences between sub-cohorts with or without UER. Especially type of surgery, extent of resection, occurrence of post-operative complications or type of adjuvant therapy were equally distributed among sub-cohorts.

For secondary treatment, surgery was necessary in 9 of 37 cases (24,3%), most commonly for surgical site infection or hydrocephalus. Surgical cases were associated with significantly increased treatment costs (average rate per case 7906±7368€ [conservative] vs 19372±12561€ [surgical]; p=0,01) and prolonged length of stay. A comparative analysis between sub-cohorts with and without UER revealed additional costs of averagely 8.737±8.273€ per case and additional 19,9±19,3 days of hospital stay (both p<0.001) for patients with UER.

### Conclusion

QoC was similar for patients with or without UER but hospital readmissions were significantly associated with additional treatment costs and in-patient hospital stay. Due to the malignant nature of glioblastoma, UER is partially avoidable in these patients.

# Rapid communication – Tumor 2 | Rapid communication – Tumour 2

## RC037

### Genauigkeit der Laserapplikation für LiTT( Laser interstitial thermal therapy) unter Verwendung eines optimierten Workflows zur stereotaktischen Implantation

***Accurycy of Laser placement for LITT (Laser interstitial thermal therapy) using a customized stereotactic workflow***

L. Buentjen[1], M. Kanowski[2], F. Schmitt[2], J. Kaufmann[2], M. Deliano[2], J. Voges[1]

[1]Universitätsklinikum Magdeburg, Stereotaktische Neurochirurgie, Magdeburg, Deutschland
[2]Universitätsklinikum Magdeburg, Neurologie, Magdeburg, Deutschland

#### Objective

Laser Interstitiell Thermal Therapy is increasingly used to perform minimally invasive epilepsy surgery. While LITT (Visualase/ Medtronic) has been available in Europe for some years similar systems are becoming available. Despite the spreading use of such stereotactically steered devices little data is available on their ability to reach a predefined target point via a predetermined trajectory.However accuracy is mandatory as deep lying vessels impose risks for intracerebral bleeding and highly eloquent areas can be found adjacent to typical trajectories. Therefore this information is important to neurosurgeons in order to make decisions on risk management for this stereotactic precedure and to compare competing technologies.

#### Methods

We performed 30 LITT procedures for Epilepsy surgery. The ablation targets were the amygdaloid hippocampal complex, periventricular heterotopias, hypothalamic hamartomas and other epileptogenic entities. For the surgical placement a special stereotactic drill and screewing device was developed to avoid skiving in non rectangular drilling situations. Furthrmore a stepless transportation system was developed to ensure safe patient transport to the MRI suite with the implanted device. All procederes were performed with a MR compatible stereotactic frame in place.

Instrument insertion was controlled by stereotactic x-ray and MRI intraoperativly. We than retrospectivly analysed the radial and the euclidian distance of the Laser position in the intraoperative MRI, the stereotactic x-ray and the original treatment plan in 30 consecutive LITT cases.

#### Results

Using a dedicated hardware configuration the mean radial distance, which is the relevant accuracy measure for thes procedure, was 1,57mm. Euclidian distance was 2,86mm reflecting different targetting strategies of the participating surgeons.

#### Conclusion

This technical study provides evidence for implantation accurycy of the Visualase™ Laser device. It implies that using a dedicated workflow yields results well comparable to other stereotactic procedures.

# RC038

## *Korrelation zwischen molekularem Status und bildmorphologischen Merkmalen bei Olfaktoriusrinnenmeningeomen auf die präoperative Riechfunktion*
## *Correlation of molecular status and image morphological characteristics in olfactory groove meningioma on preoperative olfactory function*

D. Podlesek[1], M. Alkhatib[1], D. Daubner[2], M. M. Hijazi[1], S. Menzel[3], I. Y. Eyüpoglu[1], G. Schackert[1], T. Juratli[1], T. Hummel[3]

[1]Technische Universität Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Institut und Poliklinik für diagnostische und interventionelle Neuroradiologie, Dresden, Deutschland
[3]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Hals-, Nasen- und Ohrenheilkunde; Interdisziplinäres Zentrum für Riechen und Schmecken, Dresden, Deutschland

### Objective

The study aimed to analyze the impact of driver mutations and image characteristics of olfactory groove meningioma (OGM) on preoperative olfactory function.

### Methods

Next-generation sequencing was performed in 22 patients with OGM to define the most frequent OGM driver mutations. Tumor morphology, obtained from preoperative imaging and olfactory function was assessed preoperatively with Sniffin' Sticks.

### Results

Among the 22 OGM patients, 46% had SMO/SUFU mutations, 32% had AKT1 mutations and 23% were AKT1-/SMO-wild-type (WT). Planum hyperostosis was notably present in 75% of patients, with varying rates among mutational groups (AKT1: 42%, SMO/SUFU: 90%, WT: 100%) ($p = .048$)). Median tumor volume for all patients was 25 cm³ (25[2-48] cm3). Tumor volume differed significantly among mutational groups ($p = .038$), particularly between SMO/SUFU and WT OGMs ($p = .005$). Regression analysis indicated that planum hyperostosis had a negative impact on olfaction, affecting odor threshold ($p = .001$), discrimination ($p = .008$), identification ($p < .001$) and the overall olfactory score ($p = .003$). Age over 65 ($p = .037$) and male gender ($p = .019$) were predictive factors for odor threshold and discrimination.

### Conclusion

This study reveals the links between imaging, clinical, and mutational factors and preoperative olfaction in OGM patients. Planum sphenoidale hyperostosis, perifocal edema, osseous enhancement, and gender may serve as predictive indicators of preoperative olfactory function. While OGM volume differed significantly across mutational groups, no statistically significant association was found between different mutations and olfactory subtests likely due to the limited cohort size.

# RC039

## Exoskop versus Mikroskop in der transsphenoidalen Chirurgie bei Sellar-/Suprasellarmeningeom: eine retrospektive, monozentrische Studie an 58 Patienten

***Exoscope versus microscope in transsphenoidal surgery for sellar/suprasellar meningeoma: A retrospective single-center study on 58 patients***

A. Ryba[1], P. Sumislawski[2], J. Flitsch[1], R. Rotermund[3]

[1]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland
[3]Diako Krankenhaus, Flensburg, Neurochirurgie, Flensburg, Deutschland

### Objective

Meningiomas situated within the sellar region are commonly managed through transsphenoidal approaches, involving microscopic and endoscopic techniques. Recently, our institution has introduced a novel strategy using 4K 3D orbital camera system (Orbeye, Olympus) for exoscopic transsphenoidal procedures. To date, no study has yet provided validation for the efficacy of this method in resecting tuberculum sellae meningioma (TSM).

### Methods

In this study, a total of n=58 histologically confirmed TSM, who underwent transsphenoidal surgery between 2013 and 2022 were included. Assessed parameters included surgical duration, duration of hospitalization, postoperative complications (SIADH, diabetes insipidus, CSF leak, visual impairment) and rate of recurrence to compare the outcomes of exoscopic transsphenoidal surgery (ExTS) with microscopic transsphenoidal surgery (MTS).

### Results

We identified a total of n=58 patients with confirmed TSM, that underwent transsphenoidal surgery at our institution. Out of these, MTS was performed in 71.9% (n=41) and ExTS in 28.1% (n=16). Both groups showed comparable output characteristics including gender distribution, initial tumor volume and occurrence of preoperative deficits. Mean age at diagnosis was 55.26±17.97 years. A notable female predominance was observed (Female to male ratio 4.2:1). ExTS depicted a significantly shorter surgical duration (116.0+43.29 vs 147.3+63.28 minutes, p=0.038). Postoperative complications, including diabetes insipidus, SIADH, CSF leak, hypopituitarism and visual impairment did not significantly differ between MTS and ExTS cohorts. MTS and ExTS showed similar recurrence rates (36.6% vs. 23.5%, p=0.3775).

### Conclusion

Overall, both ExTS and MTS exhibited comparable outcomes in terms of postoperative complications and recurrence rates. Nonetheless, this study revealed that MTS was associated with a significantly longer surgical duration.

# Rapid communication – Tumor 2 | Rapid communication – Tumour 2

## RC040

### Entzündung in Rezidiv-Vestibularisschwannomen.
*Inflammation in recurrent vestibular schwannomas*

F. Behling[1], L. Dörner[1], V. Goncalves[2], V. Ries[1], E. M. Suhm[1], J. Schittenhelm[3], M. Tatagiba[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]University of Porto, Faculty of Medicine, Porto, Portugal
[3]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland

#### Objective

The microsurgical resection of recurrent vestibular schwannomas (VS) is challenging. Prior surgical resection or radiation therapy can supposedly lead to scarring in the cerebellopontine angle and lead to adhesions to neurovascular structures making a re-resection difficult. Based on the increasing knowledge about inflammatory processes in vestibular schwannomas, it is of interest to gain more knowledge about inflammation in recurrent vestibular schwannomas.

#### Methods

We analyzed immunohistochemical inflammatory markers in 1266 vestibular schwannomas, including the macrophage markers CD68 and CD163, the lymphocyte markers CD3 and CD8, the inflammatory markers COX2 and the proliferation marker MIB1.

Clinical data such as age, gender and prior treatment were collected via an electronic patient file review.

#### Results

In 41 cases raidation therapy was done prior to tumor recurrence (3.2%). These tumors showed no difference in MIB1 expression (p=0.2377) but a higher score for COX2 expression (p=0.0008) compared to primary VS. Infiltration with M2-macropahges was higher (CD68 and CD163; p=0.0348 and p<0.0001, respectively), while there was no difference in lymphocyte infiltration (CD3 and CD8; p=0.9562 and p=0.8146, respectively). Sixty-six tumors were resected after prior surgery (5.2%). The tissue of these tumors did not show any difference in MIB1-expression (p=0.6694), COX2-expression (p=0.8877), macrophage infitration (CD68 and CD163; p=0.2565 and p=0.1811, respectively) or lymphocyte infiltration (CD3 and CD8; p=0.3910 and p=0.2211), opposed to primary VS.

#### Conclusion

Recurrent VS after radiation therapy is associated with increased immunohistochemical signs of inflammation.

# Rapid communication – Tumor 2 | Rapid communication – Tumour 2

## RC041

### Perioperativer Distress bei Patient:innen mit intrakraniellen Tumoren: Eine Single-Center Studie
***Peri-operative psychological distress in patients with intracranial tumors: A single center study***

J. Kasper[1], E. Güresir[1], M. K. Fehrenbach[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

#### Objective

Patients with brain tumors experience high psychological distress which negatively affects tumor treatment and survival prognosis. The Distress Thermometer (DT) was adopted to reliably evaluate distress in neuro-oncology on a scale from 1 to 10. DT values above 5 to 6 indicate major distress and should initiate psycho(onco)logical supportive care. However, data about peri-operative distress is scarce. Hence, we evaluated peri-operative distress levels in a neurosurgical patient cohort with various intracranial tumors using the DT.

#### Methods

We conducted a retrospective study including inpatients with brain tumors who underwent surgery in our department between October 2015 and December 2019. Patients were routinely assessed for distress using the DT before or after initial surgery. Baseline data as well as tumor histopathology, Neurological Performance Score (NPS) and clinical performance via KPS were also reviewed. A comparative analysis was performed via Wilcoxon rank-sum test.

#### Results

254 patients were eligible (69 with WHO 1 tumors, 22 with WHO 2, 17 with WHO 3, 68 with WHO 4, 60 with brain metastasis, 12 with CNS lymphoma and 6 with other central nervous system tumors). Mean DT value of the entire cohort was 5.38±2.39. 44.5% (n=114) of all patients exceeded DT values of ≥6. In our cohort, poor post-operative neurological performance and occurrence of motor deficits were significantly associated with major distress. When analysed for peri-operative changes, DT values significantly declined within the male sub-cohort (6.0 to 4.6, p=0.0033) after surgery but remained high for the entire cohort (5.7 and 5.3, p=0.1407). Sub-cohort analysis for other clinical factors revealed no further significant changes in peri-operative distress.

#### Conclusion

Distress levels were high across the entire cohort which indicates a high need for psychological support. Motor deficits and poor post-operative neurological performance were significantly associated with DT values above 6. Distress levels showed little peri-operative variation but decreased significantly within the male sub-cohort.

# RC042

## Die Auswirkung der Tumorelongation auf das Ergebnis des Nervus Facialis nach der Operation von Vestibularisschwannomen der Koos-Grade 3 und 4 in halbsitzender Lagerung über den retrosigmoidalen Zugang

***The impact of tumor elongation on facial nerve outcome after surgery for Koos grades 3 and 4 vestibular schwannomas in the semi-sitting position via the retrosigmoid approach***

F. Glieme[1], L. Haddad[1], F. Arlt[1], M. Vychopen[1], E. Güresir[1], J. Wach[1]

[1]Universitätsklinikum Leipzig, Leipzig, Deutschland

### Objective

Facial nerve paralysis is a significant and debilitating condition that can arise following surgery for vestibular schwannoma (VS). This study aims to assess the outcomes of facial nerve function by considering various factors such as shape features, extent of resection, baseline tumor volume, and patient-specific characteristics.

### Methods

We analyzed 120 sporadic VS patients who underwent surgery in our center from 2012 to 2022. 61 patients were included in the analysis. Inclusion criteria were primary tumor, Koos grade 3 or 4, and available imaging data for radiomic analysis. All included cases were treated in the semi-sitting position via the retrosigmoid approach. Radiomic tumor shape features (elongation, flatness, sphericity), pre- and postoperative tumor volumes, and extent of resection (%) were assessed using 3D Slicer (Version 5.2.1, Surgical Planning Laboratory, Harvard University, USA). Primary endpoint was the facial nerve outcome (FNO) at 3-months after VS surgery. FNO was dichotomized into "good" (House-Brackmann (HB) score ≤2) and "poor" (HB>2).

### Results

Poor FNO was observed in 11 patients (18.0%) at 3-months after VS surgery. Radiomic tumor shape features were analyzed and the AUC of elongation in the prediction of a poor HB at 3-months was 0.70 (95% CI: 0.56-0.85, $p$=0.03) and the optimum threshold value (≤/>0.35) yielded a sensitivity and specificity of 64.0% and 75.4%, respectively. Multivariable logistic regression analyses considering extent of resection (0.35) revealed that more elongated VSs (≤0.35, OR: 5.8, 95%CI: 1.2-28.2, $p$=0.03) and those with an increased EoR (≥93.4%, OR: 6.5, 95%CI: 1.0-42.5, $p$=0.05) are independently associated with poorer FNO at 3-months after surgery.

### Conclusion

Highly elongated VS shape seem to be a risk factor for worsened facial nerve outcome at 3-months after surgery for Koos grade 3 and 4 tumors. A surgical policy of near total resection might be superior to gross total resection regarding facial nerve preservation in those cases with an elongated tumor shape.

# RC043

## Entschlüsselung der räumlich-zeitlichen Entwicklung von Glioblastomen unter Therapie durch erklärbare künstliche Intelligenz

***Unravelling spatiotemporal evolution of glioblastoma under therapy through explainable artificial intelligence***

J. Kückelhaus[1], N. Neidert[2,3,4], J. Beck[2,3], O. Schnell[1], D. H. Heiland[1,2,3,4]

[1]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Klinik für Neurochirurgie, Erlangen, Deutschland
[2]Albert-Ludwigs-Universität Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[3]CAST Center for Advanced Surgical Tissue analysis, Medical Center and Faculty of Medicine, Freiburg i. Br., Deutschland
[4]MILO Microenvironment and Immunology Research Laboratory, Medical Center and Faculty of Medicine, Freiburg i. Br., Deutschland

### Objective

Advancements in single cell genomics have led to improved understanding of cellular plasticity and evolution in gliomas over the course of the disease. However, the reorganization of the tumor architecture and cellular interactions within the tumor microenvironment during therapy remains elusive. To address this knowledge gap, we employed spatially resolved multi-omic technologies on glioma from various treatment modalities and timepoints.

### Methods

We performed an analysis on 134 glioblastoma samples using Visium spatial transcriptomics and MERFISH in-situ sequencing on 78 patients. The study included low- and high-grade tumors, with 53 recurrent cases and 21 primary-recurrent pairs. Patients had undergone treatments like radio-chemotherapy (STUPP +/- Tumor Treating Fields), immunotherapy, and targeted therapy. Graph-neural networks were trained on spatial subgraphs to detect recurrent tumors and their treatment modalities, offering insights into modality-specific biological changes in recurrent samples.

### Results

Our 10-fold cross-validation process achieved an 85.52% accuracy rate in distinguishing between primary and recurrent tumor samples based on spatial subgraphs. Utilizing this model, we conducted in-silico perturbations by altering the tumor and its surrounding microenvironment, either by removing or adjusting cellular neighborhoods. This simulation confirmed recent findings that an increased presence of T cells and macrophages is associated with tumor recurrence. Additionally, we observed a higher abundance of oligodendrocytes and neurons in recurrent tumors. Post-immunotherapy analysis revealed a significant alteration in the tumor microenvironment, characterized by anti-inflammatory responses from myeloid cells and an increased presence of B cells and regulatory T cells. This shift led to a notable dysfunction in CD8 T cells.

### Conclusion

Graph-neural networks demonstrate the ability to distinguish between primary and recurrent tumors using spatial transcriptomic data. By providing a spatial perspective on glioma evolution through both descriptive and predictive models, these networks promise to significantly improve the accuracy of decision-making in precision oncology in the future.

# Rapid communication – Tumor 2 | Rapid communication – Tumour 2

## RC044

### Ein- versus zweizeitige Resektion von großen Meningeomen der vorderen Schädelbasis mit großem, bihemisphärischen Ödem

***Single-stage versus two-stage resection for large anterior midline skull base meningiomas with bihemispheric peritumoral edema***

L. E. Qasem[1], A. Al-Hilou[1], V. Prinz[1], D. Jussen[1], G. Marquardt[1], M. Czabanka[1]

[1]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland

#### Objective

Microsurgical resection of large midline meningiomas of the anterior skull base with bihemispheric peritumoral edema is characterized by an increased risk profile due neurovascular conflicts and postoperative edema decompensation leading to increased intracranial pressure. Craniectomy allows treatment of intracranial pressure but requires secondary cranioplasty. The aim was to compare a single-stage osteoplastic craniotomy followed by microsurgical tumor resection with a two-stage approach using bifrontal craniectomy, tumor resection, and subsequent cranioplasty after edema recovery.

#### Methods

Patients with anterior midline skull base meningiomas were included in the study. All patients underwent microsurgical resection. The final analysis included patients with large tumors (diameter > 50 mm) and bihemispheric peritumoral edema greater than the tumor diameter. Group 1 patients underwent single-stage tumor resection with osteoplastic craniotomy and served as the historical control. Group 2 patients were treated with a two-stage approach of bifrontal craniectomy, tumor resection, and subsequent cranioplasty in a second surgical step and were collected in a prospective series. All data were analyzed retrospectively. The primary outcome measure was the Karnofsky Performance Scale (KPS) at 3 months after surgery. Preoperative KPS, KPS at discharge and at last date seen, as well as intensive care unit (ICU) stay, elective mechanical ventilation, length of hospital stay, and complication rate were also analyzed. Statistical comparisons were made using the Mann-Whitney u test.

#### Results

There were no differences in baseline patient characteristics, including mean age, tumor size, and extent of peritumoral edema. KPS at 3 months after surgery was significantly improved in Group 2 (73% vs. 49%; p=0.0288) with a non-significant reduction in ICU stay (8 vs. 10 days; p=0.9001). The length of hospital stay was not significantly longer in Group 2 patients (24 vs. 17 days; p=0.1916). The complication rate was comparable between Group 1 and Group 2 patients (67% vs. 56%; p=0.6274).

#### Conclusion

Two-stage resection of large anterior midline skull base meningiomas with significant peritumoral edema demonstrates improved clinical outcomes compared to a historical single-stage resection control group in a highly selected patient population and non-randomized study design.

# RC045

## Ergebnisse der chirurgischen Behandlung von MESCC (metastatische epidurale Rückenmarkskompression) bei 175 Patienten: Single-Center-Erfahrung

***Outcome of surgical treatment for MESCC (metastatic epidural spinal cord compression) in 175 patients: A single-center retrospective study***

M. Pojskic[1], M. Bopp[2], S. Wilke[2], C. Nimsky[2], B. Saß[1]

[1]Universitätsklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Philipps-Universität Marburg, Klinik für Neurochirurgie, Marburg, Deutschland

### Objective

The aims of this single-center retrospective study were to assess the surgical results and survival of surgically treated patients affected by metastatic epidural spinal cord compression (MESCC) and identify any factors related to favorable outcome and better survival rate.

### Methods

All patients who underwent surgery for spine metastases at our Department in period 2018-2022 were included in the study. Patient data were evaluated retrospectively.

### Results

175 patients (71 female, median age 67.15, age range 29-90 years) were included in the study. Most common primary tumor was lung carcinoma (n=31), prostate (n=31), breast carcinoma (n=28), multiple myeloma (n=25), clear cell renal carcinoma (n=11) and rest (n=49). In 56 patients spinal metastasis was the initial symptom which led to diagnosis of the primary tumor. ECOG-performace status was 0 in 7 patients, 1 in 97, 2 in 27, 3 in 17 and 4 in 27. Average time from beginning of symptoms to diagnosis was 75 days. In 24 cases tumor was located in cervical spine, in 89 in thoracic, in 37 in lumbar and in rest in two regions of the spine at the same time. In 108 patients pathological fracture was present. In 42 patients only decompression was performed, in 133 additional instrumentation surgery, 23 patients underwent vertebral body replacement with implant. Most common complications were wound healing deficits (n=14, 8%) and hardware failure (n=14, 8%). 89 patients (50.85%) had motor deficits prior to surgery. In terms of pain and neurological deficits, 122 patients improved, 43 were unchanged and 10 deteriorated. Average readmission free survival was 283.74 days and average overall survival was 425.23 days. Tomita score<7, Frankel score A-C, ECOG 0-1, modified Tokuhashi score>10, were found to be significant favorable prognostic factors ($p<0.01$).

### Conclusion

The majority of patients, undergoing decompression and/or stabilization for metastatic spinal tumors, have profited from surgical therapy in terms of pain and reversal of neurological deficits and overall survival.

# RC046

## Einfluss der regionalen Radonkonzentration auf Glioblastompatienten: Ergebnisse einer 10jährigen monozentrischen retrospektiven Studie

***Regional radon concentration impact on glioblastoma patients: Findings from a 10 years monocentric retrospective analysis***

F. Bellingrodt Velázquez[1], T. Juratli[2], D. Krex[1], I. Y. Eyüpoglu[1], W. H. Polanski[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland

### Objective

Elevated residential Radon-222 concentration (RRC) is known to influence the incidence of not only lung cancer but also central nervous system tumors. There may be a relationship between a specific range of Radon exposure and the incidence of Glioblastoma (GBM).

### Methods

To assess whether a particular RRC poses a risk for the development of GBM, we gathered patient demographics, histological findings, gene mutations, survival time, and RRC data (provided by Geoportal from the Federal Office for Radiation Protection).

### Results

A total of 4435 patient files were reviewed, and 836 patients with diagnosed IDH-negative GBM WHO-Grade 4 tumors who underwent Tumor Resection or Biopsy between January 2012 and December 2022 were analyzed. The last follow-up was conducted on December 31, 2023. The median age was 66.76 years (Standard Deviation(SD) 13.64 years, range 3.2-92.3 years), with 57.1% being male. The study divided participants into four groups based on their exposure to radiation levels, which was measured in kilobecquerels per cubic meter (kBq/m3). Group 1 (0-40kBq/m3 – 151 participants (pts)), Group 2 (41-75kBq/m3 – 306 pts), Group 3 (76-111kBq/m3 – 200 pts), and Group 4 (>111kBq/m3 – 179 pts). The Pearson chi-square test indicated that gender and MGMT status were equally distributed across all groups (0.833 and 0.939 respectively). The mean age of pts in Group 1 was 63.54 years (SD 14.29 – ranging from 3.2 to 86.3 years), while Group 2 had a mean age of 67.52 years (SD 14.28 – ranging from 9.2 to 87.2 years). Groups 3 and 4 had a mean age of 68.44 years (SD 12.49, range 25.3 to 92.39) and 65.26 years (SD 12.94, range 12.1 to 87.5 years), respectively. Group 1 showed a mean survival time (MST) of 19.37 months in the first 60 months after diagnosis, whereas Group 2 had an MST of 14.87 months. Using Wilcoxon paired comparison, we found that patients in Group 1 had a significantly longer MST than those in Group 2 (p=0.024). Additionally, patients in Group 1 were younger (mean age 63.54 years) compared to the other groups.

### Conclusion

Our findings indicates a significant correlation between lower residential Radon-222 concentrations (>40kBq/m3) and reduced mean survival time in GBM patients. The reason for this association remains unclear. It may be that there is a lower threshold for tumor induction of gliomas compared to other known malignancies. Therefore, we suggest further investigations to explore this specific aspect in upcoming studies.

## RC047

### Monitoring von semantischer Assoziation in Hirntumorpatienten mit Kategoriebenennung/-beschreibung: Anatomische Korrelate und intraoperative Machbarkeit

***Monitoring semantic association in brain tumour patients using category naming/description: Anatomical correlates and intraoperative feasibility***

M. Becker[1], C. Tampier[1], P. Keil[1], R. Loução[1], J. Pieczewski[1], M. Timmer[1], J. A. Hampl[1], C. Kabbasch[2], K. Jonas[3], R. Goldbrunner[1], C. Weiß Lucas[1]

[1]University Hospital of Cologne, Center of Neurosurgery, Köln, Deutschland
[2]University Hospital of Cologne, Institute of Diagnostic and Interventional Radiology, Köln, Deutschland
[3]University of Cologne, Department of Special Education and Rehabilitation, Köln, Deutschland

#### Objective

Most tools for intraoperative speech mapping and monitoring are based on picture/ verb naming tests or biographical speech. However these tests do not capture the ability of contextual association reliably, which is critical to communication. Semantic association tasks like the pyramid and palm tree test (PPTT) are a promising option but, yet, there is little evidence regarding the suitability of different task instructions to depict dysfunction in distinct parts of the semantic network, and the respective functional network correlates. Therefore, we investigated the robustness, functional-anatomical correlation and intraoperative feasibility of a PPTT adaptation with different instruction types.

#### Methods

42 images were composed of one reference object on top and two choice objects below (triplet format), taken from the Cologne Naming Test (CoNaT). The task consisted in the forced choice/association of the semantically associated pair. Three instruction types were tested: (a) semantic choice via button-press, (b) overt naming of the semantically related object, and (c) overt naming or description of the common semantic category or description. First, the influence of the instruction type on response robustness and delay as well as on the functional cortex activations were investigated via video-based online interviews in 24 healthy adults stratified by age and gender and task-related fMRI (3T, clustered sparse acquisition; SPM 12) in 20 subjects. Thereafter, clinical feasibility was tested before and during awake surgery monitoring of glioma patients. The corresponding functional-anatomical regions were used as origin regions for tractography.

#### Results

Results showed an association of age with latency, particularly the older group ($p<0.005$). Moreover, a significant impact of gender and age on difficulty and total test time was observed ($p<0.001$). Interim fMRI data showed mainly left-hemispheric activations, similar to non-verbal semantic tasks (middle and inferior frontal gyrus, anterior superior temporal gyrus; MFG, IFG, aSTG). Comparing the instruction conditions, overt category naming led to the most comprehensive activation patterns, notably extending to the frontal association network, and proved well-feasible in the clinical context.

#### Conclusion

Semantic association tasks, and category naming instructions in particular, are a promising tool for intraoperative monitoring and mapping of communication functions, especially for tumours involving the left MFG/IFG and the aSTG.

# RC048

## Das Verhältnis des präoperativen Volumens der Hirnventrikel zum gesamten Gehirnvolumen ermöglicht die Vorhersage der postoperativen Abhängigkeit von einem VP-Shunt nach der Operation eines sporadischen Vestibularisschwannoms

***The ratio of baseline ventricle volume to total brain volume predicts postoperative VP-shunt dependency after sporadic vestibular schwannoma surgery***

L. Haddad[1], F. Glieme[1], F. Arlt[1], M. Vychopen[1], E. Güresir[1], J. Wach[1]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland

### Objective

Obstructive hydrocephalus (HCP) linked to vestibular schwannoma (VS) typically arises in giant VS. It is anticipated that symptoms associated with HCP will improve following the removal of the tumor. Nonetheless, a subset of patients may necessitate ongoing ventriculo-peritoneal (VP) surgery. This investigation aims to identify the factors linked to the need for CSF diversion after VS surgery in instances of persistent HCP.

### Methods

We analyzed 120 sporadic VS patients who underwent surgery in our center from 2012 to 2022. 71 sporadic VS patients who underwent surgery in our center from 2012 to 2022. Koos grade 2, 3, and 4 tumors were included in the analysis. Volumetric MRI analyses of the pre- and postoperative tumor volumes, extent of resection (%), cerebellum, cerebrum, ventricle, and brainstem were performed using Brainlab Smartbrush and 3D Slicer. Total brain volume was defined as the sum of cerebrum, cerebellum and brainstem. ROC analyses were performed to identify optimum cut-off values of the volumetric data.

### Results

Permanent CSF diversion after surgery was indicated in 12 patients (16.9%). The ratio of baseline volume fraction of brain ventricles to total brain volume volume (VTB-ratio) was found to predict postoperative VP-shunt dependency. The AUC was 0.71 (95% CI: 0.51-0.91) and the optimum threshold value (p=0.047) and an EoR (<96.4%, OR: 9.1, 95%CI: 1.2-69.3, *p*=0.032) are independently associated with postoperative VP-shunt dependency.

### Conclusion

Primary tumor removal remains the optimal treatment to reduce the risk of postoperative hydrocephalus necessitating VP-shunt surgery. However, patients with an increased preoperative ratio of brain ventricle volume – to – total brain volume are prone to need postoperative VP-shunt surgery and may benefit from perioperative EVD placement.

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC049

### Intraindividuelle Hormonrezeptorheterogenität bei Patienten mit Hirnmetastasen vom Ursprung des Mammakarzinoms: Der Hinzugewinn von Her2 neu bei der Hirnmetastase korreliert mit einem schlechteren Gesamtüberleben

***Intraindividual hormone receptor heterogeneity in patients with brain metastasis from breast cancer: Gain of Her2 receptor from primary tumor to brain metastasis correlates to worsened survival***

M. Heimann[1], A. L. Potthoff[1], L. L. Friker[2], V. Borger[1], P. Schuss[1], U. Herrlinger[3], H. Vatter[1], K. Kuchelmeister[2], M. Schneider[1]

[1]University Hospital Bonn, Department of Neurosurgery, Bonn, Deutschland
[2]University Hospital Bonn, Department of Neuropathology, Bonn, Deutschland
[3]University Hospital Bonn, Division of Clinical Neuro-Oncology, Department of Neurology, Bonn, Deutschland

#### Objective

Deciphering the dynamics of intraindividual tumor heterogeneity is supposed to more precisely predict long-term outcome in patients with advanced stages of cancer. In patients with brain metastasis (BM) from breast cancer (BC), intraindividual tumor heterogeneity is partly driven by hormone receptor conversion between the tumor of primary site and the BM. The aim of the present study was to evaluate the prognostic impact of hormone receptor conversion in patients that had undergone surgery for BM from BC.

#### Methods

Between 2013 and 2019, 42 patients were surgically treated for BM derived from BC at the authors neuro-oncological center. Tumor receptor status (estrogen receptor (ER), progesterone receptor (PR) and Her2/neu) was assessed histopathologically for the tumor of primary site and the BM. A multivariable analysis was performed in order to identify predictors of worsened survival.

#### Results

Median overall survival for the entire study cohort was 17 months. Overall, hormone receptor conversion was found in 15 of 42 patients (36%). Loss of ER and PR was present in 8 of 42 patients (19%), respectively. Gain of Her2/neu was present in 7 patients (17%). Multivariable analysis revealed gain of Her2/neu as an independent negative prognostic predictor for increased one-year mortality (Odds ratio 0.1, 95% confidence interval 0.01-0.7, p=0.027).

#### Conclusion

The present study indicates that gain of HER2/neu from tumor of primary site to BM is associated with elevated one-year mortality rates and worsened overall survival in patients with BM derived from BC.

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC051

### Prädiktiver Wert der intrakraniellen PD-L1-Expression in resezierten NSCLC-Hirnmetatasen-Patienten und postoperativer Immuncheckpoint-Inhibition

***Predictive role of intracranial PD-L1 expression in a real-world cohort of NSCLC patients treated with immune checkpoint inhibition following brain metastasis resection***

D. Wasilewski[1,2,3], J. S. Onken[1,4,2,3], P. Höricke[5], J. Bukatz[1], S. Murad[1], A. Früh[1,4], Z. Shaked[1], M. Misch[1,2], A. Kühl[4], O. Klein[4], F. Ehret[6], D. Kaul[6], A. Radbruch[7], D. Capper[4,7,3], P. Vajkoczy[1,2], D. Horst[2,3,5], N. Frost[2,8], P. Bischoff[4,3,5]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Charité Comprehensive Cancer Center, Berlin, Deutschland
[3]German Cancer Consortium (DKTK), Berlin, Deutschland
[4]BIH – Berlin Institute of Health, Berlin Institute of Health (BIH) Charité, Berlin, Deutschland
[5]Charité – Universitätsmedizin Berlin, Institut für Pathologie, Berlin, Deutschland
[6]Charité – Universitätsmedizin Berlin, Klinik für Radioonkologie und Strahlentherapie, Berlin, Deutschland
[7]Charité – Universitätsmedizin Berlin, Institut für Neuropathologie, Berlin, Deutschland
[8]Charité – Universitätsmedizin Berlin, Klinik für Infektiologie und Pneumologie, Berlin, Deutschland

#### Objective

Emerging evidence suggests that treatment of NSCLC brain metastases with immune checkpoint inhibitors (ICIs) is associated with response rates similar to those of extracranial disease. Programmed death-ligand 1 (PD-L1) tumor proportion score (TPS) serves as a predictive biomarker for ICI response. However, the predictive value of brain metastasis-specific (intracranial) PD-L1 TPS is not established. We investigated the role of intra- and extracranial PD-L1 TPS in NSCLC patients treated with ICI following brain metastasis resection.

#### Methods

Clinical data from NSCLC patients treated with ICI following brain metastasis resection (n=64) were analyzed. PD-L1 TPS of brain metastases (n=64) and available matched extracranial tumor tissue (n=44) were assessed via immunohistochemistry. Statistical analyses included cut point estimation via maximally selected rank statistics, Kaplan-Meier estimates, and multivariable Cox regression analysis for intracranial progression-free survival (icPFS), extracranial progression-free survival (ecPFS), and overall survival (OS).

#### Results

PD-L1 expression was found in 54.7% of brain metastases and 68.2% of extracranial tumor tissues, with a median intra- and extracranial PD-L1 TPS of 7.5% (0-50%, IQR) and 15.0% (0-80%, IQR), respectively. In matched tissue samples, extracranial PD-L1 TPS was significantly higher than intracranial PD-L1 TPS (p=0.013). Patients with a high intracranial PD-L1 TPS of >40% exhibited significantly longer icPFS as compared to patients with a low intracranial PD-L1 TPS of ≤40%. Intracranial PD-L1 TPS was independently associated with OS, icPFS and ecPFS in multivariable analyses.

#### Conclusion

Our study highlights the potential role of intracranial PD-L1 TPS in NSCLC, which could be used to predict ICI response in cases where extracranial tissue is not available for PD-L1 assessment as well as to specifically predict intracranial response.

Abb. 1

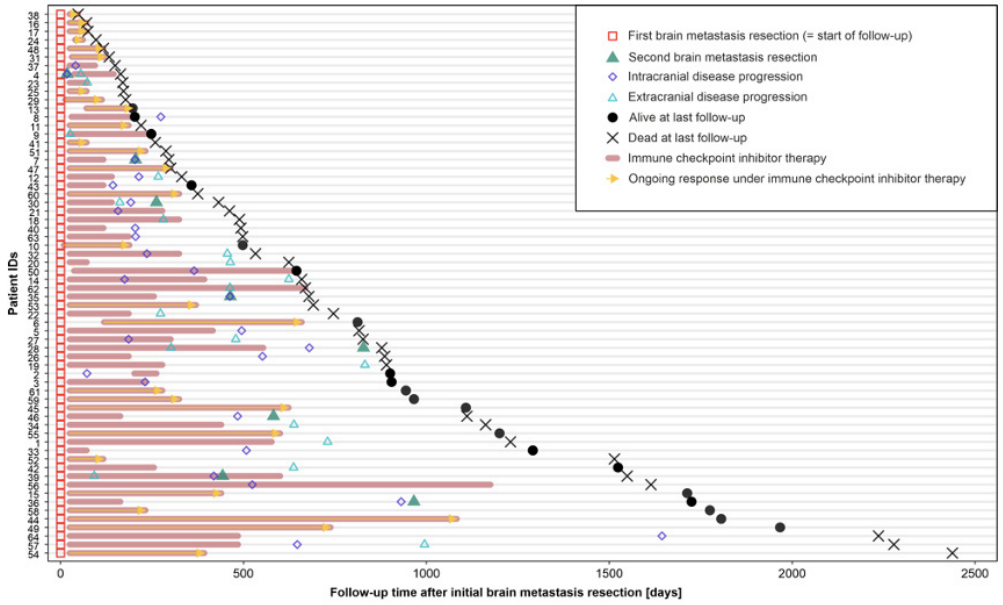
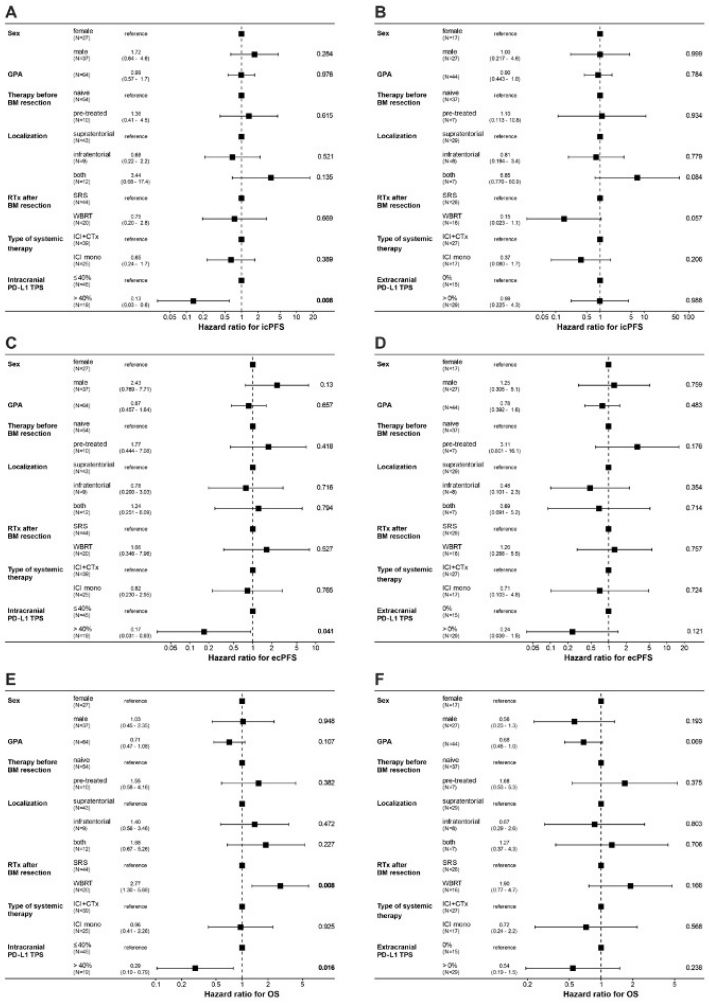

First brain metastasis resection (= start of follow-up)
Second brain metastasis resection
Intracranial disease progression
Extracranial disease progression
Alive at last follow-up
Dead at last follow-up
Immune checkpoint inhibitor therapy
Ongoing response under immune checkpoint inhibitor therapy
Patient IDs
0
500
1000
1500
2000
2500
Follow-up time after initial brain metastasis resection [days]

Abb. 2


A
B
C
D
E
F
Hazard ratio for icPFS
Hazard ratio for ecPFS
Hazard ratio for OS

# RC052

## Systemische und lokale Therapien vor und nach der Diagnose einer leptomeningealen Metastasierung bei Patienten mit Hirnmetastasen - eine explorative, unizentrische, retrospektive Kohortenstudie

***Systemic and local therapies before and after diagnosis of leptomeningeal disease in patients with brain metastases – An explorative, single-center retrospective cohort study***

D. Wasilewski[1,2,3], C. Eitner[3], Z. Shaked[3], J. A. Steinle[4], T. A. Sargut[3], A. Wetzel-Yalelis[3], C. Jelgersma[3], R. Mertens[3,5], J. Rösler[3], L. Wessels[3], D. Kronenberg[5,6], A. Kowski[6], H. Radbruch[7], F. Ehret[8], D. Kaul[8], N. Frost[9], J. S. Onken[1,2,3,5], U. Keller[1,2,5,10], U. Keilholz[1,2,5,10], J. Sehouli[1,5], P. Vajkoczy[1,3], M. Misch[1,3]

[1]Charité – Universitätsmedizin Berlin, Charité Comprehensive Cancer Center, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, German Cancer Consortium (DKTK), partner site Berlin, and German Cancer Research Center (DKFZ), Heidelberg, Germany, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland
[4]Charité – Universitätsmedizin Berlin, Department of Gynecology, Center for Oncological Surgery, Berlin, Deutschland
[5]BIH – Berlin Institute of Health, Berlin Institute of Health (BIH) Charité, Berlin, Deutschland
[6]BIH – Berlin Institute of Health, Department of Neurology, Berlin, Deutschland
[7]BIH – Berlin Institute of Health, Department of Neuropathology, Berlin, Deutschland
[8]BIH – Berlin Institute of Health, Department of Radiooncology, Berlin, Deutschland
[9]BIH – Berlin Institute of Health, Department of Infectious Diseases and Respiratory Medicine, Berlin, Deutschland
[10]BIH – Berlin Institute of Health, Department of Hematology, Oncology and Cancer Immunology, Berlin, Deutschland

### Objective

Leptomeningeal metastasis (LMD), the dissemination of cancer cells into leptomeninges and/or cerebrospinal fluid, is believed to increase in incidence due to improved survival of oncological patients. Real-world data on therapies before and after diagnosis of LMD in brain metastasis patients are still limited. We aimed to characterize local and systemic therapies before and after diagnosis of LMD in these patients.

### Methods

We included 120 patients (treated from 2012 to 2023) with underlying solid malignancy, presence of brain metastasis together with leptomeningeal spread, either confirmed by MRI, cerebrospinal fluid sampling, or both modalities. Data on demographics, radiological, and therapy-related characteristics were collected. Kaplan-Meier estimates and Cox model regression analysis were performed to identify factors associated with survival.

### Results

Breast cancer (35.8%), NSCLC (20.8%), melanomas (16.7%), and gastric cancer (5.7%) were among the most common entities. In 56% of cases, the diagnosis was made by MRI, in 5% by cerebrospinal fluid puncture (LP) alone, and in 39% by both MRI and LP. The median overall survival (OS) of the cohort was 2.77 months [95% CI: 2.27 – 4.20]. Patients who received systemic after diagnosis of LMD, either chemotherapy (n=26), targeted therapies (n=21) or checkpoint inhibitors (n=9) showed increase survival as compared to respective control patients. The only independent prognostic factors at diagnosis of LMD were presence of lung cancer (HR: 2.36 [95% CI: 1.28 – 4.4], p=0.006) and melanoma (HR: 2.30 [95% CI: 1.27 – 4.2], p=0.006). Local or systemic treatment modalities before LMD diagnosis were not associated with survival.

### Conclusion

This study provides insights into the complex treatment modalities for LMD patients, both in terms of prior therapies and therapies after diagnosis of LMD. These results underscore the need for large prospective multi-center registries and interventional studies to further improve interdisciplinary and personalized therapy for these patients.

Abb. 1

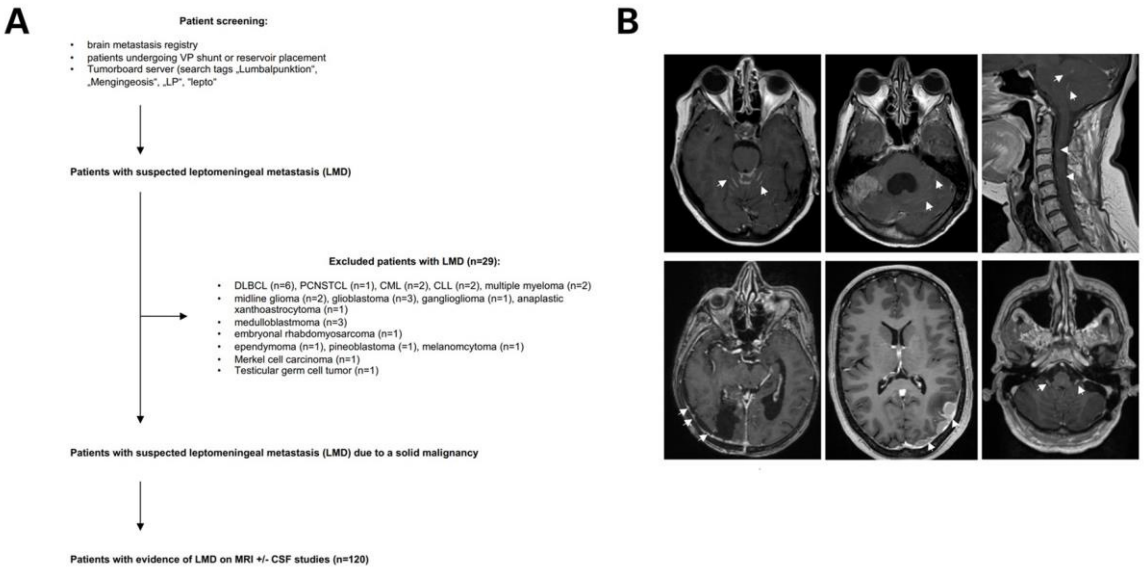
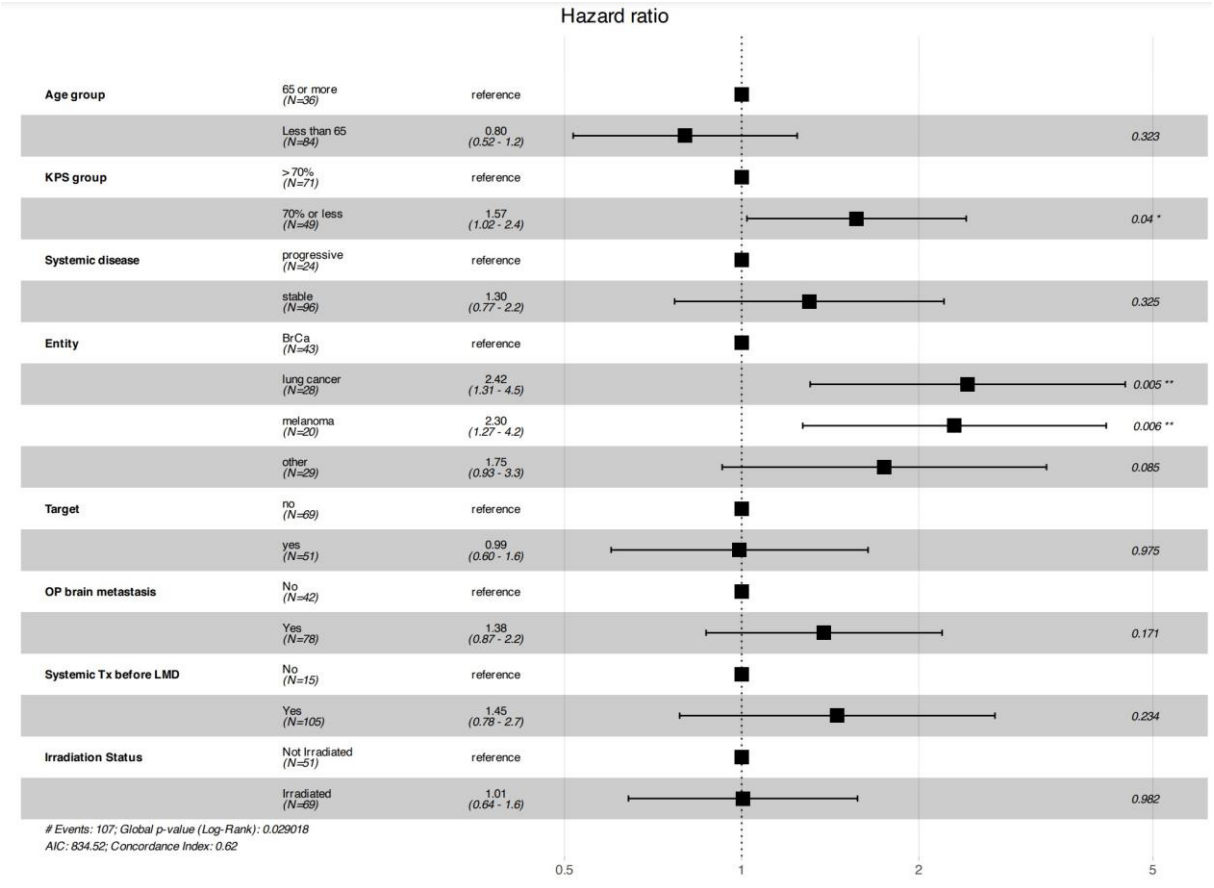

A
Patient screening:
brain metastasis registry
patients undergoing VP shunt or reservoir placement
Tumorboard server (search tags „Lumbalpunktion", „Mengingeosis", „LP", "lepto"
Patients with suspected leptomeningeal metastasis (LMD)
Excluded patients with LMD (n=29):
DLBCL (n=6), PCNSTCL (n=1), CML (n=2), CLL (n=2), multiple myeloma (n=2)
midline glioma (n=2), glioblastoma (n=3), ganglioglioma (n=1), anaplastic xanthoastrocytoma (n=1)
medulloblastmoma (n=3)
embryonal rhabdomyosarcoma (n=1)
ependymoma (n=1), pineoblastoma (=1), melanomcytoma (n=1)
Merkel cell carcinoma (n=1)
Testicular germ cell tumor (n=1)
Patients with suspected leptomeningeal metastasis (LMD) due to a solid malignancy
Patients with evidence of LMD on MRI +/- CSF studies (n=120)
B

Abb. 2


Hazard ratio
Age group
65 or more (N=36) reference
Less than 65 (N=84) 0.80 (0.52 - 1.2) 0.323
KPS group
> 70% (N=71) reference
70% or less (N=49) 1.57 (1.02 - 2.4) 0.04 *
Systemic disease
progressive (N=24) reference
stable (N=96) 1.30 (0.77 - 2.2) 0.325
Entity
BrCa (N=43) reference
lung cancer (N=28) 2.42 (1.31 - 4.5) 0.005 **
melanoma (N=20) 2.30 (1.27 - 4.2) 0.006 **
other (N=29) 1.75 (0.93 - 3.3) 0.085
Target
no (N=69) reference
yes (N=51) 0.99 (0.60 - 1.6) 0.975
OP brain metastasis
No (N=42) reference
Yes (N=78) 1.38 (0.87 - 2.2) 0.171
Systemic Tx before LMD
No (N=15) reference
Yes (N=105) 1.45 (0.78 - 2.7) 0.234
Irradiation Status
Not Irradiated (N=51) reference
Irradiated (N=69) 1.01 (0.64 - 1.6) 0.982
# Events: 107; Global p-value (Log-Rank): 0.029018
AIC: 834.52; Concordance Index: 0.62
0.5
1
2
5

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC054

### Perioperative Beobachtung von hämorrhagischen Hirnmetastasen
*Perioperative observation of hemorrhagic brain metastases*

L. Rauschenbach[1], P. Kolbe[1], A. Engel[1], M. Darkwah Oppong[1], A. N. Santos[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

In this study, we aimed to analyze the risk of spontaneous hemorrhagic events in brain metastases (BM) and to evaluate the safety of surgery on hemorrhagic BM.

#### Methods

Our institutional database was screened for patients with intracerebral metastases treated between 2016 and 2017. Among those, patients with intraoperative or postoperative hemorrhagic complications were identified. Imaging and clinical data were investigated. Uni- and multivariate analyses were performed to assess differences between hemorrhagic and non-hemorrhagic BM.

#### Results

A total of 229 patients were included. The incidence of metastasis-associated hemorrhage on preoperative imaging was high (23.6 %). For the whole cohort, melanoma (58.3 %) revealed the highest incidence of hemorrhage, and melanoma diagnosis was associated with tumor-related bleeding in univariate analysis (OR = 5.78, 95%CI = 2.39 – 13.95, p = 0.001). Moreover, poor clinical status, as measured by a KPS score of <70 (p = 0.001), and impaired prognosis, as measured by an RPA score of >2 (p = 0.001), were associated with a higher risk of bleeding events in the univariate analysis. Furthermore, larger metastases revealed a higher risk for tumor-associated hemorrhage (p = 0.044). Preoperative treatment with blood-thinning medications was not associated with the occurrence of tumor-associated bleeding (p = 0.426). Multivariate analysis confirmed that melanoma metastasis (p = 0.001), poor clinical status or impaired prognosis (p = 0.001), and large tumor volume (p = 0.020) were independent predictors of bleeding. Intraoperative investigation showed that hemorrhagic brain metastases did neither cause increased blood loss during surgery (p = 0.970) nor increased the length of surgery (p = 0.096). Postoperatively, hemorrhagic brain metastases were not more likely to result in rebleeding (p = 0.103) or even rebleeding that required revision (p = 0.396).

#### Conclusion

Different entities of BM are associated with the occurrence of spontaneous hemorrhages. Furthermore, low scores for clinical conditions and overall patient prognosis are related to the occurrence of bleeding events. However, preoperative use of blood-thinning medications does not appear to have an impact, and resection of hemorrhagic BM does not promote the occurrence of postoperative complications.

RC055

## Embolisation der Arteria meningea media als therapeutische Alternative zur operativen Therapie in Fällen von chronischen Subduralhämatomen – Erste Ergebnisse einer prospektiven Matching-Studie

***Middle meningeal artery embolization as an alternative to surgical treatment in chronic subdural hematoma – First results of a prospective matching-study***

J. Rediker[1], A. Michael[2], U. J. Knappe[1], C. Mönninghoff[2]

[1]Johannes Wesling Klinikum Minden, Klinik für Neurochirurgie, Minden, Deutschland
[2]Johannes Wesling Klinikum Minden, Universitätsinstitut für Radiologie, Neuroradiologie und Nuklearmedizin, Minden, Deutschland

### Objective

Chronic subdural hematoma (cSDH) is one of the most common diseases in neurosurgical practice with increasing incidence due to the ageing population, the rising use of antiplatelet or anticoagulant medications, and other factors. Neurosurgical treatment can be challenging regarding high recurrence rates and in cases of multimorbid patients. In the last years, endovascular embolization of the meningeal media artery (MMA) established more and more as a treatment option in cases of cSDH with small thickness or mild symptoms. The objective of this study is to compare clinical and radiological results of endovascular and surgical treatment.

### Methods

In this preleminary analysis of our single center study, the first 21 patients with cSDH and treatment by MMA embolization were prospectively included between April 2020 and September 2023. For the matching-group, 21 patients with surgical treatment were included as controls from a period in which MMA embolization was not available (before 2020). Controls were matched for age, gender, cSDH size, unilateral or bilateral occurence, and oral anticoagulation or antiplatelets medication. During follow-up, need for surgical rescue, complications of treatment, radiological development of cSDH in unenhanced CT scan, and development of clinical symptoms were recorded. Markwalder scale was used for grading the clinical status.

### Results

Patients (n=42) were between 53.0 and 94.0 years old (median 82.7), 66.7% were male and 33.3% were female. Most patients had mild symptoms scored as Markwalder grade 1 (61.9% of all patients; 66.7% of the embolization group and 57.1% of the surgical group). The number of surgical rescues is identical for MMA embolization and primary surgical treatment (6/21; 28.6% each). Regarding the complications, there is a tendency for reduction in complications with MMA embolization (1/21; 4.8% versus 3/21; 14.3%, p=0.606). Overall, primary treatment with MMA embolization reduces the total number of operations per patient ($p<0.001$).

### Conclusion

MMA embolization is a possible and at least equivalent alternative to primary surgery for cSDH treatment in patients with small hematomas or minor clinical symptoms. Especially for old and/or multimorbidid patients and patients with anticoagulation or antiplatelet medication, the endovascular therapy might offer some benefits.

# RC056

## Longitudinale angiographische Charakterisierung der vorbestehenden zerebralen Kollateralisierung und Neovaskularisation nach kombinierter Bypass-Operation bei Patienten mit Moyamoya-Angiopathie

***Longitudinal angiographic characterization of pre-existing cerebral collateralization and neovascularization after combined bypass-surgery in patients with Moyamoya Angiopathy***

R. Mertens[1,2], K. Lucia[3], K. Kersting[1], M. Stahnke[1], E. D. Sprünken[4], L. Mödl[4], G. Acker[1], P. Vajkoczy[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, BIH Charité Junior Clinician Scientist Program, Berlin, Deutschland
[3]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[4]Charité – Universitätsmedizin Berlin, Institut für Biometrie und Klinische Epidemiologie, Berlin, Deutschland

### Objective

Moyamoya angiopathy (MMA) is a cerebrovascular disease treated by surgical revascularization. The postoperative development of pre-existing collaterals has not been studied systematically before. Therefore, this study aimed to perform a postoperative longitudinal angiographic characterization of MMA collaterals, to investigate their dependency on bypass quality and Suzuki grades and to further investigate the association between direct and indirect bypass quality in Caucasian patients.

### Methods

We retrospectively identified angiographically verified MMA patients who were treated by combined surgical revascularization at our department and underwent at least one postoperative follow-up examination by digital subtraction angiography. Clinical and radiological data were analyzed, and correlations were calculated to investigate dependency and association between collaterals, bypass quality and Suzuki grades.

### Results

A total of 121 hemispheres from 81 patients were included in the study. The mean age was 41 ± 13.1 years (range 6 – 65 years) at the time of first surgery, including 58 women and 23 men. The proportion of pediatric patients (<18) was 4.9%. Ischemic events were the most common onset symptom (88.9%), followed by hemorrhage (11.1%). All hemispheres were treated by combined STA-MCA bypass and encephalodurosynangiosis (EDS). Postoperatively, collaterals within the anterior circulation showed a consistent reduction, whereas collaterals from and within the posterior circulation and extra-intracranial (EC-IC) collaterals showed less reduction and more increasement over time. Hemispheres with an increase of anterior collaterals were mainly Suzuki grade 1 and 2 hemispheres, whereas an increase of posterior collaterals and EC-IC collaterals was found in all Suzuki grades. STA-MCA and EDS bypass showed a synergistic qualitative development and pre-existing collaterals developed independent of bypass quality.

### Conclusion

Our study represents the first angiographic longitudinal characterization of pre-existing cerebral collaterals after combined bypass-surgery in Caucasian MMA patients. Anterior but not posterior collaterals showed a consistent reduction over time, and the synergistic development of direct and indirect bypasses as well as the development of pre-existing collaterals irrespective of bypass quality indicate the individual endogenous need of Moyamoya hemispheres as determining factor and highlight the enduring plasticity and dynamic nature of the MMA collateral system over time.

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC057

### Vaskuläres Risikoprofil und Veränderungen der arteriellen Hypertonie nach Revaskularisation bei erwachsenen Moyamoya-Patienten

***Vascular risk profile and changes of arterial hypertension after surgical revascularization in adult Moyamoya patients***

P. Haas[1,2], L. M. Wiggenhauser[1,2], J. Tellermann[1,2], H. Hurth[1,2], D. Feucht[1,2], M. Tatagiba[1], N. Khan[1,2,3], C. Roder[1,2]

[1]Universitätsklinikum Tübingen, Klinik für Neurochirurgie, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Zentrum für Moyamoya und cerebrale Revaskularisation, Tübingen, Deutschland
[3]Universitätskinderspital Zürich, Moyamoya Center, Zürich, Schweiz

#### Objective

Little is known about the vascular risk profile of adult patients with Moyamoya disease (MMD), especially regarding modifiable factors. This retrospective case-control study aims to examine the MMD collective of a single center regarding its vascular risk profile compared to the normal population. A specific focus was put on arterial hypertension (AHT) and possible blood-pressure changes after surgical revascularization, since this is not only a vascular risk factor, but also has a possible direct influence on patients' outcome due to their preexisting stenoocclusive cerebrovascular disease.

#### Methods

All adult MMD patients of our Moyamoya center were analyzed retrospectively for vascular risk factors. These data were subsequently compared with a reference population of a Germany-wide health monitoring program. After completion of all indicated surgical revascularizations needed, possible changes of patients' antihypertensive medication were analyzed at the 1-year postoperative follow-up as a surrogate marker for changes of the blood pressure.

#### Results

We have analyzed 133 adult Moyamoya patients and compared these with the data of more than 22.000 patients from the German Health Update database. MMD patients showed an age and sex-adjusted increased prevalence of AHT, especially in women between 30 and 44 years (p<.0001, OR 6.74), and patients of both genders between 45 and 64 years (women p=.0216, OR 2.06; men p=.0009, OR 4.30). Diabetes mellitus (DM) was diagnosed significantly more frequently in MMD patients with increasing age (45-60 years: women p=.0275, OR 2.76; men p=.0303, OR 2.87), whereas the vascular risk profile in terms of obesity, nicotine and alcohol consumption was similar to that of the normal population. Antihypertensive medication was changed one year after surgical revascularization in 67.5% of patients with a tendency towards dose reduction in 43.2% (of all patients), but without reaching statistical significance.

#### Conclusion

AHT and DM were significantly more common in MMD patients compared to the control cohort. After revascularization, physicians need to be aware of changes in AHT and therefore adjust the medication if needed. Further, all other modifiable systemic vascular risk fctors need to be controlled to achieve the best treatment possible.

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC058

### Prädiktoren für maligne Schwellungn bei raumfordernden Kleinhirninfarkten
*Predictors of malignant swelling in space-occupying cerebellar infarction*

E. Baki[1], L. Baumgart[2], V. Kehl[3], F. Hess[1], A. Wolff[1], A. Wagner[4], M. R. Hernandez Petzsche[5], T. Boekh-Behrens[5], H. S. Meyer[2], B. Meyer[4], S. Wunderlich[1], J. Gempt[2]

[1]Klinikum rechts der Isar, Technische Universität München, Neurologie, München, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[3]Klinikum rechts der Isar, Technische Universität München, KI und Informatik, München, Deutschland
[4]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[5]Klinikum rechts der Isar, Technische Universität München, Neuroradiologie, München, Deutschland

#### Objective

Malignant swelling is a severe complication that can occur abruptly in space-occupying cerebellar infarction, leading to surgical decompression as a necessary intervention. However, there is only limited literature on this subject. Therefore, we aimed to identify markers to predict malignant swelling.

#### Methods

We retrospectively analyzed all patients with stroke who were treated in our hospital between 2014-2020 to identify space-occupying cerebellar infarctions. Malignant swelling was defined as a mass effect in the posterior cranial fossa, accompanied by a decrease in consciousness due to compression of the brainstem and/or the development of obstructive hydrocephalus. Statistical analyses were performed on several clinical and radiological variables to identify possible predictors of malignant swelling.

#### Results

Among 7284 patients with cerebral ischemic stroke, we identified 487 patients with an infarct located in the cerebellum. 93 of those had a space-occupying cerebellar infarction. Malignant swelling occurred in 33/93 (35.5%). Large infarct volume (mean volume 61.8 cm3 vs 41.0 cm3, OR 1.136 [95% CI, 1.078–1.196]; $p < 0.001$), high NIHSS score on admission (median NIHSS 12 (1-38) vs 4 (0-36), OR 1.078 [95% CI, 1.034–1.124]; $p = 0.008$) and the presence of additional brainstem infarction (51.5% vs 16.7%, OR 5.312 [95% CI, 2.028–13.914]; $p = 0.013$) were significantly associated with the development of a malignant swelling (multivariate analysis). All 33 cases of malignant swellings occurred between two and six days after beginning of the symptoms, with the median day being day 3, meaning 48 - 72 hours after symptom onset. 13 cases of malignant swelling (39.4%) occurred after day 3.

#### Conclusion

Infarct volume and additional brainstem infarction are the key predictors of malignant swelling in space-occupying cerebellar infarction. Higher NIHSS score on admission is also significantly associated with malignant swelling. With many cases of malignant swelling occurring after 72 hours after symptom onset, we advocate prolonged neurological monitoring for patients with large space-occupying cerebellar infarction.

## RC059

### Größe der dekompressiven Kraniektomie kann die Ergebnisse vom raumfordernden ischämischen Kleinhinrinfarkt vorhersagen - Ergebnisse einer multizentrischen retrospektiven Studie

***Size of decompressive craniectomy predicts outcome in space-occupying ischemic cerebellar stroke – Results from a multicentric retrospective study***

S. Hernandez Duran[1], J. Walter[2], B. Behmanesh[3], J. Bernstock[4], M. Czabanka[5], N. Dinc[6], D. Dubinski[3], T. Freiman[3], J. Konczalla[5], R. Melkonian[6], D. Mielke[1], P. Naser[2], V. Rohde[1], J. H. Schaefer[5], C. Senft[6], A. Unterberg[2], S. Y. Won[3], F. Geßler[3]

[1]Universitätsmedizin Göttingen, Klinik für Neurochirurgie, Göttingen, Deutschland
[2]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[3]Universitätsklinikum Rostock, Klinik für Neurochirurgie, Rostock, Deutschland
[4]Harvard Medical School, Boston, MA, Deutschland
[5]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[6]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

#### Objective

In cases of cerebellar ischemic strokes, guidelines recommend decompressive surgery (SDC). While in supratentorial hemispheric stroke, the size of the bone flap has been the subject of many studies and of ample debate, no studies have been conducted to determine the optimal size of the bone flap to be removed in SDC. Therefore, in this study, we aim to determine the optimal size of SDC in ischemic cerebellar stroke.

#### Methods

This is a multicentric retrospective study of patients undergoing SDC for ischemic cerebellar stroke. SDC size was determined in two perpendicular planes on early postoperative CT scans: (a) maximal craniocaudal extension (CC) and (b) maximal lateral extension (L) in cm. SDC area was calculated assuming an ellipse:  . The primary endpoint was functional outcome according to modified Rankin Scale (mRS) at three months. Secondary outcome was mortality at three months, as well as surgical complications including surgical site infectionand cerebrospinal fluid  fistulas.

#### Results

Of 569 patients with cerebellar stroke identified, 39 were included in the final analysis. Mean L diameter was 5.7 cm (SD 2.0 cm). Mean CC diameter was 3.7 cm (SD 0.9 cm). Mean area was 18.3 cm2 (SD 8.5 cm2). Patients with a SDC L ≥5.5 cm were more likely to have a favorable mRS 0-2 at three months (OR=14.9, 95%CI 1.56 – 142.20, p=.008). An SDC area ≥19 cm2 was also more likely to yield a favorable outcome at three months (OR=11.33, 95%CI 1.18 – 109.26, p=.006). No significant differences in secondary outcomes were noted.

#### Conclusion

In ischemic cerebellar stroke, a craniectomy with a maximum lateral extension of ≥5.5 cm or an area of ≥19 cm2 can yield better functional outcomes. Prospective studies are needed to confirm these results.

# Rapid communication – Verschiedenes 1 | Rapid communication – Various 1

## RC060

### Schweregrad der aneurysmatischen Subarachnoidalblutung im Laufe der Zeit: Systematische Übersicht
*Severity of aneurysmal subarachnoid hemorrhage over time: Systematic review*

M. Overstijns[1], A. El Rahal[1], J. Goldberg[2], A. Raabe[2], R. Rölz[1], K. Bischoff[1], N. Neidert[1], J. Beck[1], C. Fung[3]

[1]Universitätsklinikum Freiburg, Neurozentrum, Freiburg i. Br., Deutschland
[2]Universitätsspital Bern, Bern, Schweiz
[3]Lindenhofspital, Bern, Schweiz

#### Objective

The incidence of aneurysmal subarachnoid hemorrhage (aSAH) has been extensively studied, however the evolution of the severity is unknown. This systematic review aims to analyze the distribution of aSAH severity over time.

#### Methods

We performed a systematic review according to the PRISMA-P guidelines and included studies from January 1968 up to December 2022. Inclusion criteria comprised studies reporting the severity of aSAH on the Hunt and Hess (HH) or World Federation of Neurosurgical Societies (WFNS) scale, either as single increments of the corresponding 5-point scale or as a binary measure (good grade 1-3, poor grade 4-5). Exclusion criteria encompassed studies with fewer than 50 patients, systematic and narrative reviews and those including non-aSAH.

#### Results

From an initial pool of 2465 publications, 214 met the inclusion and exclusion criteria, encompassing a cohort of 102.845 aSAH patients. Over the last 5 decades, a significant decline in the number of good-grade HH (0.741-fold, $p = 0.004$) and WFNS (0.749-fold, $p < 0.001$) aSAH patients was observed. In contrast, a significant increase in poor grade HH (2.427-fold, $p = 0.004$) and WFNS (2.289-fold, $p < 0.001$) was identified.

#### Conclusion

This systematic review showed a significant increase in poor-grade aSAH and an almost 10-fold increase in grade 5 patients, over the last 50 years. Whether this evolution is actually due to more severe hemorrhage, due to improvements in neuro-intensive care, or to change in grading behavior (e.g., overly poor grading due to early sedation and intubation) is unknown. This study strongly emphasizes the necessity for an improved grading system to differentiate grade 4 and grade 5 patients for meaningful clinical decision making.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC061

### Der Stellenwert einer Septostomie bei Überdrainageassoziierten asymmetrischen Schlitzventrikel
*Effects of septostomy in overdrainage-associated asymmetric slit ventricles*

S. Senger[1], A. Barthels[1], M. Hülser[1], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

Patients with slit ventricles harbours the risk of overdrainage-associated catheter occlusion. Although anti-syphon devices helps to overcome this problem, some patients suffer from inconsistent overdrainage-associated symptoms and present asysmmetric slit ventricles. Perfoming a septostomy might overcome these problems in combination with an anti-syphon device.

#### Methods

A retrospective database on neuroendoscopic procedures were scanned for septostomys in patients with slit ventricle configuration and previous shunt implantation. The follow-ups were evaluated for the clinical course and radiological images were evaluated regarding the ventricle configuration.

#### Results

Eight patients could be identified from 2013 to 2022. Two children (8yo/12yo) with congenital hydrocephalus and six adults with benign intracranial hypertension were included. Main symptom was cephalgia (n=8). Six of eight patients had already anti-syphon devices. A septostomy was performed in all cases and anti-syphon devices were implanted in two cases. No perioperative complications were seen. A complete relief of symptoms were seen in 62,5% (n=5) and markedly reduced headache in the remaining three patients. The MRI follow-up revealed a complete relief of the asymmetry in all cases.

#### Conclusion

Intraventricular procedures in slit ventricles are challenging due to the narrow anatomical conditions. However, a septostomy is a versatile method to overcome isolated side ventricles, when anti-syphon devices can not overcome this problem alone. Nonetheless, anti-syphon devices become more and more available and are mandatory to avoid chronic overdrainage and slit ventricle configuration in our experience.

# RC062

## Chirurgische Technik und Langzeitergebnisse bei der nichtsyndromalen Sagittalnahtsynostose
*Surgical technique and long-term results in non-syndromic sagittal suture synostosis*

E. J. Hermann[1], V. Avazov[1], S. Hertz[1], T. Palmaers[2], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Medizinische Hochschule Hannover, Klinik für Anästhesiologie und Intensivmedizin, Hannover, Deutschland

### Objective

Surgical correction of non-syndromic sagittal suture synostosis is performed usually early in the first year of life. A variety of surgical techniques depending on the age of the patient, associated features and the surgeon`s performance have been developed, but there is little agreement on a common standard. Here we present the results of our technique performing suture resection and bi-fronto-parieto-occipital craniectomy stripes.

### Methods

Over a 12-year period we operated a total of 59 patients with different premature suture synostosis. Out of these, 31 were operated for non-syndromic sagittal suture synostosis. Surgery was performed by a single neurosurgeon using a standardized technique and a bundle approach to prevent blood loss and coagulopathy during surgery.

### Results

There were 21 male and 10 female patients. Mean age at surgery in 28 patients was 7.3 months (range, 3 – 17 months).Three patients presented at 21, 48 and 49 months, respectively. While the younger 28 patients were operated according to our standard technique, the three older patients had a complex skull reconstruction procedure. No intra- or perioperative complications occurred. Mean follow-up after surgery was 7.1 years (range, 0.5 – 13 years). Satisfactory aesthetic results were achieved in all patients except in one. In this 5-month-old boy who was treated in addition with high dose Vitamin D a second correction surgery was performed 10 months after the first surgery.

### Conclusion

Suture resection and bi-fronto-parieto-occipital stripe craniectomies provides good long-term outcome in non-syndromic sagittal suture synostosis when performed in experienced hands. Comparative evaluations with competing techniques are needed.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC063

### Neurochirurgische Facharztausbildung in Deutschland - immer noch a mens world?
*Neurosurgical specialist training in Germany – Still "a men's world"?*

L. Makowski[1], M. Rapp[1], M. Sabel[1]

[1]Universitätsklinikum Düsseldorf, Düsseldorf, Deutschland

#### Objective

Der Frauenanteil in der NC wird immer größer, was auch der zunehmende Anteil der Assistentinnen zeigt. Allerdings spiegelt sich diese Zunahme nicht in den Zahlen der Fachärztinnen, Oberärztinnen und Chefärztinnen wider. Gründe für die Diskrepanz sind weitgehend nicht geklärt, da sich die aktuelle Literatur auf den Zeitraum nach der Facharztausbildung konzentriert. Daher möchten wir Gründe für die Unterbrechung der NC-Ausbildung untersuchen.

#### Methods

In dieser Arbeit werden sowohl ehemalige als auch aktuelle Assistenzärzt*innen nach ihren Erfahrungen, Gründe für einen Fachwechsel, Angaben von Diskriminierung und geschlechtsspezifischen Nachteilen befragt.

#### Results

Insgesamt haben 113 Assistenzärzt*innen in dem Zeitraum von 1998 bis 2023 in der NC gearbeitet mit folgenden Positionen/akademischen Titeln: 65 Dr. med. (21 Frauen, 44 Männer), 1 männlicher PD, 6 apl. Prof. (1 Frau, 5 Männer) und 3 männliche Univ.-Prof., 13 OA/OÄ (4 Frauen, 9 Männer), 13 ltd. OA/OÄ (5 Frauen, 8 Männer), 8 Chefärzte. 16 der 113 haben die Ausbildung abgebrochen (11 Frauen, 5 Männer). Daten von 66 ehemaligen/aktuellen Assistenten können für die Analyse ausgewertet werden. Hauptgründe für den Abbruch sind: unausgeglichene work-life-Balance (53,8%), erschwerte ambulante Niederlassung (38,5%). Untersucht man die work-life-Balance, lässt sich folgendes beobachten: 7 ehemalige Assistenten haben die unausgeglichene work-life-Balance als Grund für den Abbruch angegeben. Diese ehemaligen Assistenten waren vor allem in dem Zeitraum 2016 – 2022 in der NC tätig. Da das Arbeistzeitgesetz im Jahr 2007 in Deutschland im Gesundheitswesen umgesetzt wurde, lässt sich vermuten, dass die rechtlichen Veränderungen keine Besserung hinsichtlich der work-life-Balance brachten.

#### Conclusion

Unsere Daten hinsichtlich der aktuellen Positionen und akademischen Titeln, der in der NC tätigen Assistenzärzte*innen belegen deutlich einen weiterhin bestehenden Gender-Gap. Ein wichtiger Grund der weiblichen Kollegen für den Abbruch der Ausbildung ist weiterhin die Familienplanung. Hier muss es zu einem Umdenken kommen. Ebenfalls sollten flexible Teilzeitbeschäftigung, Sicherung der Kinderbetreuung über 24 h, Mentoring sowie Anpassung der Ausbildung hinsichtlich Zeitmanagement passend zu familienfreundlicher Beschäftigung überlegt werden.

# RC064

## Aseptische Knochendeckelnekrose nach autologer Kranioplastik: Eine retrospektive Single-Center Studie.

***Aseptic bone-flap resorption after autologous cranioplasty after decompressive craniectomy: A single-center retrospective study***

M. Jaber[1], T. Lampmann[1], H. Asoglu[1], M. Tahir[1], H. Alenezi[1], H. Vatter[1], M. Hamed[1]

[1]University Hospital Bonn, Department of Neurosurgery, Bonn, Deutschland

### Objective

Aseptic bone-flap resorption is a frequent complication following cranioplasty (CP), often necessitating reoperations with potential harm to patients. Autologous bone-flaps are traditionally stored at -80 °C. This study aims to comprehensively evaluate the influence of the time interval between decompressive craniectomy (DC) and CP on the incidence of aseptic bone-flap resorption.

### Methods

A total of 279 patients underwent autologous CP at our institution between January 2015 and December 2022. A retrospective analysis of patient characteristics, the duration from DC to CP, and the occurrence of aseptic bone-flap resorption was conducted. ROC curve analysis and Fisher exact test was performed. Significance was set at $p<0.05$.

### Results

Aseptic bone-flap resorption was observed in 23 (8.2%) patients. Optimal cut-off value in the prediction of aseptic bone-flap resorption was 145 days between DC and CP according to ROC curve analysis (AUC: 0.605; 95%-CI 0.496-0.715). Individuals undergoing a later CP (>145 days) exhibited a significantly lower incidence of aseptic bone-flap resorption compared to those with an early CP (3.1% vs. 12.7%; p=0.004).

### Conclusion

Deliberate delay of cranioplasty beyond 145 days appears to be associated with a noteworthy reduction in the risk of aseptic bone-flap resorption. This finding underscores the potential benefits of a strategic temporal approach in mitigating postoperative complications in cranioplasty procedures.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC065

### Erforschung der Unterschiede in der intrakraniellen Blutclearance nach einer aneurysmatischen Subarachnoidalblutung in Abhängigkeit von der Art der Liquorableitung.

***Exploring differences in intracranial blood clearance after aneurysmal subarachnoid hemorrhage depending on the way of cerebrospinal fluid drainage***

M. Rrusho[1,2], V. Malinova[1]

[1]Universitätsklinikum Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsklinikum Göttingen, Göttingen, Deutschland

#### Objective

The intracranial blood burden is a known risk factor for secondary complications following aneurysmal subarachnoid hemorrhage (aSAH). Enhancing blood clearance via a cerebrospinal fluid (CSF) drainage represents an approach to reduce the intracranial blood burden and ameliorate the morbidity after aSAH. This study was conducted to assess differences in blood clearance within the subarachnoid space and the ventricular system using different ways of CSF drainage.

#### Methods

A consecutive study cohort with aSAH treated at our center between 2010 and 2020 was retrospectively reviewed. Patients with available imaging within the first three days after ictus for the assessment of intracranial blood burden were included in the study. The blood amount within the subarachnoid space and the ventricular system were semiquantitatively evaluated applying the Hijdra score and the Le Roux score respectively. The way of CSF drainage (external ventricular drainage (EVD) or lumbar drainage (LD)) and the amount of drained CSF were documented within the first three days after ictus.

#### Results

A total of 290 patients met the inclusion criteria and were analyzed in the study. The mean age was 55.98 . A CSF drainage via EVD only was performed in 32% (93/290), via LD only in 31% (91/290), and EVD + LD in 37% (106/290) of all patients. The mean total CSF drainage within 72 hours was significantly higher in the EVD+LD group (549.1 +7- 204.3 ml) compared to the groups with EVD only (434.3 +/- 216.2 ml) and LD only (440.3 +/- 216.6 ml), p=0.0002. The absolute reduction of the Hijdra score between day 1 and day 3 correlated positively with a CSF drainage via EVD+LD (r=0.34, p<0.0001), but there was a negative correlation with LD only (r=-0.46, p<0.0001). The absolute reduction of the Le Roux score between day 1 and day 3 also correlated positively with a CSF drainage via EVD+LD (r=0.67, p<0.0001), but there was a negative correlation with a CSF drainage via EDV only (r=-0.43, p<0.0001) and via LD only (r=-0.27, p=0.0007). CSF drainage with EVD+LD correlated significantly with ventricular peritoneal shunt (r=0.14, p=0.04).

#### Conclusion

A CSF drainage via EVD+LD within the first three days following aSAH led to the most enhanced blood clearance within the subarachnoid space as well as the ventricular system compared to EVD only or LD only. However, a CSF drainage via EVD+LD was also associated with the need for permanent CSF diversion via ventriculoperitoneal shunt.

# RC066

## Eine präoperative Dehydierung korreliert signifikant mit einer erhöhten postoperativen Mortalität in chirurgischen Spondylodiszitis Patienten

***Preoperative dehydration status correlates with early postoperative mortality in patients with pyogenic spondylodiscitis***

J. E. Scorzin[1], E. Dikanova[1], A. L. Potthoff[1], F. Lehmann[2], V. Borger[1], M. Banat[1], P. Schuss[3], H. Vatter[1], M. Schneider[1]

[1]Universitätsklinikum Bonn, Klinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Klinik für Anästhesiologie und Intensivmedizin, Bonn, Deutschland
[3]BG Klinikum Unfallkrankenhaus Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

### Objective

Patients with pyogenic spondylodiscitis (PSD) often face advanced systemic infections and spinal instrumentation represents a prevalent treatment modality. However, due to their vulnerability and in addition their usually higher age, these patients experience high surgical risks and significant in-hospital mortality rates. Early identification of preoperative predictors for postoperative mortality is essential to improve risk assessment and guide prompt treatment decisions. This study aims at identifying preoperatively assessable risk factors for early postoperative mortality in PSD stabilization surgery.

### Methods

Between 2012 and 2018, 177 consecutive patients underwent stabilization surgery for PSD at the authors' neurosurgical department. Median age at time of surgery was 72 yrs (IQR 62-78 yrs). Preoperative dehydration status was defined as a blood urea/creatinine (U/Cr) ratio > 80. The Charlson comorbidity index (CCI) was employed to quantify the comorbidity burden of patients preoperatively. Early postoperative mortality was defined as any death occurring within 30 days post-surgery. A multivariable regression analysis was conducted to identify predictors for early postoperative mortality.

### Results

Early postoperative mortality was present in 16 out of 177 patients (9%). Six of 177 patients (3%) suffered from preoperative dehydration. Multivariable analysis revealed "CCI > 10" (p = 0.03, OR 0.1, 95% confidence interval (CI) 0.02-0.9), "associated spinal empyema" (p = 0.02, OR 0.2, 95% CI 0.06-0.8), and "preoperative dehydration" (p = 0.02, OR 0.1, 95% CI 0.01-0.6) as significant and independent predictors for early postoperative mortality.

### Conclusion

The present study identifies preoperative dehydration, besides of other well-known prognostic factors, as a risk factor for early postoperative mortality in surgery for PSD. Although chronic dehydration constitutes a common condition in elderly individuals. These findings might aid preoperative treatment stratification and improve perioperative management in this vulnerable patient cohort.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC067

### Die Entscheidungsfindung hinter künstlichen Intelligenz Algorithmen im intraoperativen neurophysiologischen Monitoring

***Unblackboxing decision making behind artificial intelligence algorithms in intraoperative neurophysiologic monitoring***

Q. Parduzi[1,2], J. Wermelinger[3], S. Koller[4], M. Sariyar[4], A. Raabe[3], U. C. Schneider[1], K. Seidel[3]

[1]Luzerner Kantonsspital, Neurochirurgie, Luzern, Schweiz
[2]Universität Bern, Graduate School of Health Sciences, Bern, Schweiz
[3]Inselspital – Universitätsspital Bern, Neurochirurgie, Bern, Schweiz
[4]Berner Fachhochschule, School of Engineering and Computer Science, Biel, Schweiz

#### Objective

We elucidate the decision making that lies behind artificial intelligence algorithms in the example of muscle classification in intraoperative neurophysiological monitoring (IONM). The goal is to uncover decisive parameters in motor evoked potentials (MEP) to understand intraoperative changes and optimize AI decision making.

#### Methods

We classified MEP in supratentorial surgery in a bi-centric setup, training on 160 patients from one center and validating on 50 patients from an independent center. We trained random forests and 1D convolutional neural nets (CNN) on a total of 37"000 MEPs and uncovered the decision making by looking into the feature importance and gradient class activation maps (Grad-CAM).

#### Results

The random forest achieved 89% test accuracy and 80% accuracy on the validation dataset from the independent center, whereas the CNN achieved 85% test and 76% validation accuracy. Inspecting the random forest feature importance reveals that the algorithm focuses on the time interval where the potential has highest amplitude. On the other hand, the grad-CAM reveals that the CNN might be focusing on the biggest slope of the potential.

#### Conclusion

Analyzing the decision making of artificial intelligence algorithms is an essential part of ensuring the quality and evidence behind the good performances of these methods. Understanding this rationale will be crucial when improving intraoperative MEP alarm criteria. We showed the key features during identification of MEPs and validated the results in a bicentric setup. To our knowledge, it is the first time an IONM machine learning classification task has been implemented in a multicenter setup.

# RC068

## Nachweis von Antikörpern bei Patienten mit Autoimmunenzephalitis mittels maschinellem Lernen auf der Grundlage von MRT-Bildern des Hippocampus

***Detection of antibodies in patients with autoimmune encephalitis using machine learning based on MRI images of the hippocampus***

M. Musigmann[1], C. Spiekers[1], J. Stake[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

### Objective

Autoimmune encephalitides are serious diseases of the central nervous system. The aim of our study is the non-invasive detection of antibodies in patients with autoimmune encephalitis using machine learning based on MRI images of the hippocampus. We analyse the accuracy of antibody prediction and which clinical and radiomic features are particularly relevant for this important diagnostic question.

### Methods

Our retrospective, IRB-approved study is based on the MRI images of 98 patients with confirmed autoimmune encephalitis and known antibody status. Antibodies were previously detected in 57 patients. Semi-automatic image segmentation of the hippocampus was performed using the open-source software platform 3D Slicer. Subsequently, a total of 107 radiomic features were determined using the PyRadiomics package. Six different machine learning algorithms were tested to differentiate between patients with previously detected and undetected antibodies. All machine learning models were fully developed 100 times each and subsequently tested to assess their stability. Without exception, we calculated all performance values as mean values of these 100 runs, each time using independent (unknown) test data. In addition to the discriminatory power and stability of the models, we investigated which radiomic features are particularly important for a correct prediction of the antibody status.

### Results

Using a 6-feature Lasso regression model, we obtained a mean AUC of 95.0 %, a mean accuracy of 89.2 %, a mean sensitivity of 89.2 % and a mean specificity of 89.1 % for antibody detection based on independent test data. Thus, our models show very high performance in predicting antibody status in autoimmune encephalitis diseases based on MRI images of the hippocampus, i.e. in distinguishing patients with detectable and undetectable antibodies. In addition, our final model proved to be extremely stable. All clinical and radiomic features included in the final model were selected almost without exception in each run of the 100 complete model developments, regardless of the specific data partitioning used.

### Conclusion

Our results show that radiomics-based machine learning models can predict the antibody status of patients with autoimmune encephalitis with high accuracy. Such methods could support the diagnosis of autoimmune encephalitis in the near future. However, larger prospective studies are required to confirm our results before application in clinical practice might be possible.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC069

### Neurochirurgische Workforce an deutschen Universitätsklinika
*Neurosurgery workforce at German university hospitals*

T. Kapapa[1], D. Latina[1], B. Maier[2], C. R. Wirtz[1], H. G. Kesseler[1]

[1]Universitätsklinikum Ulm, Klinik für Neurochirurgie, Ulm, Deutschland
[2]Institut für Epidemiologie und Medizinische Biometrie, Biometrie, Ulm, Deutschland

#### Objective

Description of the conditions inside and outside a neurosurgical university department for the in-hospital treatment of >1000 to 2000 and >2000 to 3000 patients.

#### Methods

The databases of the German Federal Joint Committee (G-BA), the German Federal Statistical Office, the Association of German University Hospitals (VUD), and Google Maps were searched for neurosurgical services on patients for the years 2012 to 2021. Only university departments were considered.

#### Results

40 neurosurgery departments at German universities were identified. A mean of 1950 (SD:154.6) in-hospital patients per year were treated in the entire period and for all departments. The median per year was 1958 (range:1700-2172) patients. This number of patients was managed by a mean of 22.4 (SD:2.23) physicians per department. Of these, a mean of 11.2 (SD:1.8) were neurosurgeons. The mean number of patients treated per physician was 97.5 (SD:17.3) or 203 (SD:39.8) per neurosurgeon. The mean number of nursing staff was calculated at 52 (SD:8.1), and 58 (SD:9.2) patients were treated by one nurse. 10% of all departments treated less than 1000 patients per year. 50% treated 1000 to 2000 patients per year. Approximately 35% treated 2000 to 3000 patients. Only 5% treated more than 3000 patients. A mean of 19.7 (SD:1.85) physicians, 9.9 (SD:1.72) neurosurgeons, and 43 (SD:7.35) nurses were employed to treat 1001 to 2000 patients, and 26.6 (SD:2.65) physicians, 13.1 (SD:2.04) neurosurgeons and 68 (SD:9.23) nursing staff to treat 2001 to 3000 patients. The univariate regression analysis revealed that the mean number of physicians (OR1.314, p=0.002, CI 95%: 1.109 to 1.557 for more than 2000 patients) had a significant influence (OR1.205, p=0.051, CI 95%: 0.999 to 1.453 for more than 3000 patients). The sole number of citizens or other neurosurgery departments in the city, and the driving distance of max. 30 minutes to another city does not have a significant impact. However, the driving distance of a max. 60 minutes (OR1.385, p=0.021, CI 95%: 1.050 to 1.826) and the presence of another neurosurgery department within a 50 km range to another city (OR1.567, p = 0.032, CI 95% 1.040 to 2.359 for 2000 patients) had a significant influence.

#### Conclusion

The majority of departments treated 1000 to 2000 patients per year. For this, a mean number of 20 doctors, including 10 specialists and 43 nursing staff was needed. The pure city's population or other neurosurgical departments in the city have no statistical influence.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC070

### Large Language Models: sind KI-basierete Chatbots in der Wirbelsäulenchirurgie als zuverlässige Informationsquelle in der Patientenaufklärung verlässlich?

***Large language models: Can AI-Based chatbots be trusted as reliable sources of patient information for spinal surgery?***

R. Stroop[1], A. Stroop[1], T. Stroop[1], C. Greiner[2], F. Möllmann[2], S. Zawy Alsofy[1]

[1]Witten/Herdecke University, Department Humanmedizin, Witten, Deutschland
[2]Neurozentrum, Klinik für Neurochirurgie, Osnabrück, Deutschland

#### Objective

Recently, Large Language Models (LLMs) have gained attention for their impressive capabilities. These AI-based systems enable dialogic communication in an almost natural language, closely resembling human interaction. LLMs, therefore, could significantly aid in patient education. To assess the effectiveness of an LLM in providing medical information, we applied ChatGPT, one of the first high-performing LLMs, to the clinical case of acute lumbar disc herniation (LDH).

#### Methods

Twenty-four spinal surgeons with expertise in LDH surgery posed patient-perspective questions about LDH to ChatGPT. They evaluated the quality of ChatGPT's responses and its utility in medical communication. These responses were then compared to the information usually given in a standard informed consent form.

#### Results

ChatGPT showed promising performance in clarity, specificity, response satisfaction, as well as medical accuracy and comprehensiveness. Although ChatGPT did not cover all information from the informed consent form, it provided some additional details not included there. However, ChatGPT occasionally made minor medically inaccurate statements, such as listing kyphoplasty and vertebroplasty as surgical options for LDH.

#### Conclusion

As AI begins to integrate into communication, LLMs are poised to become increasingly important for patients. While LLMs may not currently play a significant role in clinical communication between doctors and patients, the potential benefits and risks of this emerging technology should be closely monitored.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC071

### Bone regrowth in children with syndromic craniosynostosis and Chiari malformation type I after surgical decompression of the craniocervical junction

***Erneute Verknöcherung bei Kindern mit syndromaler Kraniosynostose und Chiari Malformation Typ I nach operativer Dekompression des kraniozervikalen Übergangs***

S. Rückriegel[1], C. Wipplinger[2], A. Stock[3], C. Monoranu[4], J. Krauß[1], T. Schweitzer[1]

[1]Universitätsklinikum Würzburg, Sektion Pädiatrische Neurochirurgie, Würzburg, Deutschland
[2]Universitätsklinikum Würzburg, Neurochirurgische Klinik, Würzburg, Deutschland
[3]Universitätsklinikum Würzburg, Institut für Neuroradiologie, Würzburg, Deutschland
[4]Universitätsklinikum Würzburg, Abteilung für Neuropathologie, Würzburg, Deutschland

#### Objective

We present a single center retrospective analysis of pediatric patients treated for syndromic and non-syndromic CM-I with a particular focus on reoperation rates and a nuanced investigation of rare complications including bone regrowth as this is scarcely reported in the current literature.

#### Methods

A retrospective analysis of all patients treated surgically for Chiari malformation in the authors' institution between 2008 and 2023 was performed. The study included all patients with CM-I under 18. Baseline demographics, operative technique, interoperative findings, and revision surgeries were recorded.

#### Results

We identified 37 (13 syndromic CM-I, 24 non-syndromic CM-I) children and adolescents who underwent surgical treatment of Chiari malformation type I in our department between 2008 and 2023. Most patients (n=21, 57%) required bony decompression followed by dural opening and reduction of the cerebellar tonsils, and an expansion duraplasty. A reoperation was needed in six patients (17%). All were deemed necessary due to restenosis at the craniocervical junction as evidenced by MRI scans. Intraoperative findings revealed that restenosis was mainly caused by significant bone regrowth around the foramen magnum.

#### Conclusion

We identified 6 cases of restenosis due to bone regrowth that necessitated reoperation. This constitutes the largest case series on the subject to the best of our knowledge. All patients with bone regrowth suffered from syndromic craniosynostosis and CM-I, with the majority having received a VP-shunt prior to the initial surgery for CM-I. Importantly, technical aspects of the initial surgery did not influence the development of bone regrowth.

# Rapid communication – Verschiedenes 2 | Rapid communication – Various 2

## RC072

### Chirurgisches vs. konservatives Management von chronischer Ischialgie (>3 Monate) aufgrund von Bandscheibenvorfall im Lendenwirbelbereich: Systematische Übersicht und Meta-Analyse

***Surgical vs conservative management of chronic sciatica (>3 months) due to lumbar disc herniation: Systematic review und meta-analysis***

A. Hammed[1], C. Tanislav[1], A. M. Hamouda[2]

[1]Diakonie Hospital Jung Stilling, Department of Geriatrics and Neurology, Siegen, Deutschland
[2]Department of neurological surgery, Rochester, NY, Vereinigte Staaten

#### Objective

Sciatica, characterized by leg or back symptoms along the sciatic nerve, often manifests as a chronic condition lasting over 12 weeks. Decision-making between nonoperative treatment and immediate microdiscectomy for chronic sciatica remains challenging, influenced by the complex relationship between symptom duration, or severity and lumbar discectomy outcomes.

#### Methods

In this systematic review, we conducted a comprehensive search across Scopus, PubMed, Web of science, and the Cochrane library, identifying relevant two-arms clinical trials up to September 2023. Rigorous screening and data extraction were performed by two independent reviewers, with study quality evaluated using the Robin 2 tool. Standard mean differences and 95% confidence intervals were actively calculated for overall effectiveness, and $I^2$ was utilized to detect variations in the dataset.

#### Results

The meta-analysis incorporated four studies comprising 352 participants. The results indicated a marginal significance in leg pain reduction with conservative treatment, suggesting a potential benefit compared to surgical intervention(z= 1.98; CI [0.02:5.18]; p = 0.05).Back pain analysis revealed a significant reduction with operative treatment(z= 3.46; CI [-5.99:-1.66]; p = 0.0005).

Both SF mental and physical improvement are associated with conservative treatment.

#### Conclusion

In conclusion, our findings suggest that surgical intervention may be more effective than non-surgical treatment for chronic sciatica-related back pain. Conservative treatment significantly reduced leg and back pain while improving mental and physical health outcomes. However, the effects on leg pain reduction are less conclusive, emphasizing the need for careful interpretation. Conservative treatment should be the initial approach unless surgery is warranted, particularly in cases with neurological deficits or cauda equina syndrome.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P002

### Umfassende Analyse der klinischen Merkmale und prognostischen Faktoren bei der Operation von spinalen Meningeomen: Einblicke aus einer umfangreichen Single-Center-Studie

***Comprehensive analysis of clinical features and prognostic factors in spinal meningioma surgery: Insights from an extensive single-center study***

B. Younes[1], D. Mielke[1], V. Rohde[1], T. Abboud[1]

[1]Universitätsklinikum Göttingen, Neurochirurgie, Göttingen, Deutschland

#### Objective

Spinal meningiomas, predominantly benign lesions, require surgical resection as the primary treatment, with radiotherapy as an infrequent adjunct. This study introduces a large series of surgically treated patients with spinal meningiomas, aiming to elucidate the clinical characteristics associated with recurrence and the potential need for adjuvant treatments.

#### Methods

We retrospectively analyzed a consecutive cohort of 93 patients who were surgically treated for spinal meningioma from 2007 to 2023. Clinical and radiological data, including tumor location, surgical approach and complications, histological findings, adjuvant treatment, and recurrence rates, were retrieved from patient charts

#### Results

The mean age at diagnosis was 66 years. Thoracic localization was the most frequent (65%), followed by cervical (25%) and lumbar or thoracolumbar localization (10%). Most tumors (44%) were located ventrally in the spinal canal, 29% dorsally, and 10% laterally. Patients with cervical meningiomas were younger, with an average age of 63 years (p=0.031) and were more likely to have ventrally located tumors (OR, 3.4; p=0.025). Hemilaminectomy was the predominant surgical approach (83%). Simpson grade II resection was achieved in 97% of the cases. Complication rate was 1%. Most tumors exhibited calcification (83%). The psammomatous pattern was the most frequent histological finding (70%), followed by meningothelial and fibroblastic patterns. Only 3% were classified as WHO Grade II. The mean follow-up was 7 years. Radiotherapy was performed in 2% of the patients. Recurrence occurred in 3% of the patients, all of whom had WHO Grade I meningiomas.

#### Conclusion

This study reaffirms the predominantly benign nature of spinal meningiomas and supports surgical resection, particularly hemilaminectomy, as a safe and effective primary treatment strategy. The low recurrence rate highlights the importance of individualized, less frequent follow-up intervals.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P003

### Analysis of postoperative sagittal alignment changes after resection of primary extradural spinal tumors and stabilization: a single center retrospective study.

***Analyse der postoperativen sagittalen Alignmentveränderung nach Exstirpation primärer extraduraler Wirbelsäulentumore und Stabilisierung. Eine Single-Center-Studie.***

P. Warnke[1], C. Schmitt[1], K. D. Schaser[1], A. C. Disch[1], A. Thomas[1], U. Platz[1]

[1]University Hospital Carl Gustav Carus at the TU Dresden, University Comprehensive Spine Center, University Center for Orthopaedics, Trauma and Plastic Surgery, Dresden, Deutschland

#### Objective

Extradural primary spinal tumors are rare neoplasms, which mostly originate from bone or soft tissue, often require radical resection (en bloc (EBR) or wide local (WLR)) and subsequent stabilization and reconstruction of the spine. Advancements in surgery and adjunctive therapies have extended patient lifespans. Sagittal malalignment is a crucial factor in spinal fusion surgery, contributing to adjacent segment degeneration (ASD) and instrumentation failure. Restoring the sagittal alignment (SA) is essential. Le Huec's benchmark establishes accurate SA parameters, including lumbar lordosis (LL), based on spinopelvic factors.

#### Methods

In this study we examined 38 patients with primary spinal tumor resection and stabilisation. Focus was the analysis of pre- and postoperative radiologic examination (RE) (X-Rays, MRIs, or CT-scans). Excluding criteria comprised: cervical fixation, sacrectomy, inadequate radiologic examination and the absence of spinal instrumentation. 38 out of 108 patients between 2017 and 2023 were included. The RE were analyzed using surgimap®, a software developed for the analysis of the SA. Global and regional SA parameters such as pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL), thoracic kyphosis (TK), T1 pelvic angle (TPA) and the local SA of the instrumented vertebrae pre- and postoperatively were analyzed. All examinations were conducted after approval by ethics committee.

#### Results

There were no significant differences in the pre- and postoperative SA. However, in case of LL, measured particularly in whole spine X-Rays, there was a significant deviation of the measured LL (95% CI -45,6°±2,7) and calculated ideal LL (95% CI 54,1°±2,3) according to Le Huec formula (LL = 0.54×PI+27.6) ($p<0,00001$). TPA as a global alignment parameter remains within the normal range. Regional SA in the instrumented area has not undergone significant changes following the treatment (95% CI -51,2°±2,3vs. -45,6°±2,8; $p=0,12$).

#### Conclusion

Evaluation of SA following significant interventions is crucial for comprehending pathologies such as ASD and implant failure. Our study shows that surgeons primarily use the preoperative, but not the ideal sagittal alignment when planning the resection of primary spinal tumors. Further studies must show whether a deviation from the ideal individual sagittal alignment is associated with a higher rate of implant-associated complications or a poorer quality of life postoperatively.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P004

### Charakteristika und chirurgischer Outcome von Patienten mit intraduraler spinaler Metastasierung: Eine retrospektive Fallserie eines spezialisierten Universitätszentrums

***Characteristics and outcome of surgically treated patients with intradural spinal metastasis – A single-center retrospective case series***

A. Lein[1], H. Salvotti[1], M. Proescholdt[1], N. O. Schmidt[1], S. Siller[1]

[1]University Hospital Regensburg, Department of Neurosurgery, Regensburg, Deutschland

#### Objective

Intradural spinal metastases are considered to be exceptionally rare. At present, limited information is available on incidence, surgical management and outcomes.

#### Methods

We conducted a retrospective patient chart review from 2003 to 2023 at our tertiary academic reference center identifying all patients surgically treated for intradural spinal metastases. Data on patient demographics, primary cancer histopathology, spinal location, relation to the spinal cord, clinical course, pre- and postoperative neurological status, the extent of tumor resection, and survival were collected and compared to literature data for patients surgically treated for extradural spinal metastases.

#### Results

A total of 172 intraspinal tumors were identified, of which 12 patients met inclusion criteria (7%). The mean age at diagnosis of metastases was 49.4 years, with diverse primary tumors including lung (n = 3), breast (n = 2), and seven other entities. Metastasis was diagnosed on an average of 2.7 years after the primary diagnosis. In total, we observed five (42%) intradural extramedullary, and seven (58%) intramedullary metastases. The majority of intradural metastasis occurred in the cervical (50%), followed by thoracic (33%) and lumbar spine (17%). The most common preoperative symptoms ranged from pain (75%) to motor (67%), sensory (83%) and vegetative deficits (25%). Gross total resection was achieved in 58% of cases, while in 42% of patients a subtotal resection was performed. Postoperatively, 90% of patients exhibited clinical improvement of symptoms, while neurologic functional status was severely affected in one patient. The most frequent postoperative adjuvant treatment was radiotherapy (42%) and/or chemotherapy (17%), while the best supportive care was chosen by 41%. The mean overall survival from the diagnosis of primary cancer to death was 5.2 years (range 0.5 – 16.7 years). The average survival after operation for spinal metastases was 1.7 years, with six patients surviving <1 year (averaging 3.5 months).

#### Conclusion

Intradural location of spinal metastases is exceptionally rare and accounts for only 7% of all spinal metastases. Despite initial neurological improvements, survival appears lower compared to reported survival of extradural spinal metastases.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P005

### *Postoperative Lebensqualität bei Patienten mit intramedullären Ependymomen und benignen Tumoren*
### *Postoperativ quality of life in patients with intramedullary ependymoma and benign tumors*

D. Podlesek[1], H. Buchta[1], M. M. Hijazi[1], W. H. Polanski[1], M. Alkhatib[1], T. Juratli[1], I. Y. Eyüpoglu[1], G. Schackert[1]

[1]Technische Universität Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

#### Objective

This monocentric study aims to analyze the postoperative long-term quality of life (QoL) in intramedullary tumors.

#### Methods

A study involving 51 patients who completed a QoL questionnaire (52.09% ependymomas, 45.1% benign, 1 malignant tumor) assessed clinical parameters, followed by statistical analysis.

#### Results

The QoL questionnaire was completed, on average, 9 years post-surgery (Range: 1-26 Y.). Comparing different time points and the presence/absence of clinical parameters revealed significant improvements in spinal ataxia one year postoperatively than immediately postoperatively for ependymomas (p .003) and benign tumors (p = .021). Patients with preoperative ataxia faced more difficulties in cycling (p= .005) and walking (p= .001) during follow-up. Those with preoperative spinal ataxia (p= .018) or incontinence (p= .027) experienced challenges in daily living. Strong correlations existed between preoperative incontinence and current status for both tumor types (ependymoma p= .039; benign p= .031), as well as for sexual function (ependymoma p= .003; benign p< .001). However, changes were not significant when comparing the 3-month postoperative status to the current status. For both tumor entities, the manifestation of ataxia at different time points was significantly different (p= .001; worse, yet stable compared to preoperative).

Laminoplasty caused more pain than laminectomy over time (p< .001), especially on the cervical and thoracic spine (p< .001). A notable disparity in the prevalence of back pain at various time intervals was observed for laminoplasty (p= .028; worsening), but not for laminectomy (p= .764; stable).

#### Conclusion

Despite study limitations (small cohort), our results indicate a statistically significant impact of the surgical approach on outcome. There's a notable association between improved body condition and intramedullary tumor localisation. Larger intramedullary tumors result in more postoperative deficits, gradually decreasing to levels similar to smaller tumors over time. Patients undergoing laminoplasty suffer from more difficulties in household tasks compared to laminectomy patients.

# P006

## Synchrone versus metachrone Wirbelsäulenmetastasen: eine vergleichende Studie zu den Überlebensaussichten nach neurochirurgischer Behandlung

***Synchronous versus metachronous spinal metastasis: A comparative study of survival outcomes following neurosurgical treatment***

M. Banat[1], A. L. Potthoff[1], M. Hamed[1], V. Borger[1], J. E. Scorzin[1], T. Lampmann[1], H. Asoglu[1], L. Khalafov[1], C. F. Schmeel[1], D. Paech[1], A. Radbruch[1], L. Nitsch[1], J. Weller[1], U. Herrlinger[1], M. Toma[1], G. Gielen[1], H. Vatter[1], M. Schneider[1]

[1]Universitätsklinikum Bonn, Neurochirurgie, Bonn, Deutschland

### Objective

Patients with spinal metastases (SM) from solid neoplasms typically exhibit progression to an advanced cancer stage. Such metastases can either develop concurrently with an existing cancer diagnosis (termed metachronous SM) or emerge as the initial indication of an undiagnosed malignancy (referred to as synchronous SM). The present study investigates the prognostic implications of synchronous compared to metachronous SM following surgical resection.

### Methods

From 2015 to 2020, a total of 211 individuals underwent surgical intervention for SM at our neuro-oncology facility. We conducted a survival analysis starting from the date of the neurosurgical procedure, comparing those diagnosed with synchronous SM against those with metachronous SM.

### Results

The predominant primary tumor types included lung cancer (23%), prostate cancer (21%), and breast cancer (11.3%). Of the participants, 97 (46%) had synchronous SM, while 114 (54%) had metachronous SM. The median overall survival post-surgery for those with synchronous SM was 13.5 months (95% confidence interval (CI) 6.1-15.8) compared to 13 months (95% CI 7.7-14.2) for those with metachronous SM (p=0.74).

### Conclusion

Our findings suggest that the timing of SM diagnosis (synchronous versus metachronous) does not significantly affect survival outcomes following neurosurgical treatment for SM. These results support the consideration of neurosurgical procedures regardless of the temporal pattern of SM manifestation.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P007

### Intraoperative Strahlentherapie in Kombination mit spinaler Instrumentierung. Eine neue Therapieooption für spinale Metastasen.

***Intraoperative radiotherapy combined with spinal stabilization surgery. A novel treatment strategy for spinal metastases. First experiences at a single center***

P. Krauss[1], C. Wolfert[1], B. Sommer[1], G. Stüben[2], K. H. Kahl[2], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland
[2]Universitätsklinikum Augsburg, Strahlentherapie, Augsburg, Deutschland

#### Objective

Contemporary treatment of spinal metastases (SM) aims on preserving spinal stability, neurological status, local control and functional status. It consists of spinal surgery followed by radio- and chemotherapy. Adjuvant therapy is performed after several weeks to prevent wound healing issues. Intraoperative radiotherapy (ioRT) is a solution to shorten treatment time, successfully applied in brain tumor, breast and colorectal surgery but not SM to date. We describe the feasibility, morbidity and mortality of a novel treatment protocol for SM combining spinal stabilization surgery with ioRT.

#### Methods

Results on morbidity and mortality of ioRT combined with stabilization surgery in SM in a first single center series are described. Stabilization is performed as CT-navigated open or percutaneous procedure using a carbon screw-rod system followed by 50kV photon-ioRT using the ZEISS Intrabeam during a single session in prone position. The ioRT probe is placed through a guide canula via navigation and positioning is controlled by ioCT to enable RT isodose planning in the OR. Patient characteristics, perioperative specifications and postoperative follow up along with adverse events (AE) are reported.

#### Results

15 (8 female) patients (71±10y) received treatment from 07/22-09/23. Median SINS was 8 [7-10] IQR, with metastasis located in thoracic (n=9) and lumbar (n=2) spine. 9 patients received open, 5 percutaneous stabilization and 1 decompression only. Mean length of surgery was 157±45 min. with 3 Patients receiving 4 and 11 patients receiving 8 screws respectively. In 2 Patients radiotherapy was not completed due to bending of the guide canula with consecutive security abortion of ioRT. All other patients received 8Gy isodoses during 2-6min.. Patients treated had ESCC 1a-3. 7 patients experienced AEs including 2 cases surgical site infection (one 65 days after surgery).

#### Conclusion

50kV photon ioRT for SM is safe and feasible and can be a promising technique for selected cases of SM.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P008

### Resektion spinaler intraduraler Tumore über mehrere Segment und Langzeit Follow-Up
*Spinal intradural tumor resection via long segment approaches and clinical long-termfollow-up*

L. Dieringer[1], L. Kraus[1], M. Wostrack[1], B. Meyer[1], V. M. Butenschön[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland

### Objective

Spinal intradural tumors account for 15% of all CNS tumors. Typical tumor entities include ependymomas, astrocytomas, meningiomas, and neurinomas. In cases of multiple affected segments, extensive approaches may be necessary to achieve complete tumor resection.

### Methods

Retrospective monocentric analysis of patients older or equal to 14 years undergoing intradural tumor resection via approaches equal to or above four segments. We assessed the surgical technique and the clinical outcome regarding signs of symptomatic spinal instability. Children were excluded from our cohort.

### Results

In total, we analyzed 28 patients with a mean age of 40 ± 20 years, including 14 ependymomas, 2 meningiomas, 1 astrocytoma, and 7 patients with other entities. The median length of the approach was five spinal segments IQR (4-6) with foremost localization in the thoracic or lumbar spine. Laminoplasty was the most chosen approach (75%). The median follow-up was 43 months IQR (11-98), with 4 patients missing a follow-up. Comparing pre- and post-surgery outcomes, 18 patients reported pain improvement after surgery. Median modified McCormick scores pre- and post-surgery were equal with 2 IQR (1-2) and 2 IQR (1-3), respectively.

### Conclusion

We achieved satisfying results with long-segment approaches. In general, patients reported pain improvement after surgery and received similar low modified McCormick scores pre-and post-surgery. Thus, we conclude that intradural tumor resection via extensive approaches does not impair long-term spinal stability.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P009

### Epigenetische und klinische Charakterisierung von erwachsenen diffus infiltrierenden intramedullären Rückenmarksgliomen

***Epigenetic and clinical characterization of adult diffusely infiltrating intramedullary spinal cord gliomas***

M. Bschorer[1], S. O. Eicker[1,2], R. Kathr[3,4], S. Hänzelmann[3,4], S. Bonn[3,4], T. Huber[5,6], J. Gempt[1], J. Matschke[7], U. Schüller[7,8,9], M. Westphal[1], F. Ricklefs[1], M. Mohme[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[2]Lubinus Clinicum, Wirbelsäulenchirurgie und onkologische Orthopädie, Kiel, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Zentrum für Molekulare Neurobiologie, Hamburg, Deutschland
[4]Universitätsklinikum Hamburg-Eppendorf, Institut für Medizinische Systembiologie, Hamburg, Deutschland
[5]Universitätsklinikum Hamburg-Eppendorf, III. Medizinische Klinik und Poliklinik, Hamburg, Deutschland
[6]Universitätsklinikum Hamburg-Eppendorf, Hamburg Center for Translational Immunology, Hamburg, Deutschland
[7]Universitätsklinikum Hamburg-Eppendorf, Institut für Neuropathologie, Hamburg, Deutschland
[8]Universitätsklinikum Hamburg-Eppendorf, Forschungsinstitut Kinderkrebs-Zentrum Hamburg, Hamburg, Deutschland
[9]Universitätsklinikum Hamburg-Eppendorf, Klinik für Pädiatrische Hämatologie und Onkologie, Hamburg, Deutschland

#### Objective

The treatment of adult diffusely infiltrative intramedullary spinal cord gliomas (IMSCG) poses significant challenges, primarily due to their rarity and limited understanding of their clinical progression and biology. Utilizing epigenetic methodologies and a large IMSCG database, this study seeks to comprehensively characterize the clinical and molecular aspects of diffusely infiltrative IMSCG.

#### Methods

This study involves a retrospective analysis of patients, who underwent surgery for diffusely infiltrating IMSCG at a university medical center between 2014 and 2023. Clinical data was retrieved from digital case records. Tumor resections are classified as either microscopically complete, that is no microscopic tumor remnants as evaluated by the surgeon, incomplete resection, or biopsy. To identify distinct molecular patterns and provide a diagnosis, we employed the 850K DNA methylation array, with subsequent classification using the Heidelberg classifier.

#### Results

Overall, we included 29 patients in our analysis. Complete resection was achieved in 27.6% of cases, with 24.1% received a biopsy only, and most patients (48.3%) undergoing incomplete resection. Histology showed 15 (51.7%) pilocytic astrocytoma (PA), 4 (13.8%) K27M-mutated gliomas, 3 (10.3%) IDH wildtype glioblastoma, 1 (3.4%) anaplastic astrocytoma and 6 (20.7) low-grade gliomas. Remaining tissue samples allowed for methylation analysis of 16 tumors. Epigenetic profiling confirmed a diagnosis in 87.5%, although a match score of >0.9 was not always achieved. In two cases, the histological diagnosis changed, as one PA and one RGNT corresponded molecularly to a subependymoma and a posterior fossa PA, respectively. In 12.5% (n=2) of cases epigenetic analysis did not match with any know molecular tumor entity. If epigenetic classification was possible, an average classifier score of .80 was achieved, demonstrating that the classifier can still be improved for IMSCG. Subsequent bioinformatic deconvolution of epigenetic data demonstrated distinct enrichment of stemness properties in high- vs. low grade IMSCG's.

#### Conclusion

Our study's integration of histological and epigenetic analysis in adult IMSCGs demonstrated heterogeneity of diffuse infiltrating IMSCG. Epigenetic profiling supported diagnosis in only 87.5% of cases and indicated distinct

biological characteristics in higher-grade tumors, highlighting its potential for future risk stratifications of IMSCG.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P010

### Erste klinische Erfahrungen mit dem ExcelsiusGPS® Operationsroboter bei kranialen uns spinalen Operationen unter Verwendung präoperativer und intraoperativer Bildgebung

***First clinical experience with the ExcelsiusGPS® in the field of robot-assisted cranial and spinal surgeries using multiple imaging modalities***

M. Kudernatsch[1]

[1]Schön Klinik Vogtareuth, Neurochirurgie, Vogtareuth, Deutschland

#### Objective

Navigated robotics is increasingly becoming established in cranial procedures (SEEG, biopsy, DBS) and spinal operations for optimized insertion of pedicle screws. Only a few navigated robotic surgical assistants support cranial and spinal procedures in the same way and enable the use of preoperative and intraoperative imaging with the same precision.

#### Methods

In 2023, the ExcelsiusGPS® was established primarily to perform SEEG examinations in children and adults. The electrode planning was carried out on a high-resolution preoperative MRI. Intraoperative registration can be performed by using fluoroscopy in a standard OR or 3D imaging (Philips Azurion) in the hybrid OR. All implantations were monitored postoperatively by MRI to check the precision and to rule out complications.

The ExcelsiusGPS® was also used on the entire spine in open and predominantly minimally invasive (MIS) procedures. Almost all spinal procedures were performed with intraoperative 3D imaging. The screw position was controlled using intraoperative 3D imaging.

#### Results

10 SEEG cases have been carried out with a total of 104 depth electrodes (8 hemisphere and two bihemispheric implantations). The implantation time for an electrode was less than 10 minutes. All electrodes reached the target point with very high precision.

In 21 spinal cases 114 pedicle screws were implanted (2 iliac, 6 lumbar (1xMIS), 6 thoraco-lumbar (5xMIS), 3 thoracic (3xMIS), 4 cervical C1/2 fusions (1xMIS)). Intraoperatively all screw positions were checked using 3D imaging. The screw positions were congruent with the screw plans.

#### Conclusion

The ExcelsiusGPS® is a robotic navigation platform developed for cranial and spinal applications. The versatility allows the system to accomodate any workflow and enables planning and navigation with multiple imaging modalities. The first clinical experience after one year in the field of robot-assisted SEEG and spinal surgeries showes very precise and time-saving results regarding implanted electrodes and pedicle screws on the entire spine.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P011

### Ein Vergleich zwischen der Präzision von Schraubenimplantationen mithilfe intraoperativer Computertomographie bildgeführter Navigation in der Lenden- und Lumbosakralwirbelsäule mit und ohne K-Wiring: eine Serie von 383 Schrauben

***A comparison in accuracy between screw implantation using intraoperative computed tomography image-guided navigation in the lumbar and lumbosacral spine with and without k-wiring: A series of 383 screws***

P. Baptist[1], B. Stemmer[1]

[1]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland

#### Objective

The emphasis of this study was to see whether accuracy and revision rates differ between the two methods, namely with and without the use of k-wiring.

#### Methods

A retrospective analysis of all patients following intraoperative computed tomography (iCT) navigated spinal pedicle screw placement between 2018 and 2021 was performed. Navigated drilling of the pedicle was followed by either a free-hand screw placement approach or guided by k-wires. Positioning of the screws was then investigated by further iCT scan and corrected if necessary. Evaluation of the initial screws positions was based on the Gertzbein and Robbins classification.

#### Results

Overall, 80 patients (47.5% male, 52.4% female) were divided into two groups of 40 each. We divided into three indications: Degenerative changes (72.5%), inflammatory diseases (16.3%) and fractures caused by metastases (11.3%). The subjetcs mean age was 66.8 years (with k-wire) and 67.6 years(w/o k-wire), respectively. In total, 383 screws were inserted in the lumbar and lumbosacral spine. The accuracy of position of the screws in the k-wire group was 76,0%, 13.9%, 6.7%, 2,0% and 0.5%based on the classification with A,B, C, D and E. In the non-k-wire group it was 78,0%, 9.5%, 7.4%, 1.6% and 3.2%. With degenerative changes making up the largest number of patients we saw a revision rate of 4.5% when using k-wire and 9.1% without using k-wire. In inflammatory and tumor patients we also saw a lower rate of revisions in the k-wire groups. An overall intraoperative revision rate of 2.3% in 80 patients could be assessed. Thereof 1,0% making up a significantly lower amount with k-wiring compared to the 4.8% without it.

#### Conclusion

Consequently, the use of the Kirschner wire indicates a more precise approach to the insertion of pedicle screws. To verify these results, however, a larger randomized prospective trial needs to be conducted.

Abb. 1

| Indication | Screws | via K-wire | w/o K-wire | Total |
|---|---|---|---|---|
| Deg | Revised | 1 | 7 | 8 |
| | Total | 22 | 36 | 58 |
| | Revision rate | 4,50% | 19,40% | 13,70% |
| | | | | |
| Inf | Revised | 1 | 1 | 2 |
| | Total | 11 | 2 | 13 |
| | Revision rate | 9,10% | 50,00% | 15,40% |
| | | | | |
| Tu | Revised | 0 | 1 | 1 |
| | Total | 7 | 2 | 9 |
| | Revision rate | 0,00% | 50,00% | 11,10% |
| | | | | |
| Total | Revised | 2 | 9 | 9 |
| | Total | 194 | 189 | 383 |
| | Revision rate | 1,00% | 4,80% | 2,30% |

**Table 1:** Revision rate depending on indication and patient group (via K-wire vs. w/o k-wire);

Abb. 2

| | A | A revision | B | B revision | C | C revision | D | D revision | E | E revision |
|---|---|---|---|---|---|---|---|---|---|---|
| via k-wire | 76,30% | 0,00% | 13,90% | 0,00% | 6,70% | 7,70% | 2,10% | 0,00% | 0,50% | 100,00% |
| w/o k-wire | 78,30% | 0,00% | 9,50% | 0,00% | 7,40% | 0,00% | 1,60% | 100,00% | 3,20% | 100,00% |

**Table 2:** Distribution of screws according to Gertzbein-Robbins classification with revision rate and patient group (via K-wire vs. w/o k-wire);

# P012

## *Analyse der Genauigkeit einer Software zur präoperativen Planung der sagittalen Ausrichtung bei der lateralen lumbalen interkorporellen Fusion*
## *Analysis of accuracy of a preoperative planning software for sagittal alignment in lateral lumbar interbody fusion*

M. Düster[1], J. Perrin[1], G. Rinkel[1], N. Etminan[1], F. Enders[1]

[1]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland

### Objective

The lateral approach for lumbar interbody fusion (LLIF) continues to gain popularity as a treatment strategy in lumbar fusion. It enables wider exposure of the disc space for insertion of interbody grafts than with posterior techniques. In particular when used as standalone construct or in combination with posterior percutaneous instrumentation, sagittal correction mainly relies on size and angulation of the interbody cage. Therefore, preoperative simulation and planning of implants are crucial to achieve spinal alignment and minimize postoperative complications.

This study aimed to evaluate the accuracy of a planning software (Surgimap®) in assisting preoperative planning for LLIF surgery by analyzing interbody cage selection and compare predicted changes in spinal alignment with radiographic outcomes.

### Methods

This retrospective monocenter study involved 15 patients with degenerative lumbar scoliosis and central or foraminal stenosis who underwent LLIF on 22 levels.

Segmental and lumbar lordosis as well as implant size and angulation were planned with Surgimap®. Segmental and lumbar lordosis were determined on pre- and postoperative standing radiographs and their differences were compared to the simulated parameters. A t-test was performed to compare the means of the two groups.

### Results

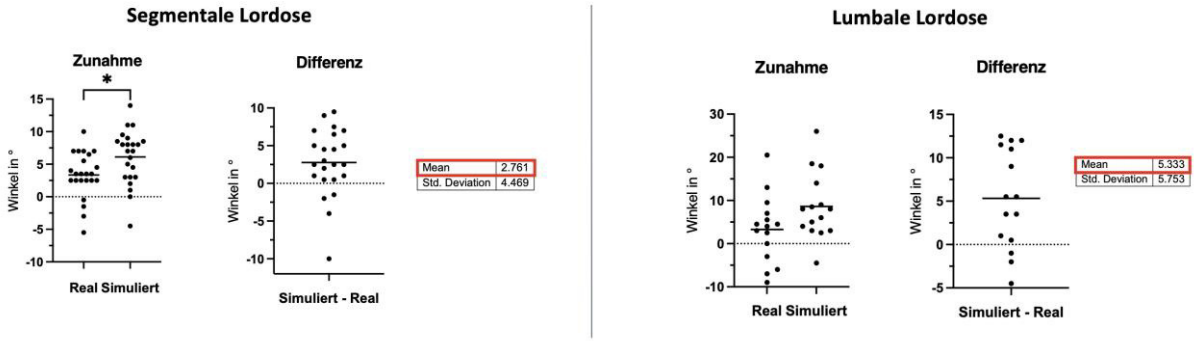
Evaluation shows that the predicted change in segmental lordosis is overstated by 2,8° on average using Surgimap® with a standard deviation of 4,5°. The difference between simulation and real results is statistically significant (p=0,01).

The change in lumbar lordosis shows a non-significant overestimation of 5,3° with a standard deviation of 5,8°.

### Conclusion

Our results show that a planning software can help in predicting the change in segmental lordosis. Since the predicted changes slightly overestimate the real outcome, this overestimation should be considered when choosing the implants. Further prospective studies, predictors of inaccuracy and larger patient cohorts are required to validate the findings.

Abb. 1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Simuliert - Real
Mean 2.761
Std. Deviation 4.469
Lumbale Lordose
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Real Simuliert
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Winkel in °
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-5
Simuliert - Real
Mean 5.333
Std. Deviation 5.753

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P013

### KI-gestützte Software zur Planung und Herstellung von patientenspezifischen Implantaten bei Korrektur adulter Deformitäten verbessert das radiographische Korrekturergebnis – Vergleich mit nicht KI-gestützter Planung und OP-Durchführung.

***AI-assisted software for planning and production of patient specific rods in adult spine deformity surgery improves radiographic correction results – Comparison with non-AI-assisted surgical planning and execution***

D. Tkatschenko[1], L. Wessels[1], N. Hecht[1], S. Bayerl[1], T. A. Sargut[1], P. Vajkoczy[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

#### Objective

Surgical planning and execution for adult spinal deformities (ASD) require profound understanding and reliable assessment and interpretation of spinopelvic parameters. We analyzed feasibility of an AI-based software for ASD surgery planning, production of patient specific rods and surgical execution and compared the results to a historical cohort where AI-based planning, rod manufacturing and surgical execution was not implemented.

#### Methods

For this study all patients were included undergoing surgery for ASD correction with use of AI-based software from October 2021 to August 2023. Preoperative whole spine x-rays were uploaded to an online platform for analysis of spinopelvic parameters followed by interdisciplinary determination of surgical correction strategy, manufacturing and implantation of patient specific rods. Spinopelvic parameters were depicted and compared to the historical cohort of the last 10 patients with correction surgery for ASD before AI implementation.

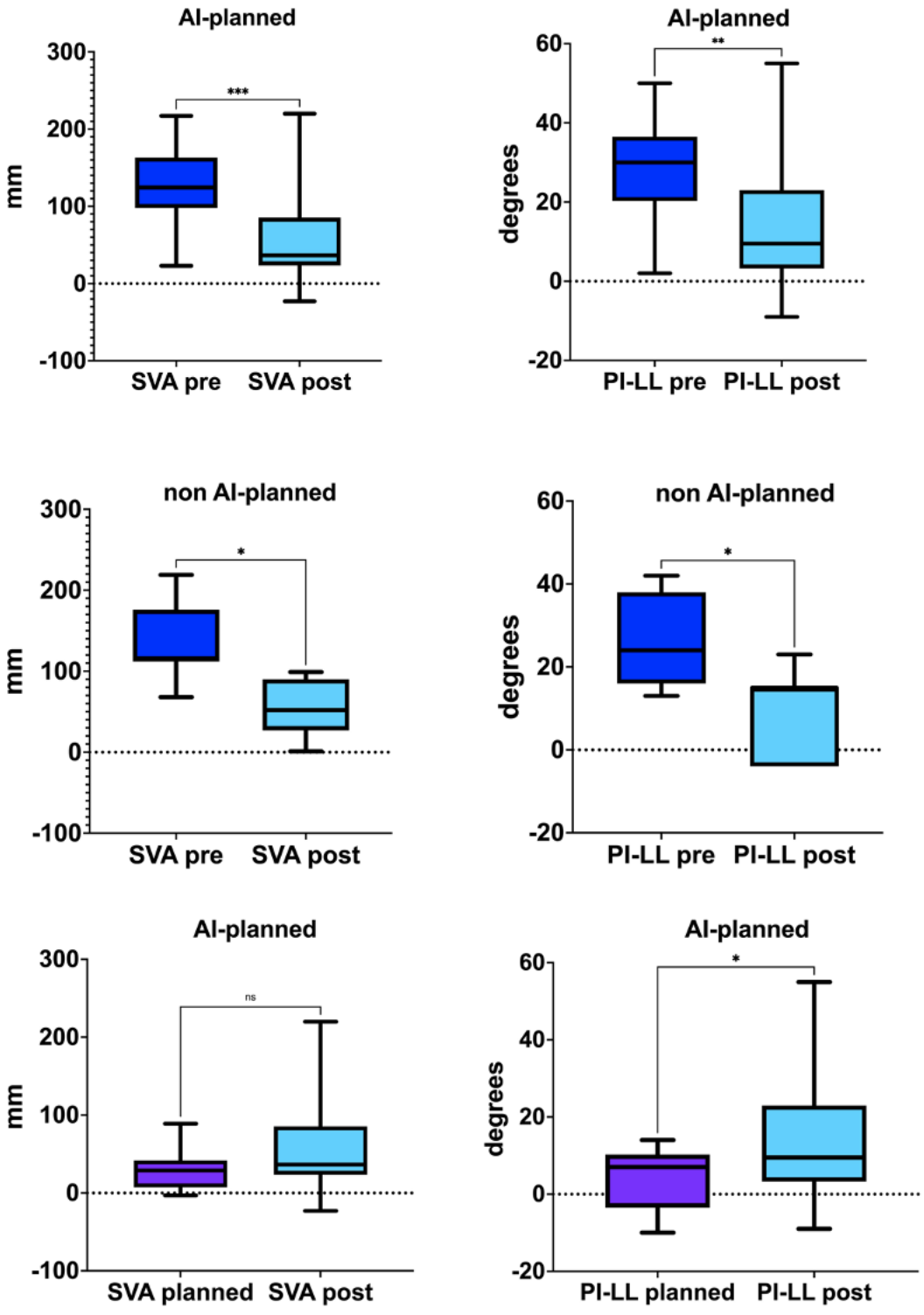
#### Results

19 patients undergoing AI-planned correction surgery (mean age 70.3 years) were identified. In all patients AI-assisted planning and rod manufacturing and implantation was feasible. 16 patients with postoperative whole spine x-rays were suitable for analysis. Highly significant reduction in SVA (*p=0.0002) and significant reduction in PI-LL (*p=0.0022) could be depicted between pre- and postoperative imaging. Difference between AI-planned and postoperative SVA was not significant (p=0.0934) whereas difference between AI-planned and postoperative PI-LL was slightly significant (*p=0.0374). The last 10 patients undergoing correction surgery before AI implementation served as historical cohort. Here, only slightly significant reduction in SVA (*p=0.0312) and in PI-LL (*p=0.0312) could be depicted between pre- and postoperative imaging. Surgical strategy with single-level correction was suggested in 94.7% of all AI-planned cases whereas in 60% of all non-AI-planned cased multi-level correction was planned and carried out.

#### Conclusion

Implementation of AI-assisted software was feasible for all cases and significant reduction in SVA and PI-LL could be depicted indicating sufficient correction execution and planning. Lower significance in postoperative SVA and PI-LL reduction in the non-AI-planned cohort indicates that AI-based planning improves radiographic correction results. AI-assisted planning prefers multi-level correction leading to more harmonic correction results compared to non-AI-based planning.

Abb. 1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# P014

## Bildwandler-gestützten perkutane posteriore Schraubenplatzierung in Seiten- und Bauchlage unter Verwendung der "tunnel view technique"

***Fluoroscopy based percutaneous posterior screw placement in the lateral and prone positions using the tunnel view technique***

G. Bodon[1], P. Richter[1], J. Degreif[1]

[1]Klinikum Esslingen, Unfallchirurgie / Orthopädie, Esslingen am Neckar, Deutschland

### Objective

Lumbar fusion using lateral single position surgery gained popularity during the last few years. Part of this technique is the percutaneous pedicle screw placement which could be done using different navigation techniques. Even if CT-based navigation or robot-assisted navigation could become the new standard, actually 70% of the surgeons still use fluoroscopy for image guided pedicle screw placement using Wiesner´s technique. This leads to variable success rates between 86-98% with high malposition rates (19.9%) even in experienced surgeons. Also the risk of violation of the cranial facet joint is high ranging between 19.4-40.2%. An alternative method is needed allowing for higher success rates in both prone and lateral positions. We describe a fluoroscopy-based navigated technique for prone and lateral percutaneous screw placement using the tunnel view technique.

### Methods

The radiologic background and principles of the tunnel view technique are described. In addition, the special positioning of the patient, the C-arm and the surgical technique is discussed in detail.

### Results

This technique is used as the standard for percutaneous screw placement in the prone or lateral positions in our department since 2017. With the use of this technique sufficient visualization of the pedicle walls and the facet joint gap during the Jamshidi neddle placement is possible. Since the introduction of this technique we had 0% reoperation rate for symptomatic malpositioned pedicle screws. On average 6 minutes is needed to insert a pedicle screw using this technique.

### Conclusion

The tunnel view technique simplifies pedicle screw placement while allowing for permanent observation of pedicle walls and the superior joint surface during placement of the Jamshidi needle. It also allows for confirmation of intrapedicular position of the screw after implantation. According to our clinical experience this technique is safe and feasible.

# Spinal – Verschiedenes 1 | Spinal – Various 1

## P015

### Das chirurgische Management der Syringomyelie im Fall der spinalen Arachnoidalzyste: klinisches und radiologisches Outcome

***Surgical management of syringomyelia associated with spinal arachnoid cyst: Clinical and radiological outcomes***

M. Gorbachuk[1], E. Weinbrenner[2], M. Tatagiba[1], S. D. Adib[1]

[1]University of Tübingen, Department of Neurosurgery, Tübingen, Deutschland
[2]University of Tübingen, Department of Neuroradiology, Tübingen, Deutschland

#### Objective

Syringomyelia associated with spinal arachnoid cyst (SAC) is a rare disease entity. This study aimed to analyze the surgical management of SAC in patients with syringomyelia, focusing on clinical and radiological outcomes.

#### Methods

A total of 135 patients with syringomyelia (not included were patients with neoplastic lesions associated with syringomyelia) underwent surgery at our department between November 2003 and December 2022. All patients underwent magnetic resonance imaging (MRI), with a special syringomyelia protocol (including TrueFISP and CINE), and electrophysiology. Among these patients, we searched for patients with SAC with syringomyelia following careful analysis of patient documents (including neuroradiological and neuropathological data, surgical reports and follow-up data). Patients were evaluated for initial symptoms, surgical strategies, and complications, furthermore clinical and radiological outcomes.

#### Results

In 17 patients (12,59%) of the 135 patients, the syringomyelia was associated with a SAC. The mean patient age was 51± 12.37 years. 12 patients were male, and 5 were female. The extension of syringomyelia involved in one case only the cervical, in nine cases the cervicothoracic, in four cases only the thoracic, in two cases the thoracolumbar and in one case the cervicothoracolumbar spinal cord. Complete removal of SAC was achieved in 16 cases, fenestration of the SAC was performed in one case. Postoperatively, one patient needed revision surgery due to spinal epidural bleeding in the level of the SAC. In first follow-up (mean duration was 3,7 months) the size of syringomyelia decreased in 16 cases (in two cases the syringomyelia was even not detectable anymore), in one case the size of syringomyelia was unchanged. Clinical symptoms improved in 15 cases and were unchanged in two cases.

#### Conclusion

In summary SACs can be safely treated by surgery. Clinical symptoms and syringomyelia improves in most cases after surgery.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P016

### Anatomische Variationen des Circulus Willisii: Eine 7-Tesla-MRT-Studie an gesunden Probanden
*Anatomical variations of the circle of willis: A 7 Tesla MRI study on healthy subjects*

L. J. Essomba Essomba[1], K. H. Wrede[1], J. Rodemerk[1], A. K. Uerschels[1], M. Darkwah Oppong[1], O. Gembruch[1], Y. Ahmadipour[1], P. Dammann[1], R. Jabbarli[1], U. Sure[1]

[1]Universitätsklinikum Essen, Neurochirurgie, Essen, Deutschland

#### Objective

The initial documentation of the Circle of Willis can be attributed to the English physician Thomas Willis, who introduced it in his groundbreaking publication, "Cerebri anatome," in 1664. Since then, the intricate angioarchitecture of the brain's arterial supply, characterized by its partially redundant arrangement and diverse variations, has been the subject of numerous studies. Much of the research has relied on cadaver examinations or observations of patients with cerebrovascular conditions. This current investigation employs non-contrast 7 Tesla MR angiography to explore Circle of Willis variations in a group of healthy volunteers, aiming to assess the prevalence of these variations in the general population.

#### Methods

In this study, 121 healthy volunteers underwent 7 Tesla MR angiography, utilizing the inherent hyperintensity of cerebral arteries at this field strength employing a non-contrast enhanced MPRAGE sequence with an isotropic resolution of 0.7 mm. The resulting images were reconstructed in both three-dimensional and multiplanar formats. Two experienced vascular neurosurgeons analyzed the images for Circle of Willis variations in consensus. The identified variations were statistically evaluated and visualized with illustrating drawings.

#### Results

Among the 121 subjects, only 38 (31%) exhibited the conventional Circle of Willis pattern. The regular pattern, along with the most common of the 30 observed variations, is schematically depicted in Figure 1. Detailed Information about the variations is presented in Table 2.

#### Conclusion

This study shows the variations of the Circle of Willis for the first time in a larger cohort of healthy volunteers using non-contrast 7 Tesla MR angiography. The data presented give a valuable insight into the assumed frequency of the most common variations of the Circle of Willis in the normal population.

Abb. 1

*Figure1*:

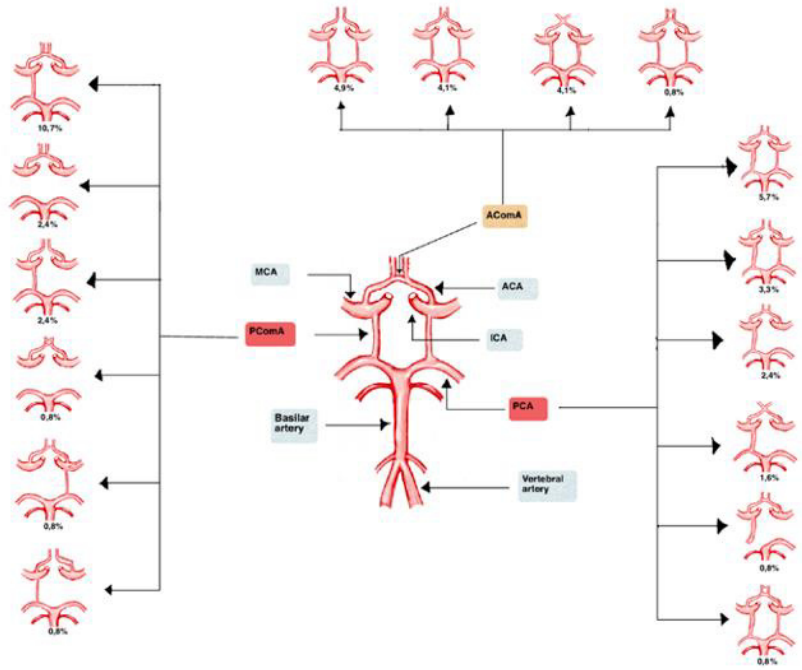



Abb. 2

*Table1*:

| | total frequency of variation | frequency by side | female / male ratio | most frequent co-variation | 2nd most frequent co-variation |
|---|---|---|---|---|---|
| PcomA aplasia | 24,8 % | R: 15,3% | R: 2 : 1 | AcomA aplasia | fusion of the ACAs |
| | | L: 6,2% | L: 1 : 1.43 | | |
| | | R&L: 3,3% | males only | | |
| PcomA hyperplasia with PCA hypoplasia | 25,4 % | R: 14,7% | R: 1 : 1.25 | AcomA aplasia | PCA aplasia |
| | | L: 7,4% | L: 2.3 :1 | | |
| | | R&L: 3,3% | R&L: 1: 1 | | |
| unilateral fetal type PCA | 14,04% | - | 1 : 1,11 | PcomA Hyperplasia with PCA Hypoplasia | - |
| AcomA aplasia | 11,5% | - | 1 : 3.33 | PcomA aplasia | PcomA hyperplasia with PCA hypoplasia |
| fusion of the ACAs | 8,2 % | - | 1 : 1.43 | PcomA aplasia | - |
| median artery of the corpus callosum | 7,4% | - | 1 : 1.67 | PcomA aplasia | - |
| bilateral fetal type PCA | 3,3 % | - | 1,4 : 1 | PcomA hyperplasia with PCA hypoplasia | - |

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P017

### Vergleich der Funktionsdiagnostik zur Beurteilung der zerebralen Reservekapazität bei der Moyamoya-Krankheit: Atemanhalte-MRT versus Goldstandard PET mit Acetazolamid

***Comparison of functional diagnostics for the assessment of cerebral reserve capacity in Moyamoya disease: Breathhold MRI versus gold standard PET with acetazolamide challenge***

P. Haas[1,2], J. Spang[1,2], M. Tatagiba[1], T. K. Hauser[3], N. Khan[1,2,4], P. Meyer[5], C. Roder[1,2]

[1]Universitätsklinikum Tübingen, Klinik für Neurochirurgie, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Zentrum für Moyamoya und cerebrale Revaskularisation, Tübingen, Deutschland
[3]Universitätsklinikum Tübingen, Department Radiologie, Diagnostische und Interventionelle Neuroradiologie, Tübingen, Deutschland
[4]Universitätskinderspital Zürich, Moyamoya Center, Zürich, Schweiz
[5]University of Freiburg, Department of Nuclear Medicine, Freiburg i. Br., Deutschland

#### Objective

The diagnosis of Moyamoya disease (MMD) is based not only on neurology but also on neuroradiological findings from angiographic (DSA) and functional cross-sectional images. The gold standard is PET imaging with acetazolamide challenge (PET-ACZ) to visualize cerebral reserve capacity (CVR). In the last years, CO2-triggered "breathhold" fMRI (bhMRI) was established as a new diagnostic tool for the evaluation of cerebral hemodynamics by depicting vasoreactivity as an indicator of CVR. We aimed to retrospectively compare a large dataset of both modalities against each other.

#### Methods

Concomitant bhMRI and PET-ACZ images were available for a total of 402 vascular territories in 67 adult patients with MMD and could be subjected to Pearson correlation analyses. Subsequently, PET-ACZ was compared with bhMRI by analyzing the area under the curve of a receiver operating characteristic (AUROC). Cut-off values of bhMRI were specified using the Youden index. The minimum signal change of the supratentorial vascular territories was set in relation to the maximum cerebellar signal change as a reference. A signal increase of <66% in the PET-ACZ was defined as the cut-off for a pathological reduction in CVR.

#### Results

Mean Pearson correlation for supratentorial vascular territories was 0.71 (95% CI 0.62 – 0.80). The highest Youden index resulted in a cut-off value of a pathologically reduced CVR at <28.2% signal increase for the bhMRI. For this threshold value, a sensitivity of 80.9% and a specificity of 83.8% with an AUC of 0.87 could be calculated for the bhMRI. Multivariate testing (arterial hypertension, nicotine abuse, diabetes, body mass index, initial MMD manifestation, gender, age) could not identify any significant predictors for height of correlation.

#### Conclusion

BhMRI is a reliable diagnostic tool for determining CVR in MMD compared to the gold standard PET-ACZ. If clinical findings, DSA and bhMRI are conclusive, the indication for revascularization can be made with this technology. Nevertheless, PET-ACZ remains the method of choice for inconclusive or borderline findings.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P018

### Vergleichende Analyse der Morphologie von intrakraniellen Aneurysmen
*Comparative analysis of the morphology of intracranial aneurysms*

W. H. Polanski[1], S. Arinrad[1], M. Lehmann[1], D. Podlesek[1], T. Juratli[1], V. Puetz[2], P. Krukowski[3], S. B. Sobottka[1], I. Y. Eyüpoglu[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Neurologie, Dresden, Deutschland
[3]Universitätsklinikum Carl Gustav Carus Dresden, Institut und Poliklinik für diagnostische und interventionelle Neuroradiologie, Dresden, Deutschland

#### Objective

Intracranial aneurysms present a complex medical challenge due to their potential to cause life-threatening hemorrhages if ruptured. In this study, we investigated the morphology of ruptured intracranial aneurysms and the influence of risk factors on aneurysm location and morphology.

#### Methods

We analyzed aneurysm height and aneurysm width of ruptured aneurysms in consecutive patients with acute subarachnoid hemorrhage who were treated at our tertiary care center between 2010 and 2020. Additionally, vascular risk factors such as hypertension, diabetes, or nicotine use and their influence on aneurysm location were evaluated.

#### Results

Among 637 ruptured aneurysms, the most common locations were the anterior communicating artery (AComA) in 29.0%, the middle cerebral artery (MCA) in 27.6%, the posterior communicating artery (PComA) in 11.2%, the supra-ophthalmic part of the internal carotid artery (ICA) in 10.9%, and the basilar artery in 6.0%. The average size (height x width) of the ruptured aneurysms varied between the vessels. The largest ruptured aneurysms were seen at the basilar artery (meadian/mean?7.6x8.9mm), while the smallest ruptured aneurysms were seen at the anterior choroidal artery(3.8x3.6mm). Ruptured aneurysms of the MCA had a median size of 6.3x6.8mm, while aneurysms at the AComA measured 4.9x6.3mm. At the PComA, the aneurysms had a median size of 5.1x6.31mm.

ANOVA analysis revealed a correlation between aneurysm location and Hunt and Hess (H&H) grade. In 63.3% of MCA aneurysms, H&H grades 4 and 5 hemorrhages were seen ($p=0.04$). In 66% of aneurysms of the PComA, H&H hemorrhages of grades 1-3 were observed ($p=0.038$). For all other aneurysms, no correlation between H&H grade and aneurysm location was found.

In aneurysms of the posterior inferior cerebellar artery, 72% were associated with Fisher grade 4 hemorrhages ($p<0.001$), while Fisher grades 1-3 hemorrhages were significantly more common in PComA aneurysms, observed in 82.1% of cases ($p<0.001$).

No correlation could be found between hypertension, diabetes, nicotine abuse, or coronary heart disease and a specific aneurysm location.

#### Conclusion

This study highlights significant variations in size and location of ruptured intracranial aneurysms, with notable correlations to H&H grades in specific areas. No association was found between vascular risk factors and aneurysm location, emphasizing the need to focus on anatomical aspects in their treatment and management.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P019

### Entwicklung und Charakterisierung von tierfreien Chip-basierten vaskulären Organoiden zur Etablierung eines in-vitro Modells der Moyamoya-Krankheit

***Development and characterization of xeno-free chip-based vascular organoids to establish an in-vitro model of the Moyamoya Disease***

R. Mertens[1,2], H. Gerhardt[3], P. Vajkoczy[1], A. Nitzsche[4]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, BIH Charité Junior Clinician Scientist Program, Berlin, Deutschland
[3]Max-Delbrück-Centrum für Molekulare Medizin (MDC), Integrative Vaskuläre Biologie, Berlin, Deutschland
[4]Charité – Universitätsmedizin Berlin, Experimentelle Neurochirurgie, Berlin, Deutschland

#### Objective

Chip-based vascular organoid models offer the opportunity of providing both, an alternative to animal experimentation and a more reliable bench-to-bedside translation for the study of neurovascular diseases, such as the Moyamoya disease. However, these models often still rely on animal-derived products which, apart from causing animal suffering, may negatively influence the translatability to human conditions. Here, we aimed to develop a completely xeno-free human microvasculature-on-a-chip model.

#### Methods

Three major steps of the protocol containing animal products had to be addressed: routine cell culture of endothelial cells and pericytes, culture of the cells in the microfluidic chip and the immunofluorescence staining.

#### Results

We found that human umbilical vein endothelial cells (HUVECs) could readily be cultured in xeno-free medium. Intriguingly, HUVECs under xeno-free conditions showed a more homogenous morphology compared to the standard, animal-product containing culture conditions, highlighting the benefit of replacing animal products. The adaptation of the microvasculature-on-a-chip model proved to be challenging. While initial vessel-like networks formed quickly, these vessels were less stable after several days in the xeno-free protocol compared to the standard protocol. This challenge was overcome by reducing the amounts of growth factors and human serum in the xeno-free medium applied on the chip, resulting in stable vessels. High quality immunofluorescence staining was possible with xeno-free commercial blocking buffers and recombinant antibodies. As an increasing number of recombinant antibodies are becoming commercially available, it is feasible to replace all animal-derived antibodies in the future. However, the combination of antibodies that can be used in parallel is currently still limited due to the predominant rabbit-IgG form of the available recombinant antibodies and the lack of directly fluorophore-conjugated antibodies. The organoid model was further adapted to study the Moyamoya Disease by introducing RNF213 mutated endothelial cells into the chip, which formed a stable microvascular network.

#### Conclusion

In summary, we have successfully established a completely xeno-free human microvasculature-on-a-chip model. This model can be adapted to study vascular biology and specific neurovascular diseases, such as the Moyamoya Disease.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P020

### Vorteile der anatomischen Visualisierung mit VR-Technologie bei Patienten mit mikrovaskulären Konflikten
***Advantages of anatomical visualisation with VR technology in patients with microvascular conflicts***

S. Zawy Alsofy[1,2], M. Nakamura[2,3], T. Fortmann[1,2], E. Wilbers[1,2], M. Lewitz[1,2], C. Ewelt[1], A. Salma[4], I. Sakellaropoulou[1], R. Stroop[2]

[1]St. Barbara-Klinik Hamm-Hessen, Neurochirurgie, Hamm, Deutschland
[2]Witten/Herdecke University, Department of Medicine, Faculty of Health, Witten, Deutschland
[3]Academic Hospital Koeln-Merheim, Neurochirurgie, Köln, Deutschland
[4]St. Rita's Neuroscience Institute, Department of Neurosurgery, Lima, OH, Vereinigte Staaten

#### Objective

Trigeminal neuralgia (TN) is a lightning bolt of violent, electrifying, and stinging pain, often secondary to the neurovascular conflict (NVC). The vessels involved in NVC are mostly arteries and rarely veins. Evaluation of NVC in the deep infratentorial region is inseparably connected with cranial imaging. We retrospectively analyzed the potential influence of three-dimensional (3D) virtual reality (VR) reconstructions compared to two-dimensional (2D) magnetic resonance imaging (MRI) scans on the evaluation of NVC for the surgical planning of microvascular decompression in patients with TN.

#### Methods

Medical files were retrospectively analyzed regarding patient- and disease-related data. Preoperative MRI scans were retrospectively visualized via VR software to detect the characteristics of NVC. A questionnaire evaluated the influence of VR visualization technique on identification of anatomical structures involved in NVC and on surgical strategy.

#### Results

Twenty-four patients were included. Image presentation using 3D-VR modality significantly influenced the identification of the affected trigeminal nerve (p=0.004), the vascular structure involved in the NVC (p=0.0002), and the affected side of the trigeminal nerve (p=0.005).

#### Conclusion

In patients with TN caused by NVC, the reconstruction of conventional preoperative 2D-MRI scans into 3D images and the spatial and anatomical presentation in VR models offers the possibility of increased understanding of the anatomy and pathology, and thus influences operation planning and strategy.

Abb. 1

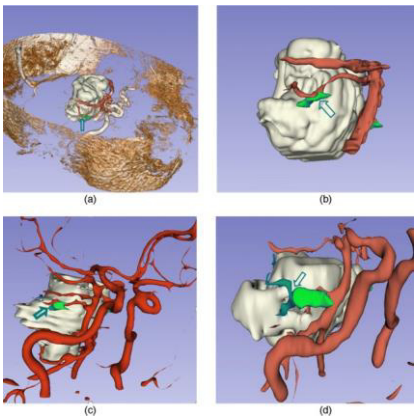
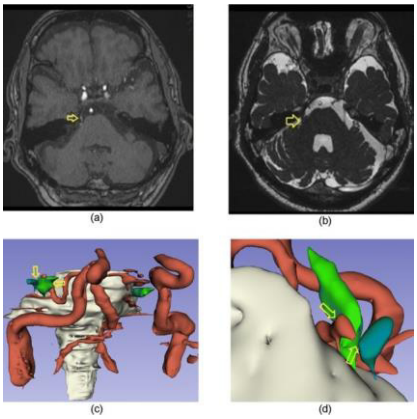


Abb. 2



# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P021

### Funktionelles Ergebnis nach erster und mehrfacher intrazerebraler Blutung bei Patienten mit einer kavernösen Hirnstamm-Malformation

***Functional outcome after initial and multiple intracerebral hemorrhage in patients with a brainstem cavernous malformations***

A. N. Santos[1], L. Rauschenbach[1], H. H. Gull[1], T. F. Dinger[1], Y. Ahmadipour[1], R. Jabbarli[1], K. H. Wrede[1], U. Sure[1], P. Dammann[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie, Essen, Deutschland

#### Objective

Brainstem cavernous malformations (BSCM) can be related to spontaneous intracerebral hemorrhage (ICH). The aim of this study was to assess the natural course of disease and to identify predictors of functional neurological outcome after single and multiple bleeding events.

#### Methods

We included BSCM patients with complete baseline characteristics, MRI dataset, ≥1 ICH, and ≥1 follow-up examination treated between 2003 and 2022. Functional neurological outcome was obtained using the modified Rankin Scale (mRS) at diagnosis, before and after each ICH, and last follow-up.

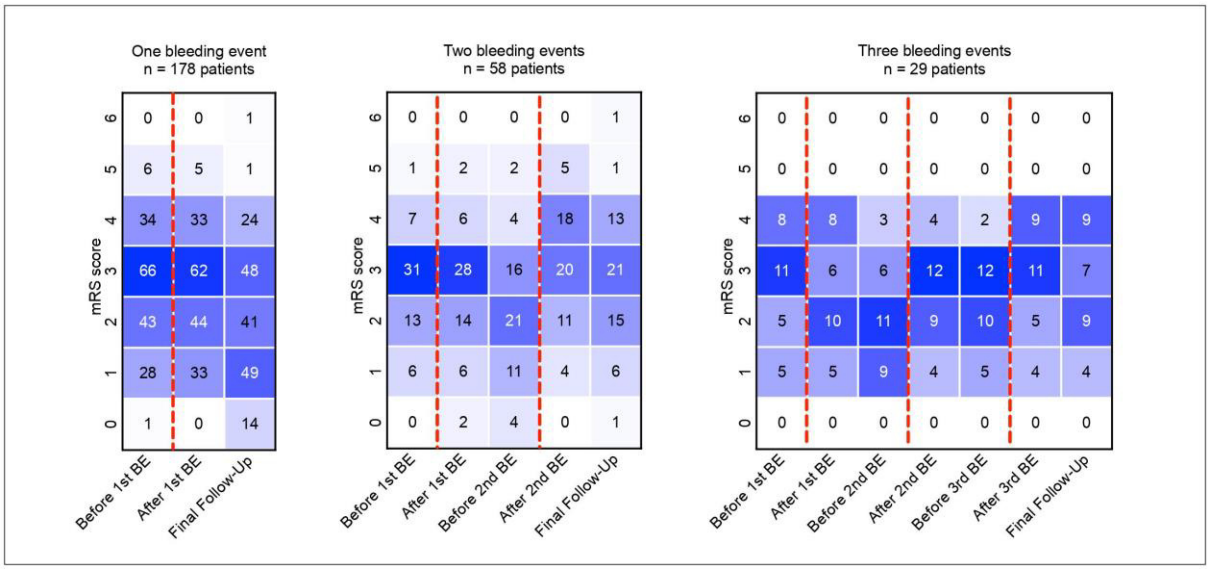
#### Results

A total of 265 patients were included. Functional neurological outcome deteriorated in 40.2% ($P$=0.003) after the second bleeding event and in 44.8% ($P$ =0.038) after the third bleeding event. Moreover, the functional neurological status was reduced in 15.8% ($P$<0.001) of patients at last available follow-up compared to the time of BSCM diagnosis.

#### Conclusion

ICH due to a BSCM generally implies neurological deterioration. Our study shows that functional outcome tends to improve after each bleeding event, but with each ICH the chance of full recovery decreases. Bleeding was significantly associated with neurological deterioration compared to initial ICH. This deterioration is further accentuated after subsequent hemorrhagic events.

Abb. 1


One bleeding event
n = 178 patients
Two bleeding events
n = 58 patients
Three bleeding events
n = 29 patients
mRS score
Before 1st BE
After 1st BE
Before 2nd BE
After 2nd BE
Before 3rd BE
After 3rd BE
Final Follow-Up

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P022

### Direkte orale Antikoagulation (DOAC) und Plättchenhemmung (PAI) bei intrakraniellen Blutungen - Analyse einer prospektiv gesammelten Datenbank

***Direct Oral Anticoagulation (DOAC) and Platelet Inhibition (PAI) in intracranial hemorrhages – Analysis of a Prospectively Collected Database***

O. Petr[1], P. Geiger[1], G. Tschiderer[1], C. Preuss-Hernandez[1], C. Thomé[1]

[1]Medizinische Universität Innsbruck, Universitätsklinik für Neurochirurgie, Innsbruck, Österreich

#### Objective

The role of direct oral anticoagulants (DOAC), acetylsalicylic acid (ASA), clopidogrel, and vitamin K antagonists (VKA) in relation to intracranial hemorrhages is inadequately defined. Although DOACs are known for their ease of use, their real impact on the surgical risk and outcomes of in patients with intracranial hematomas following surgical evacuation remains unclear.

#### Methods

In this single-center study, 359 consecutive patients over 18 years old with surgically treated intracranial hemorrhage were included. All related data including demographics, type of medication (i.e., DOAC, VKA, ASA, Clopidogrel), laboratory values, administration of blood products and antidotes as well as long-term clinical outcomes after 3/6 months were collected.

#### Results

Among the 359 predominantly male patients (56%), 17 took DOAC, 72 ASA, 24 VKA, and 9 clopidogrel. Univariate analysis showed a detrimental impact of these medications on clinical outcomes ($P<0.001$). After adjusting for age, sex, laboratory values, and blood products in the multivariate analysis, DOAC and VKA lost their statistical significance. Age, red blood cell count, and INR at the time of surgery were strongly associated with clinical outcome ($P<0.001$ and $P=0.01$, respectively). In univariate analysis, administered blood products and anticoagulation-correcting medications were associated with a worse outcome.

#### Conclusion

The study demonstrated that all DOAC, platelet aggregation inhibitors (PAI), and VKA have relevant impact on clinical outcomes. Yet, importantly, both INR and red blood cell count appeared to be indicative of treatment risk and outcome, not the anticoagulation medication directly.

DOAC, VKA, and PAI seem not to be the primary risk factors of unfavorable outcomes in intracranial hematoma patients after hematoma evacuation. Rather, albeit indirectly associated with the administered anticoagulation medication, age, red blood cell count, and INR play more indicative role for outcome prediction.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P023

### Cortical Spreading Depolarization bei der chirurgischen Behandlung von zerebralen arteriovenösen Malformationen und arteriovenösen Fisteln

***Cortical spreading depolarization during surgical management of cerebral arteriovenous malformations and arteriovenous fistulas***

P. Dömer[1,2], S. Helgers[1,2], F. Meinert[1], M. Said[1], R. Sanchez-Porras[1], C. Mathys[3,2], J. Woitzik[1,2]

[1]Carl-von-Ossietzky Universität Oldenburg, Department of Neurosurgery, Oldenburg, Deutschland
[2]Carl von Ossietzky University Oldenburg, Research Center Neurosensory Science, Oldenburg, Deutschland
[3]Evangelisches Krankenhaus Oldenburg, Department of Radiology and Neuroradiology, Oldenburg, Deutschland

#### Objective

Spreading Depolarization (SD) is characterized by a wave of neuronal and astrocytic mass depolarization, causing severe disruptions in ion homeostasis and leading to altered local cerebral blood flow. This phenomenon is notably linked to the secondary progression of lesions in acute pathologies such as traumatic brain injury, hemorrhagic stroke, and cerebral ischemia.

Cerebral arteriovenous malformations (AVMs) and arteriovenous fistulas (AVF) represent pathological vascular anomalies characterized by abnormal arterio-venous anastomoses, bypassing the typical intervening capillary network. This results in altered hemodynamics and an increased risk of hemorrhage. Despite the description of SD in chronic diseases like migraine and Moyamoya disease, there is currently no direct evidence for the occurrence of SDs in patients with AVMs or AVFs.

#### Methods

Using intraoperative Laser Speckle Contrast Imaging, cortical perfusion was recorded in nine patients undergoing surgical AVM resection and two patients with surgical AVF treatment.

#### Results

Interestingly, spontaneous SD activity was observed in 2 patients. One patient was undergoing AVM resection, whereas the in the other patient, a AVF was surgically treated. Within those two patients, at least 4 SDs were observed and all SDs were associated with local hyperperfusion.

#### Conclusion

By employing intraoperative laser speckle perfusion measurement, spontaneous intraoperative SD activity was observed for the first time during the treatment of AVM and AVF. SDs could potentially be triggered by the altered hemodynamics induced by surgical interventions. Furthermore, SD might play a role in the pathomechanism of symptoms related to AVM and AVF and should be considered in the postoperative phase of these pathologies.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P024

### Retrospektive Analyse von Risikofaktoren und der Häufigkeit von Blutungen bei Kavernomen
*Retrospective analysis of risk factors and bleeding incidence in cavernoma*

A. Guranda[1], T. Wende[1], E. Güresir[1], U. Nestler[1]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland

### Objective

Hemorrhagic events in cavernous malformations (CCM) are linked to significant morbidity and mortality. Identifying factors contributing to bleeding is crucial for effective clinical and surgical management. This retrospective study aims to analyze potential risk factors for bleeding in patients with cavernomas.

### Methods

This is a retrospective observational single-center study. Our aim was to examine potential and known risk factors for bleeding, such as age, gender, smoking habits, arterial hypertension, antithrombotic medication, diabetes mellitus, cavernoma shape, size changes in follow-up MRIs, and the occurrence of epileptic seizures.

### Results

We included 143 patients (43% male, 46% with hemorrhagic events, 20% with epileptic seizures). Anticoagulation was inversely related to the frequency of hemorrhage (21% versus 50%, p=0.008). Gender, arterial hypertension, diabetes mellitus, or seizures were not associated with bleeding events. However, statistical significant correlation was observed in relation to bleeding events for irregular cavernoma shape ($p<0.001$) and changes in cavernoma size during follow-up (p=0.001), as well as for smoking (p=0.03). In multivariate linear regression, only anticoagulation ($p = 0.045$) and growth ($p = 0.006$) were significantly associated with cavernoma hemorrhage.

### Conclusion

We observed a reduced percentage of bleeding in cavernoma patients utilizing antithrombotic agents, compared to patients without antithrombotic medication. Factors such as smoking habits, irregular cavernoma shape, and changes in size during follow-up were associated with higher frequency of bleeding events.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P025

### Konservative Behandlung von 661 Patient*innen mit unrupturierten, intrakraniellen Aneurysmen: eine Risikofaktorevaluierung über vier Dekaden

***Conservative management of 661 patients with unruptured intracranial aneurysms: A risk factor evaluation over four decades***

P. Lederer[1], B. Ecker[1], M. Dogan[1], D. Hirschmann[1], W. T. Wang[1], A. Hosmann[1], A. Cho[1], E. Strasser[1], K. Rössler[1], C. Dorfer[1], A. Gruber[2], G. Bavinzski[1], P. Dodier[1], J. Frischer[1]

[1]Medizinische Universität Wien, Universitätsklinik für Neurochirurgie, Wien, Österreich
[2]Kepler Universitätsklinikum, Universitätsklinik für Neurochirurgie, Linz, Österreich

#### Objective

The decision-making process in the management of unruptured intracranial aneurysms is complex and multifactorial. Our study evaluates the natural history of intracranial aneurysms and identifies risk factors for aneurysm rupture.

#### Methods

All patients who first presented to our department between 1984 and 2020 with the diagnosis of at least one unruptured intracranial aneurysm were included. Of 4715 patients, 661 patients (14%) with 767 aneurysms were assigned conservative management for various reasons. To identify risk factors for aneurysm rupture and growth both patient-based and aneurysm-based analyses were performed.

#### Results

Of the overall study population, 66% were female. Aneurysms were predominantly located in the anterior circulation and had a median size at diagnosis of 5mm. For 23 patients, aneurysm rupture was reported during the conservative observation period, leading to a calculated annual hemorrhage rate of 0.6%. Patients who experienced rupture were significantly older and their aneurysms larger, symptomatic, and often partially thrombosed at diagnosis compared to patients without aneurysm rupture. ELAPSS-score and PHASES-score were found to reliably predict aneurysm growth and rupture.

#### Conclusion

The natural history of unruptured intracranial aneurysms may vary substantially depending on several patient- and aneurysm-specific risk factors. Thus, in the management of unruptured intracranial aneurysms, the patient"s individual aneurysm rupture risk has to be carefully weighed against the center specific treatment outcome and complication rates.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P026

### Mikrochirrugische Klippung eines großen MCA Aneurysmas bei einem 3 Monate alten Säugling: Fallpräsentation und Literatur Review

***Surgical therapy of a large ruptured MCA Aneurysm in a 3-month-old infant: Case report and review of the literature***

D. Hirschmann[1], A. Cho[1], J. Shawarba[1], K. Novak[1], C. Dorfer[1], G. Bavinzski[1], M. Niederle[1], K. Rössler[1]

[1]Medizinische Universität Wien, Neurochirurgie, Wien, Österreich

#### Objective

A case of a 3-month-old infant suffering from spontaneous subarachnoid hemorrhage (SAH) from a 15 mm distal M2 aneurysm is reported.

#### Methods

No history of familiar genetic vascular disease history, infection or trauma was evident. Aneurysm rupture happened in a so far healthy and normally developed 3-month-old female infant. Sudden screaming followed by loss of consciousness lead to urgent hospitalization and performance of head ultrasound, CCT and MRI. SAH and a left insular hematoma was diagnosed. A 15 mm M2 aneurysm at the distal insula was identified by CTA as the origin of the hemorrhage.

#### Results

Interdisciplinary endovascular- microvascular counselling within our vascular working group was performed and pro and cons as well as risks of endovascular versus open microsurgical therapy were weighted. Open surgery was chosen for aneurysm therapy and after insertion of an EVD, trap ligation and excision of the aneurysm via a fronto-temporal osteoplastic craniotomy was performed. The postoperative course was uneventful and no ICP crises or vasospasm occurred, with daily CSF drainage of about 20 ml. In a postoperative CT scan only a small ischemic brain area at the angular region distal to the excised aneurysm was diagnosed showing no significant brain swelling. Weaning and extubation of the infant was possible 10 days after surgery with no apparent neurological deficits detected. Dismission to the hometown hospital was possible 20 days after surgery.

#### Conclusion

Aneurysmal SAHs in infants up to 3 months of age are exceedingly rare, only about 20 cases are reported in the literature with the MCA being the most common location. Preservation of the parent vessel is usually not feasible neither by endovascular, nor by open surgical approach, mainly due to aneurysm morphology and a mismatch in size between vessels and aneurysm. Hence, endovascular or surgical trapping of the aneurysm is the treatment of choice. Fortunately, collateral vascularization at this young age seems to be capable to impede large clinically relevant strokes as our case had demonstrated.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P027

### Evaluierung präoperativer Low-Flow Areas bei STA-MCA-Bypass unter Verwendung von 3D-Color Map Fusion Images

***Evaluation of preoperative low-flow areas in STA-MCA bypass surgery using 3D color map fusion images***

R. Tanaka[1], D. Jankovic[1,2], K. Sasaki[1], T. Takamitsu[1], Y. Yamada[1], F. Komatsu[1], Y. Kato[1]

[1]Fujita Health University Bantane Hospital, Department of Neurosurgery, Nagoya, Japan
[2]University Medical Center, Department of Neurosurgery, Mainz, Deutschland

#### Objective

The identification and understanding of low-flow areas play a crucial role in surgical planning and outcome assessment. Low-flow areas, characterized by compromised blood supply, are significant factors that can influence the success of the bypass surgery. The Target Bypass Method allows surgeons to select the most suitable anastomosis vessel for STA-MCA bypass surgery using high-resolution fusion images. While the TB method can identify the morphologically optimal site for anastomosis, additional validation is necessary to identify the ideal anastomosis location and select the most appropriate vessel for anastomosis among the relevant vessels in the region with diminished blood flow. The objective of our study is to assess preoperative low-flow areas in STA-MCA bypass surgery using 3D Color Map Fusion Images.

#### Methods

We conducted a retrospective analysis of patients who underwent STA-MCA bypass at the Department of Neurosurgery, Fujita Health University Bantane Hospital, spanning from August 2022 to March 2023.Preoperative computed tomography (CT) angiography and perfusion imaging with magnetic resonance imaging (MRI) was conducted to detemine cerebral blood flow in the bypass area. Using 3D Visualization Analysis Software Amira (Amira®; Thermo, Tokyo, Japan), we constructed 3D Perfusion images. For the identification of preoperative low-flow areas, we utilized CT Perfusion, 3D Computed Tomography Angiography (3D CTA), and Digital Subtraction Angiography (DSA) to reconstruct the Vascular Flow Map (VFM).

#### Results

Our study comprised eight patients who underwent STA-MCA bypass procedures at our department. Postoperatively, the patency of the STA-MCA bypass was confirmed in all cases, and there were no occurrences of hyperperfusion syndrome, infarction, or bleeding. The VFM scores ranged from 0.71 to 1.57 for Mean Transit Time (MTT) and from -0.29 to 1.71 for Delay Time (DLY). In three out of the eight cases, both MTT and DLY scores exceeded 1. In four cases, either MTT or DLY scores surpassed 1. In the remaining case, both MTT and DLY scores were below 1.

#### Conclusion

With the advancement of the ATB method, preoperative blood flow assessment and accurate recipient selection have become possible. This method not only provides surgeons with a morphological assessment but also offers insights into anatomical interrelationships. Future studies should focus on exploring optimal anatomical locations based on a larger sample size.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P028

### Versorgungsstrukturen bei Patienten mit einer Moyamoya-Erkrankung basierend auf Qualitätsberichten deutscher Krankenhäuser

***Treatment trend and care structures in patients with moyamoya disease using the quality reports of German hospitals***

N. Dinc[1], S. Y. Won[2], C. Senft[1], M. A. Kamp[3]

[1]Universitätsklinikum Jena, Neurochirurgie, Jena, Deutschland
[2]Universitätsklinikum Rostock, Neurochirurgie, Rostock, Deutschland
[3]Universitätsklinikum Brandenburg, Berlin, Palliativmedizin, Rüdersdorf bei Berlin, Deutschland

#### Objective

Moyamoya disease (MMD) is a rare cerebrovascular disorder characterized by progressive narrowing and occlusion of the internal carotid arteries, leading to formation of abnormal collateral vessels. An extracranial-intracranial (EC-IC) bypass is an established treatment for MMD. Nevertheless, diagnosis and the use of EC-IC bypass is considered critically in Germany and treatment is limited to few large centers. This study aims to determine the number of patients with MMD who were treated in Germany between 2019 and 2022.

#### Methods

We evaluated caseloads, medical supply structures and distributions of MMD patients in Germany in a retrospective fashion using national wide data bank obtained from the quality reports of German hospitals covering the years 2019 to 2022. All patients diagnosed with I67.5 were selected. Age, treatment methods, mortality and hospital type were recorded and data underwent statistical analysis.

#### Results

In total, 3260 patients were identified with the code I67.5, 1020 (31.3%) were male and 2240 (68.7%) were female. Most of the patients age ranged between 30 to 49 years (37.2%). Overall mortality was 1.8% without statistical significance in sex distribution (male 31.1% vs female 68.9%, p=0.89). 39 (1.2%) females with MMD were pregnant and received cesarean section. In 1822 (55.9%) cases, patients underwent treatment in public hospitals/university hospitals and microsurgical revascularization was performed in 661 (20.3%) patients. A re-surgery was necessary in 25 (0.8%) cases and additional cerebral aneurysms were found in 34 (1.0%) cases.

#### Conclusion

MMD mostly affects young patients and females are more often affected than males. Mortality among females is high and assessing predictive factors play a significant role in treatment. In order to understand MMD and ensure the best medical care, a national wide network is required.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P029

### Risikobewertung von klinischem Outcome bei der Behandlung von nicht-rupturierten, intrakraniellen Aneurysmen: Evaluierung der PHASES-, ELAPSS- und UIATS-Scores im klinischen Alltag

***Risk assessment of clinical outcome in the treatment of unruptured intracranial aneurysms: Appraisal of PHASES, ELAPSS, and UIATS scores in a daily clinical practice***

P. Geiger[1], C. Preuss-Hernandez[1], C. Thomé[1], O. Petr[1]

[1]Medizinische Universität Innsbruck, Universitätsklinik für Neurochirurgie, Innsbruck, Österreich

#### Objective

The clinical management of unruptured intracranial aneurysms (UIA) requires a balance between the risks of treatment and the consequences of potential aneurysm rupture. Risk assessment scores such as PHASES, ELAPSS, and UIATS provide quantitative evaluations of rupture and growth risks, thus supporting decision-making. However, their predictive value for postoperative outcomes remains uncertain.

#### Methods

In this single-center study, aneurysm characteristics and common risk assessment scores were collected for patients with UIA. The focus was on the predictive value for the risk of poor postoperative outcomes. From January 2010 to January 2021, 378 patients were included. Clinical outcomes were assessed using the modified Rankin scale (mRS).

#### Results

The cohort of 378 patients was predominantly female, with an average age of 54.8 years. The average aneurysm diameter was 8.03 mm, with most being saccular. PHASES and UIATS achieved statistical significance in predicting poor clinical outcomes ($P<0.05$), and all 3 scores were able to predict the increased risk for new neurological deficits postoperatively ($P<0.05$). Age was a significant factor for postoperative neurological deficits and worse clinical outcome ($P<0.03$), while aneurysm size was significant for new neurological deficits ($P=0.01$).

#### Conclusion

Scoring systems that allow for surgical risk estimation are still lacking. While the ELAPSS score was effective in predicting immediate postoperative complications, it was less predictive for long-term clinical outcome. The PHASES and UIATS scores showed significant predictive value for both new neurological deficits and overall clinical outcome. Aneurysm size seems to be a significant predictor of postoperative morbidity, while the presence of intraluminal thrombi or multiple aneurysms did not increase postoperative morbidity.

Our study highlights the potential role of PHASES, ELAPSS, and UIATS scores in the preoperative assessment of UIA and provides valuable insights for surgical risk assessment, aiming to improve clinical decision-making and patient outcome.

# Vaskuläre Neurochirurgie – Verschiedenes 1 | Vascular Neurosurgery – Various 1

## P030

### Unterschiedliche Zugangswege für die gleiche Aneursmalokalisation: Simulationtraining in der vaskulären Neurochirurgie

*Different approaches for the same aneurysm: Simulation training in vascular neurosurgery*

A. Amini[1], V. M. Swiatek[1], F. Taskaya[1], S. Al-Hamid[1], J. Reiser[1], K. P. Stein[1], A. Rashidi[1], I. E. Sandalcioglu[1], B. Neyazi[1]

[1]Otto-von-Guericke-Universität Magdeburg, Universitätsklinik für Neurochirurgie, Magdeburg, Deutschland

#### Objective

Surgical approaches in vascular neurosurgery are typically guided more by established methods than by specific pathologies. Modern and established simulators, however, offer the opportunity to train diverse strategies, thus shifting the focus towards vascular pathologies in determining the surgical approach. In this context, we present an effective phantom model designed for clipping aneurysms in the anterior circulation. This model facilitates training in various approaches to identical aneurysms, thereby allowing for an in-depth evaluation of the nuances inherent in different surgical access routes.

#### Methods

The simulator, developed with 3D software, features realistic, reusable phantoms of the skull, brain, and cerebral vessels, crafted using additive manufacturing and expert neurosurgical input. It facilitates training in clipping anterior circulation aneurysms. Its effectiveness and educational value were assessed by twelve neurosurgeons and quantified using objective metrics by senior neurosurgeons.

#### Results

The subjective evaluation, derived from a 5-point-Likert scale, yielded high face and content validities across all categories, with a mean score of 4.9/5. Objective assessments indicated that the simulator accurately reflected the skills of the participants, demonstrating high construct validity. Novice participants exhibited a rapid and significant acceleration in confidence and acquisition of surgical skills, indicating high predictive validity and transferability of the training.

#### Conclusion

The simulator, replicating the tactile properties of the brain and vasculature, effectively enhances vascular neurosurgery training. It enables varied approaches for managing anterior circulation aneurysms, offering high realism and cost-effectiveness. Proven to improve surgical skills, it accelerates the learning curve and safely allows testing of new techniques. Further integration into training programs is necessary to maximize its impact.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P031

### Anwendbarkeit und Stellenwert der stimulierten Raman Histologie in der Epilepsiechirurgie kortikaler Malformationen

***Applicability and value of intraoperative stimulated Raman histology for epilepsy surgery of cortical malformations***

J. M. Nakagawa[1], D. Saifi[1], C. Donkels[2], C. Scheiwe[3], J. Strähle[3], N. Neidert[3], J. Beck[3], U. Häussler[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Translationale Epilepsieforschung, Freiburg i. Br., Deutschland
[2]Universitätsklinikum Freiburg, Sektion Grundlagen epileptischer Erkrankungen, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[3]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Intraoperative SRH is applicable for near real-time tissue analysis of cortical malformations following an adjusted workflow. Core diagnostic elements, i.e. cortical architecture and layering, neuronal orientation and atypical cell types, can be detected. Correlation with standard diagnostic techniques remains essential for future assessment of the diagnostic value of this promising alternative in epilepsy surgery of cortical malformations.

#### Methods

Overall 61 SRH images from cortical samples of 28 patients were analyzed using a Raman imaging system (Invenio Imaging Inc.). N=21 patients underwent tailored, navigation-guided lesionectomy due to intractable epilepsy with and without cortical malformation, for comparison normal access tissue to distant lesions (n=8) was analyzed. The established technique for near real-time SRH so far has been optimized for tissue analysis in tumor surgery using squash preparation. For analysis of cortical integrity or malformation, however, tissue collection and preparation require certain consideration. We advanced the workflow of tissue preparation within the operation tract, slicing cortical samples on a vibratome for immediate label-free SRH analysis. For diagnostic neuropathological correlation, the scanned tissue slice and adjacent samples were H&E-stained and immunolabelled (NeuN, neurofilament H (SMI-32), Calretinin, Parvalbumin, Vimentin, glial fibrillary acidic protein).

#### Results

Our newly established workflow enables the application of intraoperative, near real-time SRH for the assessment of cortical integrity or malformation. The sliced tissue preparation enables label-free identification of cortical architecture and layering, axonal directionality, the gray-white matter boundary, and atypical cell types. To estimate the diagnostic value of this innovative technique for complementary intraoperative decision-making and classification of pathology, the unconventional H&E-based neuropathological diagnostic of FCD requires further training integrating standard immunolabelling.

#### Conclusion

Intraoperative SRH is applicable for near real-time tissue analysis of cortical malformations following an adjusted workflow. Core diagnostic elements, i.e. cortical architecture and layering, neuronal orientation and atypical cell types, can be detected. Correlation with standard diagnostic techniques remains essential for future assessment of the diagnostic value of this promising alternative in epilepsy surgery of cortical malformations.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P032

### Cirq-robotikgestützte stereotaktische Biopsie und stereotaktische Elektroenzephalographie (sEEG) in Kombination mit robotergesteuertem Kegelstrahl-CT (Artis Pheno) zur Bildregistrierung

***Cirq-robotic arm assisted stereotactic biopsy and stereotactic electroencephalogaphy (sEEG) in combination with the Artis Pheno robotic cone-beam CT for image registration***

P. Truckenmüller[1], M. Misch[1], P. Vajkoczy[1], J. S. Onken[1,2,3], R. Xu[1,3,4]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Deutsches Konsortium für Translationale Krebsforschung (DKTK), Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Berlin Institute of Health (BIH) Charité, Berlin, Deutschland
[4]Deutsches Zentrum für Herz-Kreislauf-Forschung e.V., Berlin, Deutschland

#### Objective

The Cirq® Surgical System serves as an automated robotic alignment tool for cranial procedures with cranial navigation. Unlike traditional surface matching, integrating patient-to-image registration through intraoperative cone-beam CT might enhance accuracy. In this study, we delineate our experience with the Cirq-robotic arm for stereotactic biopsies and stereotactic electroencephalography (sEEG) using the Artis Pheno robotic cone-beam CT as a registration tool.

#### Methods

This retrospective analysis included 11 patients undergoing stereotactic biopsy (n=9) or sEEG (n=2) with the Cirq® system from January 2023 to January 2024. For patient-to-image registration, the Cirq® was mounted, and an external registration Matrix was positioned near the patient's head prior to conducting cone-beam CT with the robotic Artis Pheno. Following registration, the CT dataset was fused with the preoperative MRI, and used as the navigation data set. Demographic and clinical data were evaluated.

#### Results

In 11 Cirq-robotic arm assisted surgeries, 8 cases were combined with robotic cone-beam CT for image registration. Among these, 6 patients had biopsies with median 7 (6.7-7) specimens, and 2 underwent sEEG with 12 depth electrodes. The median age was 54 (IQR 32-80), with an equal male-to-female ratio. Median lesion size was 25 (8-41) $cm^3$ on contrast enhanced T1 and 45 (15-59) $cm^3$ on T2 weighted imaging. Histological results were obtained for all biopsy cases. Fluorescein, confirming accurate biopsy location, was used in 4 cases and showed positivity in 75% of biopsy specimens (21/28). Median operating room times were 147 (123-151) minutes for biopsies, and 360 (339-380) minutes for sEEG procedures. Incision-to-closure times were 30 (27-37) and 236 (225-301) minutes, respectively. No complications were reported. The median dosage area product was 866 (835-966) $\mu Gym^2$ during biopsies and 2669 (2259-3079) $\mu Gym^2$ during electrode implantation, including two scans per sEEG procedure.

#### Conclusion

In this study, we demonstrate the feasibility and safety of intracranial interventions using the Cirq-robotic arm for stereotatic biopsies and sEEG, especially for procedures in the prone position, as surface matching can often be technically challenging in this setting. The Artis Pheno enables autonomous, surgeon-controlled intraoperative cone-beam CT scans with acceptable radiation exposure, while maintaining short incision-to-closure times. Future studies will be required to elucidate the accuracy of this technique.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P034

### Vergleichende Analyse der standardmäßigen und der modifizierten bitemporalen Elektrodenimplantation in der prächirurgischen Epilepsie-Evaluation: 10-Jahres Review in einem tertiären Epilepsiezentrum

***Comparative analysis of standard and modified bitemporal electrode implantation in presurgical epilepsy evaluation: A 10-year review at a tertiary epilepsy center***

E. Shabo[1], A. L. Potthoff[1], V. Gnatkovsky[2], I. Ilic[1], A. Racz[2], T. Baumgartner[2], T. Rüber[2], M. Schneider[1], F. Mormann[2], R. Surges[2], H. Vatter[1], V. Borger[1]

[1]Universitätsklinikum Bonn, Klinik mit Poliklinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Klinik und Poliklinik für Epileptologie, Bonn, Deutschland

#### Objective

Invasive diagnostics using stereotactic bitemporal implantation of depth electrodes is indicated for patients with temporal lobe epilepsy (TLE) if the non-invasive evaluation could not precisely determine and lateralize the epileptogenic zone (EZ). The vast majority of studies describes a symmetric bitemporal insertion of depth electrodes in certain temporomesial regions. This study seeks to critically analyze and compare the outcomes of symmetric bitemporal (traditional) depth electrode placement with alternative placement schemes in patients with TLE. The focus is on evaluating the efficacy in determining the EZ, while also assessing operative challenges and peri-operative complications.

#### Methods

In this retrospective, single-center study, we included all patients with pharmacoresistant TLE who underwent stereotactic bitemporal implantation of depth electrodes between January 2012 and December 2022. The patients were divided into two groups, standard (traditional) symmetric and modified implantation scheme. All patients underwent an expanded non-invasive evaluation prior to depth electrodes insertion.

#### Results

In total, 86 patients were identified and included in this study. Forty-four of 86 patients (51.2%) underwent an implantation according to standard scheme and forty-two (48.8%) underwent a placement according to modified scheme. Univariate analysis showed that preoperative trajectory planning of depth electrodes was significantly longer in the group of modified schemes (p=0.003). Duration of surgery was also significantly higher in the group of modified schemes (p=0.01). Other patient-related and surgery-related factors, including peri-operative complications, did not significantly differ between both groups. However, the multivariate analysis revealed no significant independent risk factors.

#### Conclusion

This study shows that in TLE, the modified bilateral placement of depth electrodes is equally safe and beneficial compared to the standard bitemporal implantations regarding peri-operative risk profile and diagnostic accuracy. Individualized electrode placement strategies for precise EZ localization may potentially enhance diagnostic accuracy and patient outcomes in TLE.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P035

***Implantationsgenauigkeit und -dauer der Stereoelektroenzephalographie in einem Schädelphantom: Vergleich eines modularen Robotiksystems mit einem traditionellen stereotaktischen Rahmen***
***Implantation accuracy and procedural time for stereoelectroencephalography in a phantom: Comparison of a modular surgical robot with a traditional stereotactic frame***

R. Kurtev-Rittstieg[1], M. Zaus[1], S. Weber[1], P. C. Reinacher[2]

[1]Brainlab AG, München, Deutschland
[2]Universitätsklinikum Freiburg, Stereotaktische & Funktionelle Neurochirurgie, Freiburg i. Br., Deutschland

### Objective

In drug-resistant epilepsy patients, the epileptogenic zone can be identified safely and effectively through Stereoelectroencephalography (SEEG). Traditionally, stereotactic frames are used, but interest in robotic systems is growing to increase operational efficiency. Our study aimed to compare the accuracy and performance of a table-mounted robotic platform (Cirq®, Brainlab AG, Germany) to a Leksell Coordinate Frame G (Elekta, Sweden) on phantoms. Cirq is already used in spinal procedures and cranial biopsies and recently obtained the CE mark for SEEG.

### Methods

Using publicly available MRIs (IXI database), 1 bilateral and 2 unilateral SEEG cases with 10 realistic trajectories each were planned in Brainlab Elements. 6 skull models (Sawbones, USA) were coated with epoxide gel to mimic bone layers and filled with 1.6% agar. For implantation, 2 sets of 10 SEEG electrodes and anchor bolts (Ad-Tech Medical, USA) were used. Each SEEG case was performed twice by P.R. in identical phantoms positioned laterally with a Leksell head ring. For Cirq, Automatic Image Registration (AIR, Brainlab) was performed using cone-beam computed tomography (CBCT, Loop-X Mobile Imaging Robot, Brainlab). CBCT was also used for stereotactic frame localization and for post-op imaging in both workflows. Accuracy metrics were calculated for all 60 electrodes as shown in Fig. 1. For both workflows implantation time per electrode was measured. Results between the two groups were compared using the Mann-Whitney U-Test.

### Results

In the robotic workflow, the mean radial entry error was 0.62 ± 0.40 mm, and in the frame workflow 0.61 ± 0.38 mm ($p=0.982$). For the target point, the mean Euclidean error was 1.60 ± 0.94 mm with the robot and 0.99 ± 0.36 mm with the frame ($p<0.0001$). The mean radial error was 1.03 ± 0.53 mm vs. 0.51 ± 0.30 mm ($p<0.0001$) and the absolute depth error 1.03 ± 1.02 mm vs. 0.75 ± 0.45 mm ($p=0.266$). With the robotic system, mean implantation time per electrode was shorter than with the frame, at 5.5 ± 1.3 min vs. 8.0 ± 1.9 min ($p < 0.0001$).

### Conclusion

In our phantom setup, robot-assisted SEEG with automatic CBCT based image registration proved simpler and faster compared to the Leksell frame, while maintaining clinically acceptable accuracy. Its versatility across procedures suggests potential for wider clinical availability. Further research involving patients is warranted.

Abb. 1

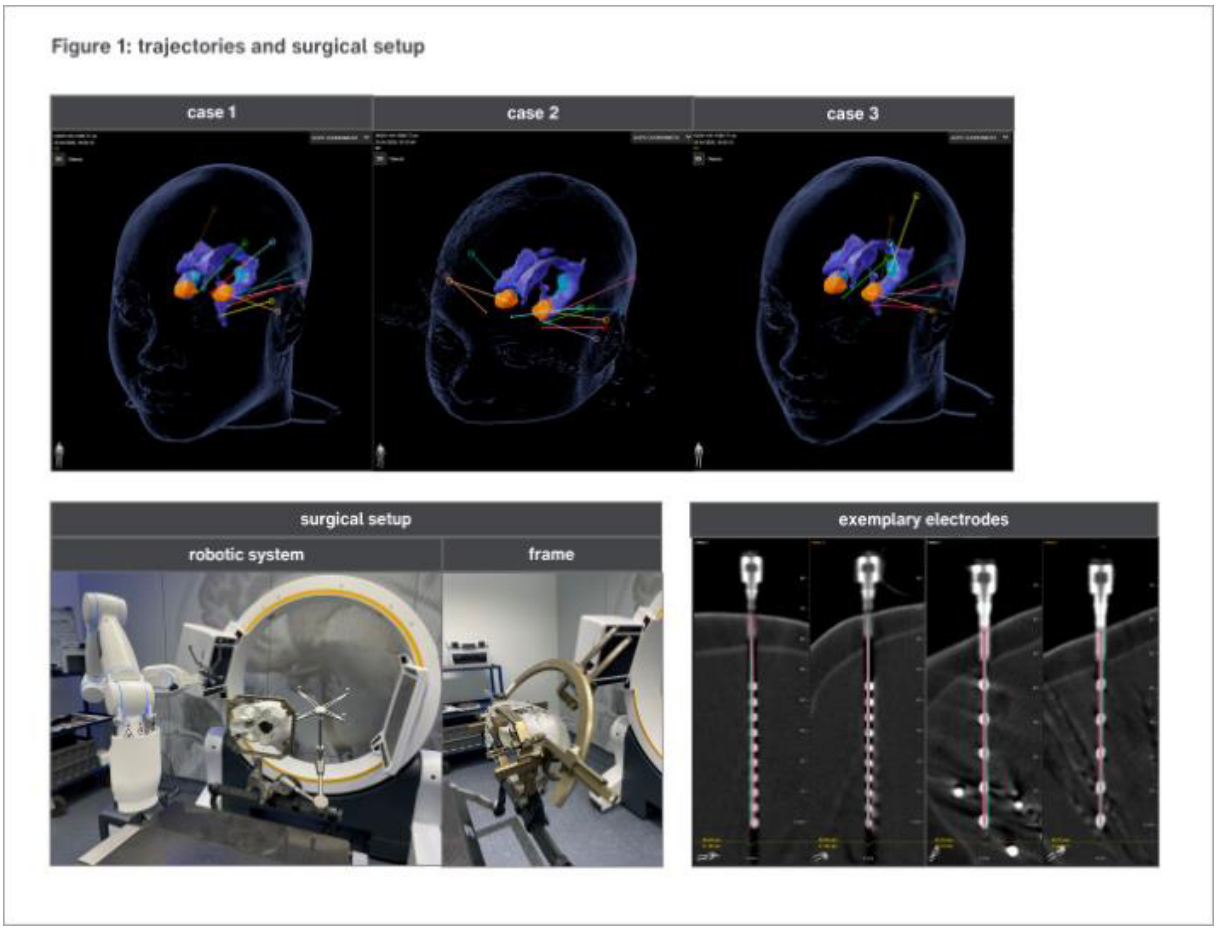


Figure 1: trajectories and surgical setup
case 1
case 2
case 3
surgical setup
robotic system
frame
exemplary electrodes

Abb. 2

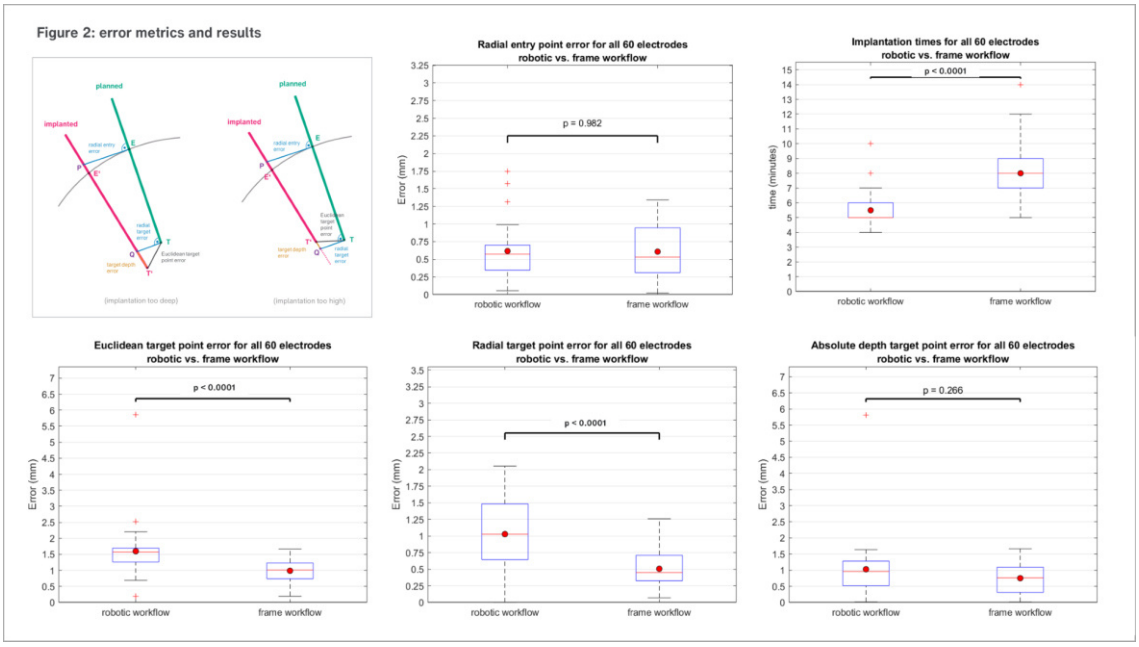


Figure 2: error metrics and results
planned
implanted
Radial entry point error for all 60 electrodes
robotic vs. frame workflow
p = 0.982
Error (mm)
robotic workflow
frame workflow
Implantation times for all 60 electrodes
robotic vs. frame workflow
p < 0.0001
time (minutes)
Euclidean target point error for all 60 electrodes
robotic vs. frame workflow
p < 0.0001
Radial target point error for all 60 electrodes
robotic vs. frame workflow
p < 0.0001
Absolute depth target point error for all 60 electrodes
robotic vs. frame workflow
p = 0.266

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P036

### Stereo-EEG Planung mit multimodaler Bildgebung bei Patienten mit nicht-läsoneller fokaler Epilepsie
*Intracerebral stereo-EEG in non-lesional focal epilepsy guided by multimodal imaging*

P. C. Reinacher[1,2], T. Demerath[3], D. Altenmüller[4], M. Heers[4]

[1]Universitätsklinikum Freiburg, Abteilung für Stereotaktische und Funktionelle Neurochirurgie, Freiburg i. Br., Deutschland
[2]Fraunhofer Institut für Lasertechnik (ILT), Klinische Diagnostik und mikrochirurgische Systeme, Aachen, Deutschland
[3]Universitätsklinikum Freiburg, Neuroradiologische Klinik, Freiburg i. Br., Deutschland
[4]Universitätsklinikum Freiburg, Epilepsiezentrum, Freiburg i. Br., Deutschland

#### Objective

Planning of invasive intracerebral Stereo-EEG (sEEG) in non-lesional focal drug resistant epilepsy is challenging and accurate spatial information about the organization of the epileptic focus is needed. Planning of sEEG is even more demanding, if patients with non-lesional epilepsy underwent prior epilepsy surgery.

#### Methods

Between 10/2019 and 10/2022 in 14 patients with non-lesional focal epilepsy with suspected monofocal epilepsy based on electro-clinical findings from non-invasive video-EEG-monitoring underwent sEEG implantation based on multimodal imaging. Four patients underwent prior epilepsy surgery and two of them prior invasive subdural EEG. All patients underwent multimodal diagnostics including high-resolution 3 T epilepsy MRI, MRI morphometry. A subgroup of patients underwent functional imaging using source imaging or FDG-PET. sEEG was planned considering findings from all available methods coregistered within the sEEG planning system.

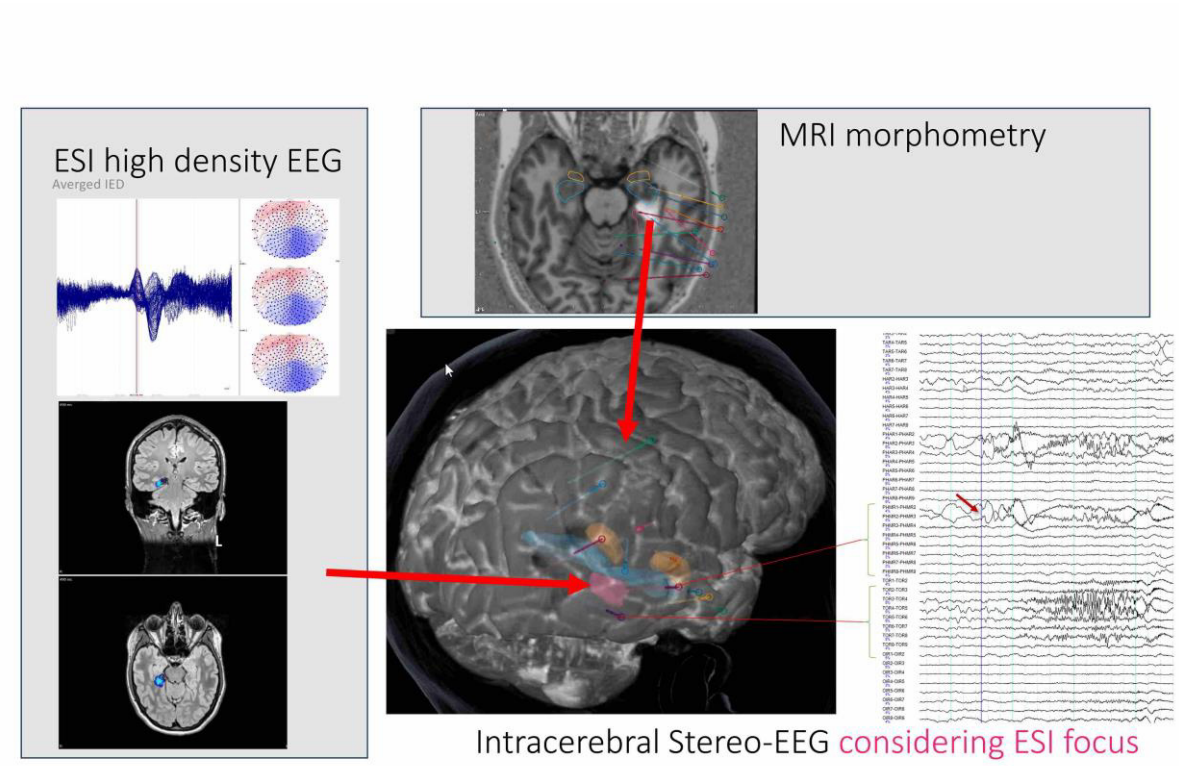
#### Results

Nine (± 2) sEEG electrodes were implanted per patient considering the primary hypothesis and usually several secondary hypotheses of the epileptic focus. No bleeding complication occurred. In sEEG recordings a focal seizure onset could be identified in 11/14 patients, and all of these patients underwent subsequent epilepsy surgery. Eighty percent (9/11 patients) had Engel 1 postsurgical outcome, 2/11 patients had Engel 2 postsurgical outcome. In 2/14 patients a multifocal epilepsy was diagnosed based on sEEG findings and only in 1/14 patients the epileptic focus could not be identified.

#### Conclusion

In patients with non-lesional focal epilepsy and suspected monofocal epilepsy sEEG diagnostics considering advanced multimodal imaging is highly successful identifying the seizure onset zone. After identification and exclusion of multifocal epilepsy patients based on sEEG findings epilepsy surgery in patients with identified monofocal seizure onset zone often results in seizure-free postsurgical outcome.

Abb. 1


ESI high density EEG
Averged IED
MRI morphometry
Intracerebral Stereo-EEG considering ESI focus

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P037

### Lösungsansätze technische Limitationen des SEEGs bei Anwendung des Leksell Vantage frames
*Technical aspects of SEEG limitations and solutions using the Leksell Vantage frame*

I. Prilop[1], S. B. Sobottka[1], G. K. Leonhardt[1], G. Schackert[2], I. Y. Eyüpoglu[2], W. H. Polanski[2]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurologie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland

#### Objective

Stereo-electroencephalography (SEEG) serves as an advanced technique over traditional EEG for precisely locating the epileptogenic zone (EZ) in patients with drug-resistant epilepsy. Challenges in aligning the stereotactic frame with the entry point during setup prompted further investigation into the frame"s limitations.

#### Methods

We use the Leksell Vantage frame (Elekta, Stockholm, Sweden) or the ZD Inomed frame (Inomed Medizintechnik GmbH, Emmendingen, Germany) along with AD-Tech"s (Oak Creek, U.S.) SEEG-instruments. Planning was performed using Elements software (Brainlab AG, Munich, Germany) based on 3-tesla MRI scans, merging preoperative MRI with stereotactical CT for coordinate generation. The orientation of the Leksell Vantage frame"s ring-shaped z-scales was crucial for electrode placement . To ensure frame compatibility, we explored all possible instrument positions across various ring orientations, arc alignments (lateral left or -right), arc-angle and x-coordinates.

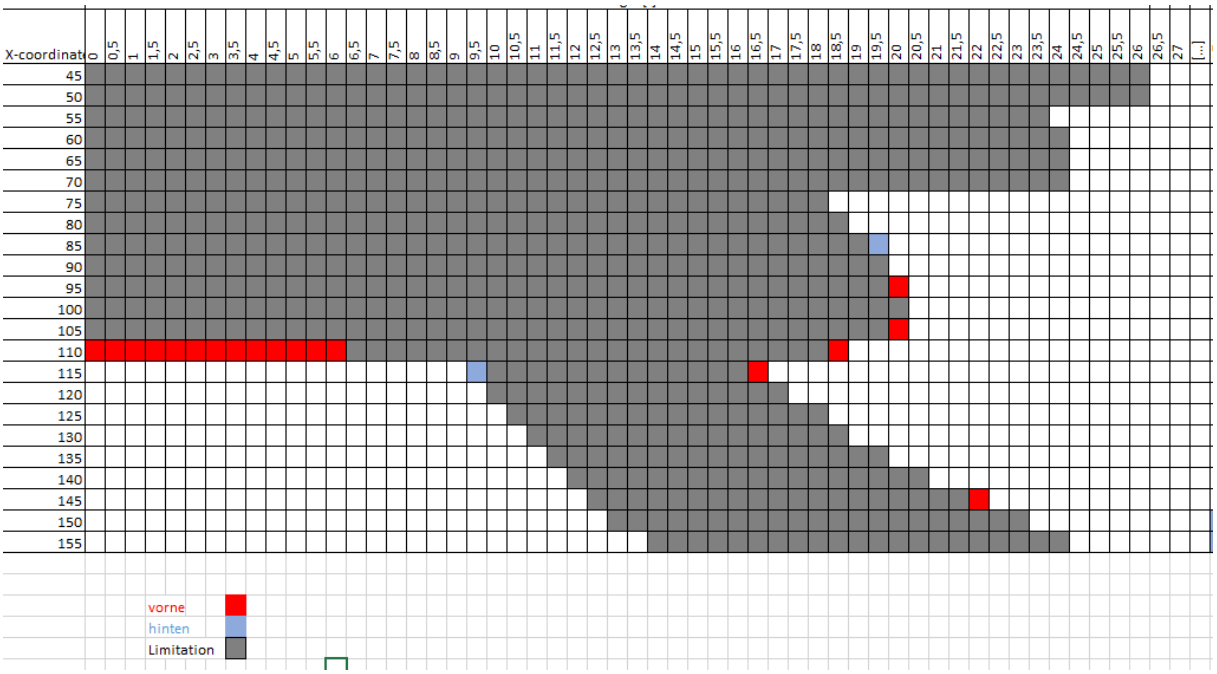
#### Results

The accompanying table illustrates two alignments of the semi-circular arc (lateral left and – right). For each, it highlights unfeasible positions when the ring-shaped z-scales face forwards or backwards (Tab 1.). In, our department 19 SEEG-implantations were performed. The average age at presentation of the 15 male and 4 female patients was 42 years. In 6 out of these 19 cases, the ZD Inomed frame was used, while the remaining 13 cases were performed with the Leksell Vantage frame. An average of 9 elektrodes were applied while using the ZD Inomed frame compared to 11 electrodes with the Leksell Vantage frame. The average implantation time per electrode was 20.7min using the ZD Inomed frame, versus 16.6min with the Leksell Vantage frames. Instances of electrode repositioning, deviation, or postoperative complications were rarely. Notably, in at least 3 cases involving 4 electrodes, intraoperative trajectory replanning was necessary due to conflicts between the frame setup and entry point of the trajectory.

#### Conclusion

Our clinical experience has shown that the complex planning of SEEG trajectories can sometime result in conflicts between the frame setup and their entry points. Systematic exploration of the stereotactic frame and SEEG-instruments, particularly the use of the Leksell Vantage frame, not only helps in preventing mid-surgery replanning but also significantly reduces operation time, enhancing overall efficiency and patient safety.

Abb. 1


X-coordinate
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2
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3,5
4
4,5
5
5,5
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6,5
7
7,5
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Limitation

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P038

### Tumorassoziierte Epilepsie bei Glioblastom-Patienten. Eine bizentrische Studie
*Tumor-associated epilepsy in glioblastoma patients. A bicentric study*

D. Dimov[1], L. Kotakova[2], H. R. Clusmann[2], D. Delev[2], M. Simon[1]

[1]Universitätsklinikum OWL Campus Bielefeld-Bethel, Klinik für Neurochirurgie, Bielefeld, Deutschland
[2]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland

#### Objective

The role of epilepsy in glioblastoma patients is not very well researched. Postoperative seizures may complicate the patients" clinical course and herald tumor recurrence. This present study aims at describing and analyzing epilepsy outcomes after glioblastoma surgery in a bicentric setting.

#### Methods

We analyzed 472 patients with IDH1-wildtype glioblastoma treated in two tertiary neurosurgical centers which offer epilepsy in addition to tumor surgery services. Pertinent clinical data were assessed retrospectively in 399 and prospectively in 73 cases. We recorded early postoperative seizures (EPS, <30 days) and epilepsy outcomes 1 and 2 years after surgery.

#### Results

The cohort was 60.8% male. Median KPI was 80 (IQR 70-90)% and median age was 65.0 (IQR 57.0-74.0) years. 61.9% had gross total and 19.9% had partial resections (biopsies: 18.2%). 64.5% received combined radiochemotherapy with temozolomide. Preoperative epilepsy was recorded in 32.6% of patients (16.7% single seizure). EPS occurred in 14.0%. ILAE1 outcomes (completely seizure-free) excluding EPS were seen in 62.9% of patients alive at 1 year (at 2 years for the preceding year: 56.9%). However, 1 and 2 year Kaplan Meyer estimates for overall survival (OS) were only 42.8% and 15.9%. 82.3% of EPS patients had recurring seizures at 1 year (1 year OS for EPS patients: 27.4%). De-novo postoperative seizures at 1 year were seen in 39.5% (cf. postoperative seizures in cases with preoperative seizures: 32.9%, p=NS). Seizures >3 months coincided with tumor recurrence in 34.7%. The occurrence of EPS was the only significant predictor of seizures at 1 year (RR 9.484, 95%CI 2.628-34.229, p<0.001). Notably, neither preoperative seizures nor degree of resection (or age, sex, preoperative/postoperative KPI/NANO score, MGMT status, and postoperative radiochemotherapy) correlated significantly with epilepsy outcomes at 1 year.

#### Conclusion

Seizures occur frequently in glioblastoma patients before and after surgery including de-novo epilepsy. The latter finding may reflect in part a correlation between tumor recurrence and seizures. Interestingly, preoperative epilepsy and surgical treatment had little impact on seizure outcomes and control. Limited survival resulted in progressively less patients at risk for postoperative seizures which renders interpreting epilepsy outcome figures and their relevance in glioblastoma patients difficult.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P039

### *Verteilung sprachrelevanter kortikaler Knotenpunkte bei Patient:innen mit anterioren vs. posterioren hochgradigen Gliomen*
### *Distribution of language-relevant cortical hubs in patients with anterior vs. posterior high-grade glioma*

L. Kram[1,2], J. Köck[1], A. Schröder[1], B. Meyer[1], S. Krieg[1,2], S. Ille[1,2]

[1]Klinikum rechts der Isar, Technische Universität München, Department of Neurosurgery, München, Deutschland
[2]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland

### Objective

High-grade gliomas (HGG) are associated with restricted reorganization potential and functional deficits due to rapid and aggressive tumor growth. Still, aphasia-promoting and -preventing mechanisms remain poorly understood. This study compared the distribution of cortical language-relevant sites identified with navigated transcranial magnetic stimulation (nTMS)-based language mappings and the expression of aphasia in patients with anterior vs. posterior HGG.

### Methods

Post-hoc comparisons of nTMS-induced cortical error rates (ER) across highly language-eloquent left-sided perisylvian areas and the pre-and postoperative functional status between patients with anterior and posterior HGG were carried out.

### Results

Our analysis indicated persistent function within the tumor area across 13 anterior (53.2±14.4 yrs, eight male) and ten posterior HGG patients (59.4±9.6 yrs, five male). Descriptive results showed comparable ER within triangular and even higher ER within opercular inferior frontal gyrus (opIFG) in posterior compared to anterior cases. Group-wise comparisons demonstrated significantly lower ER within the angular gyrus (AnG) for anterior compared to posterior HGG ($p<0.05$). The occurrence of pre- and postoperative aphasia did not differ between groups. Correlational analyses linked higher AnG ER to more severely pronounced expressive aphasia irrespective of tumor location ($r_s=0.39$, $p=0.04$).

### Conclusion

The present results demonstrated persistent function within tumor areas irrespective of HGG location. While posterior HGG showed a significantly higher AnG recruitment than anterior HGG for naming, descriptive results demonstrated higher opercular IFG recruitment, suggesting additional distant reorganization in posterior HGG cases. A higher reliance on the AnG was linked to more severely pronounced expressive deficits, potentially indicating compensatory mechanisms.

# Funktionelle Neurochirurgie – Epilepsie, Tumoren | Functional Neurosurgery - Epilepsy, tumours

## P040

### Neuroprotektive Eigenschaften von niedrig dosiertem Nifedipin auf Schwann Zellen
*Neuroprotective characteristics of low-dose nifedipine in Schwann cells*

C. Strauss[1], C. Scheller[1], J. Prell[2], C. Strauss[2], M. Scheer[1], S. Leisz[3]

[1]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[2]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[3]Universitätsklinikum Halle, Klinik mit Poliklinik für Neurochirurgie, Halle, Deutschland

#### Objective

Nifedipine is a calcium channel antagonist and is mainly used as an antihypertensive and in vasospastic angina pectoris. Recent studies have shown a neuroprotective effect of nifedipine in demyelinated nerves and on the dopaminergic substantia nigra. This suggests that nifedipine may have a neuroprotective potential similar to that of nimodipine. Therefore, the aim of this study was to analyse the mode of action of nifedipine on different cell lines, to investigate stress-induced cell death, calcium balance and the effects of nifedipine on the molecular mechanism of neuroprotection.

#### Methods

We investigated the effect of nifedipine on murine (SW10) and human Schwann cells (HSC) and on rat neuronal cells (RN33B). All assays were performed with nifedipine-pretreated and untreated groups, under cytotoxic and oxidative stress (20µM Cisplatin; 2% EtOH). We analysed cytotoxicity by measuring lactate dehydrogenase (LDH) activation in the cell culture supernatant and calcium assay to measure intracellular Ca2+ levels. To investigate the effect on expression and protein signalling cascades, we performed Western blots of pretreated and untreated SW10 and RN33B cells.

#### Results

Nifedipine is cytotoxic at concentrations >10µM, but has a neuroprotective effect of 12% on murine and of 25% on human Schwann cells exposed to cytotoxic and oxidative stress. In stressed cells, it caused increased phosphorylation of AKT at serin residue 473 and of CREB at serin residue 133. The AKT pathway is a signalling pathway that responds to extracellular signals to promote survival and growth, and by activating AKT and CREB it suppresses apoptosis. Nifedipine did not show a neuroprotective effect on neuronal cells.

#### Conclusion

We have shown that low doses of nifedipine have a neuroprotective effect on Schwann cells. Further studies are necessary to investigate the intracellular Ca2+ concentration in Schwann and neuronal cells. In addition, the effects on human primary cell cultures and HSCs need to be analysed. Based on the preliminary results, and assuming that nifedipine is not lipophilic, it may be particularly relevant for peripheral neuropathies caused, for example, by chemotherapy. It would therefore be necessary to investigate the penetration of nifedipine into the cerebrospinal fluid and the serum concentrations of nifedipine.

# Tumor – Meningeome | Tumour – Meningiomas

## P043

### Ein neuartiger Fluoreszenzfarbstoff als Point-of-Care Diagnostik zur Einschätzung des Rezidivrisikos von Meningeomen

***A novel fluorescent diagnostic probe as a potential Point-of-Care diagnostic tool to estimate recurrence risk of meningiomas***

S. Hemmer[1], X. Hui[2,3], J. Dräger[2], J. Menges[2], E. C. Schwarz[3], A. Wrede[4], J. Oertel[1], L. Kaestner[3,5], G. Jung[2], S. Urbschat[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Universität des Saarlandes, Biophysikalische Chemie, Saarbrücken, Deutschland
[3]Universität des Saarlandes, Theoretische Medizin und Biowissenschaften, Homburg a. d. Saar, Deutschland
[4]Universitätsklinikum des Saarlandes, Institut für Neuropathologie, Homburg a. d. Saar, Deutschland
[5]Universität des Saarlandes, Experimentalphysik, Saarbrücken, Deutschland

#### Objective

Deletion of the short arm of chromosome 1 (1p) represents an independent biomarker for increased recurrence risk in meningiomas. The alkaline phosphatase gene is located on chromosome 1p36.1-p34. Intracellular absence of the alkaline phosphatase enzyme in meningiomas correlates with 1p deletion. Conventional molecular genetic screening methods for 1p deletion are resource-consuming and infrastructure-demanding, hence alternative screening methods are required.The fluorescent probe AlkaPhos represents a novel tool to detect intracellular alkaline phosphatase activity by allowing for the distinction of product and substrate emission. In this study, the authors sought to evaluate the capability of AlkaPhos to detect alkaline phosphatase in meningioma cells and correlate observations with fluorescence *in situ* hybridization (FISH), loss of heterozygosity (LOH) and conventional histochemical analysis.

#### Methods

Via microscopic fluorescent ratio measurements, specificity of AlkaPhos to detect alkaline phosphatase was evaluated on BEN-MEN-1 cells. Conventional histochemical analysis was performed on the same tumors as a reference for intracellular presence of alkaline phosphatase. AlkaPhos was applied to primary meningioma cell cultures and results were compared to FISH, LOH and histochemical results from the corresponding tumors.

#### Results

AlkaPhos specifically indicated alkaline phosphatase activity in BEN-MEN-1 cell cultures.In 11/14 (78%) samples, matching results for 1p deletion in FISH and AlkaPhos reaction were obtained. For LOH, matching results with AlkaPhos reaction was recorded in 10/14 (71%) of tumor samples. In 10/14 (71%) samples, matching results in histochemical analysis and AlkaPhos testing were obtained. AlkaPhos correctly identified 8/8 (FISH) and 7/7 (LOH) (100%) tumors with 1p deletion and LOH of 1p, whereas histochemical analysis could only identify 6/8 (75%, FISH) and 5/7 (71%, LOH), respectively.

#### Conclusion

AlkaPhos bears the potential for a future diagnostic tool to identify absence of alkaline phosphatase in meningiomas and thereby indicate 1p deletion. Compared to histochemical analysis, AlkaPhos tended to be superior in correctly identifying tumors with 1p deletion and LOH of 1p. Further evaluation of AlkaPhos on a larger number of native meningioma samples is required to approach routine clinical application.

# Tumor – Meningeome | Tumour – Meningiomas

## P044

### Klinische Charakteristika von bestrahlungsassoziierten Meningeomen – eine monozentrische Studie
*Clinical characteristics of radiation induced meningiomas – A single-center study*

L. Schmidt[1], M. Kosterhon[1], F. Ringel[1], D. Kalasauskas[1]

[1]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgische Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Intracranial meningiomas may be induced after radiation exposure, for example radiotherapy of CNS malignancies. However, little data is available regarding their nature and characteristics of affected patients.

This study aimed to evaluate clinical features and potential differences in surgical treatment of radiation induced meningiomas.

#### Methods

A single-center retrospective study including patients undergoing resection of intracranial meningiomas between 2007 and 2018 was performed. Patients with intracranial radiation exposure were identified using hospital records and compared with non-radiation induced cases.

#### Results

During this period, 841 meningioma patients with sufficient medical records were identified. Radiation-induced meningiomas were present in 33 (3.9%) cases.

Median age at diagnosis was 60 (50-70) years. Patients being exposed to radiotherapy prior to development of meningiomas were younger (49.3±14.4 vs 59.8±13.3 years, $p<0.001$) and presented with smaller tumor diameter (31.9±18.2 vs 32.9±17.1mm $p<0.001$). The proportion of higher-grade tumor was larger ($p=0.001$): WHO grade 1 tumors were present in 82.8%, grade 2 in 16.34% and grade 3 in 0.85% of cases. Simpson grade 1 resection was achieved in 38.9%, 2 in 31.3%, 3 in 16.2%, 4 in 13.5%. and 5 in 0.1% of cases. There were no differences in Simpson grade ($X2= 1.2$ $p=0.9$) or comorbidities (CCI 2.5±1.6 vs 2.2±1.8 $p=0.5$).

Location differed significantly favoring more surgically complex regions in radiation-exposed patients (i.e. olfactory groove, cavernous sinus, tuberculum sellae $p<0.001$). Resection of radiation induced meningiomas subsequently required more manipulation of large intracranial vessels (60% vs 37% $p<0.001$), but manipulation of cranial nerves was less frequently necessary (30% vs 36% $p<0.001$).

#### Conclusion

The management of radiation-induced meningiomas poses additional challenges due to younger patient population, larger proportion of higher-grade tumors and more demanding location.

# P045

## Geruchsempfinden im Langzeitverlauf nach transkranialer Resektion von Olfaktoriusrinnenmeningeomen – eine monozentrische Studie

***Olfactory function in the long-term course after endoscope assisted transcranial resection of olfactory groove meningiomas – A monocentric study***

V. Bogaczyk[1], I. Peters[1], S. Reinhardt[1], M. B. Schilling[1], H. W. S. Schroeder[1]

[1]Universitätsmedizin Greifswald, Klinik mit Poliklinik für Neurochirurgie, Greifswald, Deutschland

### Objective

Olfactory groove meningiomas often lead to a reduced sense of smell and have measurable influence on quality of life. However, the interest and extent of examination of the olfactory function is quite low in everyday clinical practice.

### Methods

Prospective analysis of patients who underwent transcranial resection of olfactory groove meningiomas from October 2005 to December 2022 was performed. Data on clinical presentation, pre- and postoperative neurologic examinations, operative approach, tumor size and further follow-up were recorded. Olfactory function was assessed using the extended test of Sniffin' Sticks, which consists of three parts: the odor threshold for n-butanol, the ability to discriminate different odors and identification of 16 different smells. Also information about quality of life was gained using the Questionnaire for Olfactory Dysfunction (QOD).

### Results

24 patients (6 male, 18 female, age 44.8 ± 14.5 years, follow up period of 6.7 years) were assessed. In 11/24 patients surgical approach was done via supraorbital craniotomy and in 11/24 patients a frontolateral craniotomy was performed. Also two patients received a pterional approach. In 12/24 operations endoscopic assistance was used. Average tumor volume was 13.4cm3. In 19 patients a WHO grade I tumor was detected; in 5 patients a grade II tumor was confirmed.

Fortunately, the sense of smell has been fully preserved in 9 patients. Initially in 12 patients normosmia was measured. Hyposmia was preoperative measured in 7 patients and postoperative confirmed in 6 patients, whereas anosmia increased from 5 patients to 9 patients postoperative. In summary, after excluding patients with anosmia, preservation of olfactory function was confirmed in 15/19 patients (78.9%). 7 patients stated a reduction regarding olfaction-related quality of life. 4 of these 7 patients suffer from total anosmia.

### Conclusion

29.2% of the patients who were examined stated a reduction of olfactory-related quality of life in long-term follow up. This highlights the influence of olfactory function on everyday life and should be investigated in further studies.

# P046

## Visuelle Einschränkung in der Chirurgie medialer Keilbeinflügelmeningeome: Eine Analyse von Patient-reported Outcomes und Prädiktoren der postoperativen Rekonvaleszenz

***Visual deterioration secondary to medial sphenoid wing meningioma: Systematic assessment of patient-reported outcomes and factors contributing to recovery after surgical treatment***

M. Schneider[1], S. Hajdari[1], A. L. Potthoff[1], J. Bernstock[2], U. Herrlinger[3], M. Czabanka[4], V. Seifert[4], H. Vatter[1], P. Schuss[1,5], F. Kilinç[4], F. Geßler[4,6]

[1]University Hospital Bonn, Department of Neurosurgery, Bonn, Deutschland
[2]Brigham and Women's Hospital, Department of Neurosurgery, Boston, MA, Vereinigte Staaten
[3]University Hospital Bonn, Division of Clinical Neuro-Oncology, Department of Neurology, Bonn, Deutschland
[4]University Hospital Frankfurt a.M., Department of Neurosurgery, Frankfurt a. M., Deutschland
[5]BG Klinikum Unfallkrankenhaus Berlin, Department of Neurosurgery, Berlin, Deutschland
[6]University Medicine Rostock, Department of Neurosurgery, Rostock, Deutschland

### Objective

Visual acuity (VA) constitutes an important outcome measure in surgery for medial sphenoid wing meningioma (SWM). This study aimed to assess the recovery of tumor-associated impairment of visual acuity and its impact on patient-reported outcome measures (PROMs) as an indication for vision-related quality of life (QoL) in patients that had undergone surgery for medial SWM.

### Methods

From 2010 to 2018, 153 consecutive patients with medial SWM underwent surgical treatment at the authors" institutions. Tumor-associated visual acuity was evaluated both upon admission and during postoperative follow-up examinations, employing Snellen charts. Multivariable analysis was performed to identify independent predictors for postoperative improvement of visual acuity. PROMs were collected based on The National Eye Institute 25-Item Visual Function Questionnaire (NEI VFQ-25).

### Results

A total of 53 of 153 patients with medial SWM (35%) suffered from preoperative impairment of visual acuity. Mean preoperative duration of visual symptoms was 12 ± 9 months for the entire study cohort. Multivariable analysis revealed preoperative duration of visual symptoms for ≤ 4 months to be independently associated with postoperative improvement of visual acuity (p=0.009). Evaluation of PROMs indicated a superior postoperative qualitative extent in the categories "overall health" (p=0.027) and "activities of daily life" (p=0.033) if preoperative duration of visual impairment was ≤ 4 months.

### Conclusion

Preoperative overall duration of tumor-related visual impairment significantly correlates to the extent of postoperative visual improvement as well as vision-related PROMs in medial SWM surgery. These results might aid preoperative patient counseling, optimized decision-making, and preoperative estimation of long-term visual outcome.

# Tumor – Meningeome | Tumour – Meningiomas

## P047

### Behandlungskosten bei Patienten mit kranialen Meningeomen: Eine Metaanalyse
*Treatment costs in patients with cranial meningioma: A meta-analysis*

A. Ilgeldiev[1], V. Yushenko[1], V. Braun[1], A. Carolus[1]

[1]Klinikum Diakonie Jung-Stilling, Neurochirurgie, Siegen, Deutschland

#### Objective

Meningeoma treatment includes radiotherapy, surgery and pharmacological therapy. All those treatments are highly cost-intensive. It is topical and necessary to evaluate approaches from the economic point of view. The so-called "high-value" meningioma therapy involves resource expenditures relative to patient outcomes. To define this therapy, prognostic factors for patients have to be find.

#### Methods

Based on an extended literature research in PubMed Library 35 publications were analyzed. Different parameters of meningeoma treatment were taken under view. Special focus was placed on "Simpson degree" (degree of surgical resection completeness) and "WHO degree" (classification of subtypes due to cell characteristics and growth) and the combination of both in various constellations.

#### Results

The constellation WHO degree 1 and Simpson degree 1 has the lowest treatment costs compared to all other combinations. Cost for a surgery is 9108,73 Euros on average, cost for a radiosurgery is 6476,81 Euro. However, low grade meningioma usually come along with radiological, clinical and laboratory follow-ups over years (medical examination 295,41 Euro, MRI of the skull with contrast medium 450 Euros ending in a total of 745,41 Euros). If applied 15 times, for example, the total costs would be increased by 11.181 Euro. In addition, this observation time can go along with psychological factors leading to anxiety and inability to work. Those long-term cost in sum end into high overall treatment costs.

#### Conclusion

Due to the long overall survival and the necessity of follow ups it seems that low grade and complete resected meningioma have higher treatment cost than meningioma with a more aggressive growth and/or an incomplete resection. Under the aspect of "high value" therapy it has, to be discussed if treatment costs as well as psychological stress could be reduced by economizing the follow-up care: MRI controls in symptom-free patients should be reduced.

# P048

## Das Migrations- sowie Invasionspotential von malignen Meningeom-Zellen hängt von der Glukose-Konzentration sowie der Glykierung ab

***The migratory and invasive behaviour of malignant meningioma cells depends on glucose concentration and glycation***

P. Selke[1], C. Strauss[2], R. Horstkorte[1], M. Scheer[3]

[1]Medizinische Fakultät der Martin-Luther Universität Halle-Wittenberg, Institut für Physiologische Chemie, Halle, Deutschland
[2]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[3]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland

### Objective

Meningioma is the most common non-malignant intracranial tumour and the risk of developing the disease increases with age. It is known that glucose tolerance decreases with age, leading to higher glucose levels. Like almost all tumours, meningiomas use altered aerobic glycolysis to generate energy, also known as the Warburg effect. This leads to an accumulation of highly reactive by-products such as methylglyoxal (MGO). MGO has been discussed by as a possible link between diabetes, serum glucose levels and cancer. MGO is 20,000 times more reactive than glucose and reacts mainly with proteins, DNA or lipids to form advanced glycation end products (AGEs), a non-enzymatic reaction between the carbonyl groups of dicarbonyls or sugars (such as glucose or fructose) and the amino groups of proteins. However, whether the behaviour of meningiomas depends on glucose levels and glycation has not been investigated. The aim of this study was to investigate the influence of glucose levels and glycation on the migration and invasion behaviour of meningioma cells.

### Methods

We used a benign meningioma cell line (WHO grade 1, BEN-MEN1) and a malignant meningioma cell line (WHO grade 3, IOMM-Lee). Cells were cultured for 24h with different glucose levels: normal (5.5mM), low (3mM) and high (15mM) and additionally treated with 0.3mM MGO. Cell cycle analysis was performed with propidium iodide staining using a BD Accuri C6 flow cytometer. Migration was analysed by Electric Cell-substrate Impedance Sensing (ECIS) and invasive behaviour by Real-Time Cell Analysis (RTCA).

### Results

We have observed that the cell cycle in the malignant meningioma cell line is influenced by different glucose levels and glycation. At low glucose levels, the cell cycle was slowed down. In addition, the malignant tumour cells showed reduced migration and invasion behaviour at low glucose levels. With the addition of the glycating agent MGO, we saw no more migration and a reduction in invasive behaviour. In contrast, these effects were not observed in the benign meningioma cell line.

### Conclusion

This study shows that low glucose levels can reduce the migration and invasion behaviour of malignant meningioma cells. This could be an indication that the western lifestyle may influence the behaviour of meningioma cells. An appropriate diet with a reduction in carbohydrates could lead to a better oncological outcome for patients. This should be further investigated in future studies.

# Tumor – Meningeome | Tumour – Meningiomas

## P049

### SAM-Score: Ein neuer Ansatz zur Prädiktion der Vorhersage des Tumorrezidivs von sporadischen kranialen WHO-Grad 1 Meningeomen

***SAM-Score: A novel approach to predict tumor recurrence of sporadic cranial WHO grade 1 meningioma***

M. Vogel[1], A. E. Basaran[1], C. Seidel[2], A. Barrantes-Freer[3], M. Vychopen[1], F. Arlt[1], E. Güresir[1], J. Wach[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland
[2]Universitätsklinikum Leipzig, Klinik und Poliklinik für Strahlentherapie, Leipzig, Deutschland
[3]Universitätsklinikum Leipzig, Paul-Flechsig-Institut für Neuropathologie, Leipzig, Deutschland

#### Objective

Despite WHO grade 1 meningiomas are suggested to be benign tumors, there is a high proportion of recurrences in the long-term follow-up. The present study aims to establish a pragmatical scoring by analyzing clinical, radiomic, and histopathological characteristics.

#### Methods

We included 302 sporadic WHO grade 1 cranial meningioma patients who underwent surgery in our center from 2011 to 2021. Inclusion criteria were age ≥ 18 years, primary case, sporadic tumor, available imaging as follow-up data. Radiomic shape features, MIB-1 index data, extent of resection, and patient-specific characteristics were assessed. Statistical analyses were performed using R studio (RStudio, Boston, MA, USA) with the *R package Survminer*. Based on the Cox regression analysis of meningioma progression a scoring system was developed.

#### Results

Twenty-four (7.9%) patients had a local tumor progression. Multivariable Cox regression analysis revealed that MIB-1 Index ≥5% (HR: 4.1, 95%CI: 1.5-11.5), age ≤54 (HR: 2.7, 95%CI: 1.1-6.7), and Simpson grade ≥III (HR:2.9, 95%CI: 1.1-8.1) were independently associated with meningioma recurrence and were included in the final score, which assigns 1 point for age ≤ 54 years, 1.5 points for Simpson grade ≥ III, and 2 points for MIB-1 ≥ 5%. The rate of meningioma recurrence per 100 patient-years was 0.098 in patients with a score of ≤1.5 (low risk), 0.30 in patients with a score between 1.5 and 3 points (intermediate risk), and 0.91 in patients with a score ≥3.0 (high risk). The mean times to recurrence of patients in the low-risk group, intermediate risk group, and high-risk group was 145.5 months (95% CI: 137.1-153.8), 114.7 months (95% CI: 100.1-129.4), and 71.0 months (49.0-93.1), respectively ($p < 0.001$). Compared to low-risk patients, the risk of WHO grade 1 meningioma recurrence was significantly higher in intermediate-risk (HR: 3.2, 95% CI: 1.2-8.5) and high-risk (HR: 11.0, 95% CI: 4.1-29.5). The area under curve of the score was 0.73 (95% CI: 0.61-0.84).

#### Conclusion

The proposed SAM-score can assist in the identification of patients with sporadic cranial WHO grade 1 meningiomas at increased risk for tumor recurrence.

# Tumor – Meningeome | Tumour – Meningiomas

## P050

### Der Proteasom-Inhibitor Marizomib zeigt antiproliferative Wirkung in allen drei Meningeom-Graden
*The proteasome inhibitor marizomib shows antiproliferative effects in all three grades of meningioma*

A. E. Basaran[1], J. Wach[1], C. Bach[1], T. Detzer[1], E. Güresir[1], F. Gaunitz[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

#### Objective

The management and limited therapeutic options for high-grade meningiomas present a therapeutic challenge. Proteasome inhibitors have shown antiproliferative activity in glioblastoma in vivo and in vitro. Hence, there is a need to investigate the antiproliferative effect of proteasome inhibition in meningiomas.

#### Methods

Here, we investigated the antiproliferative effect of marizomib in all three WHO grades of meningiomas in vitro. We investigated two WHO grade 1, two WHO grade 2, and three WHO grade 3 primary meningiomas. WHO grading was performed according to the WHO classification system 2021. These studies with human primary meningioma cell cultures were performed with apoptosis and viability assays under 24-hour incubation.

#### Results

Our results showed that the median effective dose (ED50) values for growth inhibition were at concentrations between 0.05 – 0.07 µM in WHO grade 1, 0.08-0.11 µM in WHO grade 2 and 0.1-0.3 µM in WHO grade 3 meningiomas. The Spearman correlation test showed a strong positive correlation between dose and anti-proliferative activity in each culture of all three WHO grades ($R^2$=1.0).

#### Conclusion

We have shown that the blood-brain barrier penetrating proteasome inhibitor marizomib might be a promising therapeutic option for meningiomas.

# Tumor – Meningeome | Tumour – Meningiomas

## P051

### Quantifizierung verschiedener Untergruppen von Immunzellen in primären Meningeomen
*Quantification of diverse immune cell subsets in primary meningiomas*

N. Giuliani Canizales[1], C. Lotsch[1], R. Warta[1], L. Jassowicz[1], A. von Deimling[2], F. Sahm[2], A. Unterberg[1], C. Herold-Mende[1]

[1]Heidelberg University, Division of Experimental Neurosurgery, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Department of Neuropathology, Heidelberg, Deutschland

### Objective

Meningiomas (MGM) often exhibit clinically aggressive progression, although being primarily benign. Immunotherapy could be an alternative treatment, but knowledge regarding meningioma immunobiology remains limited. This study delved into less explored subtypes, such as B-cells, NK-cells, and granulocytes, to analyze their associations with disease progression and cell-cell relations.

### Methods

A cohort comprising 100 primary MGM cases was used, including all WHO grades (°1, °2, and °3), and DNA-methylation classes (MC; benign, intermediate, and malignant). To quantify infiltration of T cells, B cells, NK cells, neutrophils, and eosinophils, tumor tissue cryo-sections were obtained from the institutional biobank. Immunofluorescence stainings were performed on tumor cryo-sections and digitized as high-resolution multiple image alignments for semi-automated cell counting. The infiltration rates were then correlated with clinical data, including clinical grading, age, sex, progression-free survival (PFS) and overall survival.

### Results

Each subtype´s median cell infiltration varied, with T cells (0.64%) having the highest, followed by neutrophils (0.079%), B cells (0.003%), NK cells (0.006%), and eosinophils (0.0018%). B cell infiltration correlated with increasing T cells, as did eosinophils with neutrophils. WHO°1 cases exhibited higher NK cell and eosinophil infiltration compared to other WHO-grades. High NK cell infiltration was characteristic of the benign MC. Neutrophils and NK cells infiltrated more in the younger sub-population (<61yo). Overall, patients with higher PFS tended to have higher infiltration of T cells, NK cells, and eosinophils, but lower B cells and neutrophils. Aggregates of T cells and B cells were found on 10% of cases, which also showed high infiltration rates of all cell types and higher PFS.

### Conclusion

This study provides infiltration rates of rarer immune cell subtypes and their variation with clinical grading, age, and sex, as well as their relevance for MGM progression.

# Tumor – Meningeome | Tumour – Meningiomas

## P052

### Vorhersage des postoperativen Resektionsstatus bei Meningeomen durch maschinelles Lernen auf der Grundlage klinischer Merkmale

***Predicting postoperative resection status for meningiomas using machine learning based on clinical features***

M. Musigmann[1], B. Brokinkel[2], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland
[2]University Muenster and University Hospital Muenster, Department of Neurosurgery, Münster, Deutschland

#### Objective

The extent of achievable resection in the surgical treatment of meningiomas is of high importance for the further prognosis and treatment planning. Subtotal resections are often associated with recurrent tumor growth and thus the risk of disease progression. For further treatment planning, it is therefore important to determine as early as possible whether a meningioma can be completely resected or not. The aim of our study is to predict the postoperative resection status of meningiomas using machine learning based on clinical features.

#### Methods

Our retrospective, IRB-approved study is based on a cohort of 138 patients. A gross total meningioma resection was performed in 107 cases and a subtotal resection in the remaining 31 cases. Approximately 20 clinical features, such as the location of the tumor, its shape and volume, were analyzed with regard to the predictability of the achievable postoperative resection status. The features to be included in the models were selected using recursive feature elimination. A total of 14 machine learning algorithms, including a neural network, were trained and tested to predict postoperative resection status. All models were developed a total of 100 times, each time with new training data. The model performance was subsequently determined for each of the 100 runs using new independent test data.

#### Results

We achieved our best results using a neural network containing only 4 clinical features. This model exhibits a mean AUC of 88.7 %, a mean accuracy of 87.4 %, a mean sensitivity of 92.8 %, a mean specificity of 68.5 %, a mean Cohen's kappa of 62.6 % and finally a mean positive and negative predictive value of 91.3 % and 75.1 % respectively. Very good results were also achieved using a generalized linear model. Thus, our models show a very high performance in the preoperative prediction of the achievable postoperative resection status of meningiomas. We were able to identify clinical features that are of particular importance regarding the achievable postoperative resection status. In addition, we have determined in which cases it is particularly difficult to make a precise preoperative statement.

#### Conclusion

Our results show that the achievable postoperative resection status of meningiomas can be predicted very accurately using machine learning algorithms based on only a few clinical features. In the near future, such machine learning based methods may enable physicians to accelerate further treatment planning.

# Tumor – Meningeome | Tumour – Meningiomas

## P053

### Vorhersage des postoperativen visuellen Outcome mittels real-time ICG-Angiographie nach Resektion von perichiasmatischen Meningeomen

***Prediction of postoperative visual outcome following resection of perichiasmatic meningiomas using real time ICG-angiography***

F. Khafaji[1,2], G. Fischer[2], S. Linsler[1,2]

[1]Klinikum Bayreuth, Medizincampus Oberfranken der FAU, Klinik für Neurochirurgie, Bayreuth, Deutschland
[2]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

The most common clinical presentation of patients with perichiasmatic meningiomas is visual disturbance, and surgical resection is the main mode of treatment to preserve vision. The only available, however not reproducible, intraoperative measurements to evaluate the visual function is the iVEP (intraoperative visual evokes potential). This study aims to provide a reproducible safe alternative for iVEP to predict the visual outcomes of perichiasmatic meningiomas.

#### Methods

Five patients with perichiasmatic meningiomas and 5 patients with other perichiasmatic pathologies were included and studied retrospectively. Each patient received a complete imaging study, ophthalmological examination and iVEP and a standardized ICG-angiography. ICG-angiography was done pre-and postresection applying flow 800 software, (Kinevo, Carl Zeiss Co). The intervals between the first appearance of ICG in the internal carotid artery (ICA) and pial circulation of the ON (optic nerve) to full saturation of both were measured at each pre-and postresection situation.

#### Results

5 Patients (1M,4F) and 5 controls (4M,1F) are included. The mean age was 60.2±15.35 and 56.4±10.31 years old for cases and controls respectively. Visual disturbance was reported in 5 cases and 4 controls preoperatively. The main pathologies included 5 perichiasmatic meningiomas, 1 hypophysis adenoma, 2 craniopharyngiomas and one hypophysis metastasis. Visual improvement was reported in 4 cases, 1 unclear and 4 controls. Comparing the tumor volume of meningioma to other pathologies does not show any significant difference ($p>0.05$). Peak time differences of ICA-ON before tumor resection was 2.44±2.81ms for meningiomas and 3.03±2.81ms for controls ($p>0.05$). After tumor resection, the peak time was 2.14±1.73ms for meningioma patients and 3.66±2.79ms for control patients respectively ($p>0.05$). The peak-time improvement of ICA-ON between the two groups showed no significant difference. Prolonged iVEP latency was observed in both groups, more at the affected side of chiasma.

#### Conclusion

Applying ICG-angiography to evaluate the ophthalmic postoperative outcome seems to be a safe reproduceable method comparing to the iVEP. Compared to other perichiasmatic pathologies, meningiomas has not shown a significant difference in term of visual outcomes. Further studies need to evaluate the significance of ICG-angiography as a tool of intraoperative monitoring of the optic nerve.

# P054

## Pädiatrische Schädelbasistumore: Klinische Merkmale und chirurgische Ergebnisse; eine retrospektive monozentrische Studie

***Pediatric skull base tumors: Clinical features and surgical outcomes; a single center retrospective study***

M. Grutza[1], P. Lenga[1], M. Issa[1], S. Krieg[1], A. El Damaty[1]

[1]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland

### Objective

Intracranial tumors in pediatric population are scarce, especially those located at the skull base. Skull base tumors are challenging to pediatric neurosurgeons and pediatric oncologists due to their unique anatomical considerations and histopathological diversity. Nevertheless, robust evidence is still marginal concerning their clinical and surgical courses. We aim to describe our experience regarding surgical approaches, with special focus on surgical features, postoperative outcomes, adverse events as well as adjuvant therapeutic concepts.

### Methods

Patients aged <18 years undergoing skull base surgery between 2017 and 2021 at our institution were retrospectively enrolled. Patient demographics, tumor characteristics, surgical approach, pre -and postoperative clinical status and possible adjuvant therapy as well as mean overall progression free survival were assessed.

### Results

Eleven children with a mean age of 5.2 ± 2.14 years were analyzed. There was a predominance of the female gender (70%). The mean tumor diameter was 3.5 ± 2.0 cm. In two children the tumor was located suprasellar, in one children temporobasal, in four children adjacent to the cerebellar pontine angle, in 2 children in the clivus and in 2 children petroclival. A subfrontal approach was performed in two cases, a subtemporal approach in one case, a retrosigmoidal approach in 5 cases and in one case two-stages approach; retrosigmoidal and later pterional approach was conducted. In one case the clivus tumor was resected via a transnasal endoscopic assisted approach and in one case via a transoral endoscopic assisted approach. Gross total resection was achieved in 4 patients (36.0 %). Tumor types included meningioma, clivus-chordoma, epidermoid cyst, anaplastic ependymoma, Ewing"s sarcoma and Atypical Teratoid Rhabdoid Tumor (ATRT) as well as embryonal *tumor* with multilayered rosettes (ETMR). Hydrocephalus occurred in one patient, and a ventricoperitoneal shunt was inserted. Moreover, one child (9.1 %) suffered from a residual neurological deficit at last follow-up evaluation. Five patients (45.4 %) received adjuvant therapy.

### Conclusion

Skull base tumors in children present a therapeutic challenge due to their rarity and unique pathological composition and can lead to considerable morbidity and mortality. An interdisciplinary approach involving neurosurgeons, pediatric oncologists and radiotherapists is mandatory to guarantee the best clinical course.

# Tumor – Meningeome | Tumour – Meningiomas

## P055

### Die Rolle der Epigenetik bei Meningeomen in der klinischen Praxis
*The role of meningioma epigenetics in routine clinical practice*

L. Karamani[1], W. Müller[2], P. Baumgarten[1], C. Senft[1]

[1]Universitätsklinikum Jena, Klinik mit Poliklinik für Neurochirurgie, Jena, Deutschland
[2]Universitätsklinikum Leipzig, Paul-Flechsig-Institut für Neuropathologie, Leipzig, Deutschland

#### Objective

Meningeoma are benign tumors arising from the arachnoid in the brain and spinal cord. Lately there is a growing emphasis on individualized prognostication, incorporating DNA methylation profiles alongside WHO grading. Our study aimed at reporting the use and clinical significance of routine epigenetic testing of meningiomas.

#### Methods

We retrospectively analyzed meningioma patients operated between Januar 2021 and August 2023 with comprehensive demographic information. Histological examinations and genome wide DNA-methylation analyses were performed by an independent neuropathologist.

#### Results

80 patients were included in our study. Median age was 64 years, with a female predominance of 17-to-63 patients. 74 patients (93%) had WHO grade 1 meningiomas, 5 (6%) WHO grade 2 meningioma, and 1(1%) WHO grade 3 meningioma. In epigenetic analyses, 48 (60%) of meningiomas were classified as benign,9 (11%) as intermediate,and 1(1%) as malignant, while 19 tumors (24%) remained unclassified and 3(4%) were not epigenetically tested. Among WHO grade 1, 45 patients (61%) presented as benign, 8 (11%) intermediate, 4 (24%) unclassified. The single case with malignant classifier had a WHO grade 3 meningioma. The initial histological report, categorizing WHO grades, was typically obtained soon postoperatively, with a median turnaround time of 5 days. The tumor board convened at a median interval of 8 days. Subsequently, the second histological report, focusing on epigenetic analysis, was acquired later (median 22d). We found significant association between meningioma classifier and progression (r -0.37, p=0.0046, Spearman test). Additionally, a positive correlation was observed between meningioma classifier score and tumor volume (r 0.53, p <0.0001, Spearman test).No correlations were found between the meningioma classifier and the presence of edema or calcification on brain imaging. Similarly, no correlation was observed between the classifier and clinical performance status (KPS) at three months post-op, suggesting that the classifier likely does not influence the clinical course.

#### Conclusion

There is a high concordance between WHO grade and methylation classifier score in real-life meningioma treatment.10% of the patients had a higher classifier score than WHO grade, but this did not translate into management changes. The classifier score usually is not known when postsurgical follow-up and treatment plans are discussed. Thus, the clinical relevance of routine methylation analysis is unclear.

# Tumor – Meningeome | Tumour – Meningiomas

## P056

### Die Rolle des molekularen Tumorboards in der Neuroonkologie: eine deutschlandweite Umfrage
*The role of molecular tumor boards in Neuro-Oncology: A nationwide survey*

L. Hönikl[1], S. Lange[2], V. M. Butenschön[1], C. Delbridge[3], B. Meyer[1], S. E. Combs[4], A. L. Illert[5], F. Schmidt-Graf[6]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Medizinische Klinik, München, Deutschland
[3]Institut für Pathologie, Technische Universität München, Klinikum rechts der Isar, München, Deutschland
[4]Klinikum rechts der Isar, Technische Universität München, Strahlentherapie, München, Deutschland
[5]Klinikum rechts der Isar, Technische Universität München, Medizinische Klinik, München, Deutschland
[6]Klinikum rechts der Isar, Technische Universität München, Neurologie, München, Deutschland

#### Objective

In neuro-oncology, the inclusion of tumor patients in the molecular tumor board has only become increasingly widespread in recent years, but so far there are no standards for indication, procedure, evaluation, therapy recommendations and therapy implementation of neuro-oncological patients. The present work examines the current handling of neuro-oncological patients included in molecular tumor boards in Germany.

#### Methods

We created an online based survey with questions covering the handling of neuro-oncologic patient inclusion, annotation of genetic analyses, management of target therapies and the general role of molecular tumor boards in neuro-oncology in Germany. We contacted all members of the Neuro-Oncology working group (NOA) of the German Cancer Society (DKG) by e-mail.

#### Results

38 responses were collected. The majority of those who responded were specialists in neurosurgery or neurology with more than 10 years of professional experience working at a university hospital. Molecular tumor boards (MTB) regularly take place once a week and all treatment disciplines of neuro-oncology patients take part. The inclusions to the MTB are according to distinct tumors and predominantly in case of tumor recurrence. An independently MTB member mostly create the recommendations, which are regularly implemented in the tumor treatment. Recommendations are given for alteration classes 4 and 5. Problems exist mostly within the cost takeover of experimental therapies. The experimental therapies are mostly given in the department of medical oncology.

#### Conclusion

Molecular tumor boards for neuro-oncological patients, by now, are not standardized in Germany. Similarities exists for patient inclusion and interpretation of molecular alterations; the time point of inclusion and implementation during the patient treatment differ between the various hospitals. Further studies for standardization and harmonisation are needed. In summary, most of the interviewees envision great opportunities and possibilities for molecular-based neuro-oncological therapy in the future.

# Tumor – Gliome | Tumour – Gliomas

## P057

### Einfluss und Akzeptanz von klinischen Leitlinien in der Neuroonkologie: Ergebnisse einer bundesweiten Umfrage
*Assessing the influence and acceptance of neurooncology clinical guidelines: Insights from a national survey*

A. Lawson McLean[1], A. C. Lawson McLean[1], J. Walter[2], C. Senft[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland
[2]Klinikum Saarbrücken, Klinik für Neurochirurgie, Saarbrücken, Deutschland

#### Objective

The rapidly evolving field of neurooncology necessitates dynamic and up-to-date clinical guidelines to effectively incorporate novel therapeutic advancements. This study explores the perceptions and challenges of neurooncology professionals regarding these guidelines, with a particular focus on their adaptability to new treatments like Tumor Treating Fields (TTFields).

#### Methods

An electronic survey was disseminated through the German Neuro-Oncological Working Group"s mailing list, encompassing questions on demographics, attitudes towards clinical guidelines, and the integration of novel therapies like TTFields. The survey included Likert-scale questions, direct queries on guideline utility and adaptability, and specific questions about TTFields' incorporation in guidelines. Analytical methods comprised chi-squared tests, Pearson"s correlations, and Fisher's exact test for statistical validation.

#### Results

Of 87 valid responses, predominantly from neurosurgeons (66.7%), a significant majority (81.6%) recognized that guidelines enhance treatment quality. However, 32.2% felt that these guidelines constrain therapeutic freedom. Concerning TTFields, 78.2% of respondents were cognizant of its absence from the DGN glioblastoma guideline. The data revealed a correlation between the belief that guidelines improve treatment quality and the support for their regular updates. The survey also uncovered variations in the perception of guidelines across different demographics, reflecting diverse attitudes towards their application and evolution.

#### Conclusion

Medical guidelines in neurooncology are essential yet require frequent updates to reflect the latest therapeutic innovations. The study highlights the demand for guidelines to evolve dynamically, ensuring their reliability and relevance in clinical practice. It underscores the importance of balancing evidence-based rigor with timely updates, particularly in the inclusion of new treatments like TTFields.

# Tumor – Gliome | Tumour – Gliomas

## P058

### Koinzidenz von Gliosarkom und Desmoid-Fibromatose: Fallbericht und Literaturübersicht
*Coincidence gliosarcoma and desmoid-type fibromatosis: A case report and review of the literature*

J. D. Garcia Salas[1], G. Kvitsaridze[1]

[1]Klinikum Memmingen, Neurochirurgie, Memmingen, Deutschland

### Objective

Gliosarcoma is a histopathological variant of glioblastoma, with a poor prognosis, due to the aggressive nature and metastatic potential. Desmoid tumors are malignant mesenchymal proliferations. Here, we describe the appearance of a recurrent Gliosarcoma and an extracranial desmoid tumor, both with similar histological characteristics, but from distinct tissue origin. We report the histology and the molecular and genetic similarities and differences.

### Methods

A 54-year-old woman presented to our hospital with a progressively worsening frontal headache, with subsequent dysgraphia and unsteady walking. MRI, showed intracranial tumor on the left parietal lobe. Craniotomy was performed with total resection. Histopathological examination revealed pleomorphic glial tumor with predominant sarcomatoid differentiation. Radiotherapy as well as chemotherapy had to be discontinued due to severe bone marrow aplasia and vaginal bleeding, treated with transfusions and hormonal therapy. A recurrence of Gliosarcoma confirmed by pathology was resected one year later. Two years later, the patient returns to our hospital with painful, progressive swelling on the left shoulder. The resection of the lesion was performed without complications. The histopathological examination showed proliferation of spindle cells. Somatic mutation in the β -catenin (CTNNB1) gene was detected. Finally, it was reported Desmoid-type Fibromatosis.

### Results

The clinical, radiological and histological features from the trapezius muscle tumor initially suggested extracranial metastasis of a previously diagnosed Gliosarcoma. CTNNB1 sequencing is particularly useful to resolve cases in which histological interpretation of tumor samples is complicated. Mutation in the β -catenin (CTNNB1) gene is a specific diagnostic tool for the diagnosis of desmoid tumors.Hormone therapy is one of the factors associated with the appearance and progression of sporadic desmoid tumors and has already been described in the literature.

### Conclusion

The spontaneous occurrence of desmoid tumors with estrogen treatment has been previously reported. Histological coincidence of two tumors alone is not sufficient to differentiate between the appearance of a new primary tumor or the manifestation of a metastasis. Molecular and genetic studies are important as support tools for better tumor differentiation. The care and treatment of patients will be significantly impacted by the outcome.

Abb. 1

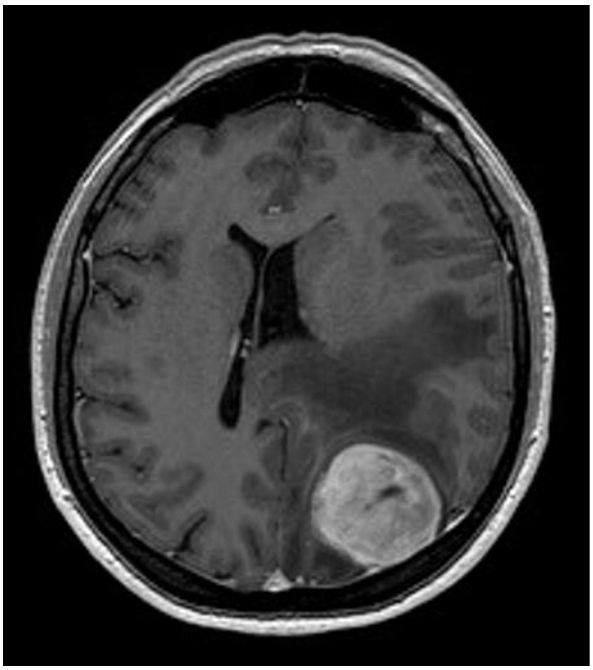


Abb. 2

# Tumor – Gliome | Tumour – Gliomas

## P059

### Implantierbares optisches Sensorsystem zur Überwachung von rezidivierenden Glioblastomen
*Implantable optical sensor system for glioblastoma recurrence monitoring*

A. Schaufler[1], A. Y. Sanin[2], A. Boese[3], I. Fischer[4], U. D. Kahlert[2], I. E. Sandalcioglu[1]

[1]Otto-von-Guericke-Universität Magdeburg, Universitätsklinik für Neurochirurgie, Magdeburg, Deutschland
[2]Otto-von-Guericke-Universität Magdeburg, Molekulare und Experimentelle Chirurgie (MEC), Magdeburg, Deutschland
[3]Otto-von-Guericke-Universität Magdeburg, INKA Health Tech Innovation Lab, Magdeburg, Deutschland
[4]Heinrich-Heine-Universität Düsseldorf, Neurochirurgische Klinik, Düsseldorf, Deutschland

#### Objective

Despite combination therapy, glioblastoma patients face poor prognoses and eventual relapse, commonly at the site of resection. With conventional MRI surveillance, histologic changes might be overlooked or misinterpreted. We propose an implantable system that provides accurate continuous monitoring of recurrence through the optical detection of fluorescently labeled cancer cells.

#### Methods

A 5ALA-fluorescence detecting precision sensor was designed and manufactured. To evaluate the sensor's ability to detect fluorescence in cancerous tissue, human glioblastoma cells from the BTSC322 and NCH421K cell lines were employed. These cells were cultured in 3D spheroid models and encapsulated within extracellular matrix domes. The samples were incubated with two concentrations of 5-ALA (0.1mM; 1mM) for 8 hours prior to measurements. Further, to devise an extracorporeal wireless energy supply for the implant, electromagnetic field simulations were conducted with three transmitter and receiver coil configurations. The most promising design was then implemented in a prototype energy transmission system, manufactured and subjected to energy transfer tests through animal tissue. Lastly, a comprehensive bi-modal implantable system was designed.

#### Results

All 5-ALA-treated samples were successfully detected by the sensor, with effectively suppressed interfering signals such as excitation light. The relationship between 5-ALA concentration and the measured signal could be accurately modeled for both cell lines using the power law, proportional to the forth root of the 5-ALA concentration (linear regression, $\beta = 567.4$ & $1293.3$ for BTSC322 and NCH421K respectively, CI: $482.2 – 652.5$ & $805.6 – 1781.1$, $R2 = 0.99$ & $0.95$, $p < 0.01$). Energy transfer simulations showed maximum energy transfer efficiencies of 0.7, 0.8 and 0.47 for the three alternative coil configurations. The configuration featuring a 4-layer implantable receiver coil and an external transceiver flat coil was fabricated and achieved an efficiency of 0.6 at the resonant frequency during testing.

#### Conclusion

The examined prototype successfully detected samples with human cancer cells even at dimensions of a few millimeters. The proposed monitoring system could enable early detection of recurrences and contribute to the optimization of treatment for GBM patients.

# Tumor – Gliome | Tumour – Gliomas

## P060

### Suche nach der am besten geeigneten MRT-Sequenz zur Vorhersage des IDH-Mutationsstatus mithilfe von radiomikbasiertem maschinellem Lernen

***Finding the most appropriate MRI sequence to predict IDH mutation status using radiomics-based machine learning***

M. Musigmann[1], D. Kasap[1], N. G. Nacul Mora[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

#### Objective

The IDH (isocitrate dehydrogenase) mutation status is one of the most important factors regarding the 2021 WHO classification of CNS tumors. The aim of our study is to analyze which of the commonly used MRI sequences is best suited to obtain this information non-invasively using radiomics-based machine learning. We develop several machine learning models based on different MRI sequences and determine which of the analyzed MRI sequences achieves the highest discriminatory power in predicting IDH mutation status.

#### Methods

In our retrospective IRB-approved study, we used MRI images from 106 patients with histologically confirmed gliomas, including 71 patients with an IDH mutation and 35 patients without an IDH mutation (IDH wild-type). MRI images were available for all patients, acquired with each of the following four MRI sequences: 1.) T1-weighted without contrast administration, 2.) contrast-enhanced T1-weighted, 3.) T2-weighted and 4.) FLAIR. Image segmentation of the tumors was performed semi-automatically using the open-source software platform 3D Slicer. For each of the four MRI sequences analyzed, 107 radiomic features were extracted from the corresponding MRI images by hand-delineated regions of interest. Various algorithms such as Random forest and Lasso regression were analyzed to predict the IDH mutation status.

#### Results

Among the different approaches we investigated, T1-weighted contrast-enhanced images proved to be the most suitable for predicting IDH mutation status using radiomics-based machine learning models. Regarding the machine learning algorithms we tested, we achieved the highest discriminatory power overall using Lasso regression. Using independent test data and contrast-enhanced T1-weighted MRI images, we obtained an AUC of 84.6%, accuracy of 79.2%, sensitivity of 84.7% and specificity of 68.1% with a 7-feature Lasso regression model. T2-weighted and native T1-weighted MRI images proved to be the least suitable for the prediction of IDH mutation status among the analyzed MRI images. In particular, when using T1-weighted images, it was shown that the administration of a contrast agent significantly increased the discriminatory power of radiomic-based prediction of IDH mutation status.

#### Conclusion

Our analyses show that the IDH mutation status can be predicted non-invasively with high accuracy using radiomics-based machine learning. Among the MRI images acquired with the commonly used sequences, contrast-enhanced, T1-weighted images are best suited for this purpose.

# Tumor – Gliome | Tumour – Gliomas

## P061

### Untersuchung der Mechanismen, die für die antineoplastische Wirkung von Metformin bei malignen Gliomen verantwortlich sind
*Investigation of the mechanisms responsible for the antineoplastic effect of metformin in malignant gliomas*

T. Detzer[1], C. Bach[1], E. Güresir[1], F. Gaunitz[1]

[1]Uniklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

#### Objective

Metformin has an antineoplastic effect on various types of cancer, including gliomas. To date, the mechanisms or targets underlying this effect have not been identified. The aim of our study is to investigate the glycerol-3-phosphate shuttle (G3PS) as a potential target of metformin in different glioblastoma (GBM) cell lines.

#### Methods

To investigate the effect of metformin on cell viability, cells were exposed to different concentrations of metformin (0–20 mM). After 24 hours, viability was determined by measuring ATP in cell lysates using the CellTiter-Glo assay. Cells were then exposed to metformin at the IC50 (half maximal inhibitory concentration) for several days while confluence was measured at 4-hour intervals by live-cell imaging. RT-qPCR and Western blotting were performed to quantify the expression of GPD1, GPD1L and GPD2 enzymes responsible for G3PS.

#### Results

Most GBM cell lines showed a sigmoidal response to 24-hour incubation with metformin, but with differences in IC50 (1.1–3.9 mM) and total viable cell count. G55T2, U251 and LN229 showed the strongest response with a final value of less than 70 % compared to the control (0 mM metformin). LN405, MZ18 and MZ54 showed a deviating behavior with a cell viability of more than 100 % at lower metformin concentrations. During long-term incubation, all cell lines showed significant differences in cell growth when incubated with metformin. The greatest effect was observed in 1321N1, U343 and LN229 with a percentage increase in doubling time during treatment of over 65 %. U87 showed little to no response with a percentage increase of 2.89±0.75 %, and U251 even showed a shorter doubling time than the control (control: 30.93±1.09 hours; with treatment: 27.84±0.19 hours). The GBM cell lines showed significantly higher mRNA expression of GPD1L and GPD2 than normal tissue. Expression at the RNA and protein level in GBM cell lines correlated significantly for both GPD1L and GPD2. The GPD1 protein was expressed at such low levels that it was not detectable by Western blot.

#### Conclusion

Since the antineoplastic effect of metformin is different in different cell lines, we hypothesize that a more comprehensive knowledge of the mechanisms and cellular targets may increase the utility of metformin for stratified tumor treatment.

# Tumor – Gliome | Tumour – Gliomas

## P062

### Nicht-invasive Klassifizierung von Astrozytomen durch radiomikgestütztes maschinelles Lernen
*Non-invasive classification of astrocytomas using radiomics-based machine learning*

M. Musigmann[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

#### Objective

Our aim is the non-invasive differentiation between low-grade and anaplastic astrocytomas and the prediction of IDH mutation status using radiomics-based machine learning. The first of these two distinctions is particularly important with regard to the 2016 WHO classification of CNS tumours. IDH mutation status, on the other hand, is one of the most important markers for the current WHO classification of 2021. The correct classification of astrocytomas is of great importance for further therapy planning. We analyse which clinical and radiomic features are relevant for each of the two classifications. Based on these results, we determine which radiomic features might indicate a reclassification due to the WHO classification of 2021.

#### Methods

The analyses of our retrospective IRB-approved study are based on CT images of 190 patients with histologically confirmed astrocytomas. 107 radiomic features were extracted from the CT images of each patient using the open-source PyRadiomics software. Several conventional machine learning algorithms and a neural network were trained and tested to discriminate between low-grade and anaplastic astrocytomas and to predict IDH mutation status. All machine learning models were fully developed 100 times each and subsequently tested to assess their stability.

#### Results

Using independent test data, we achieved a mean AUC of 92.5 %, a mean accuracy of 86.3 %, a mean sensitivity of 77.1 % and a mean specificity of 91.1 % in differentiating between low-grade and anaplastic astrocytomas. In predicting the IDH mutation status, we achieved a mean AUC of 87.8 %, a mean accuracy of 83.3 %, a mean sensitivity of 59.4 % and a mean specificity of 91.6 %. Many of the features included in the two models are relevant for both distinctions. In addition, we were able to identify certain radiomic features that might be particularly relevant for reclassification to WHO grade 4 according to the 2021 WHO classification.

#### Conclusion

Our study demonstrates that radiomics-based machine learning can be used to non-invasively predict WHO grade and IDH mutation status of astrocytomas, potentially allowing physicians to reduce the use of biopsies and accelerating further treatment planning. Although the WHO classification has recently been revised, many of the radiomic factors that were relevant in relation to the WHO classification of 2016 remain relevant for a classification according to the 2021 WHO classification.

# Tumor – Gliome | Tumour – Gliomas

## P063

### Re-Resktion beim Glioblastomrezidiv - Spielt der Zeitpunkt eine Rolle?
***Re-Resection for recurrent glioblastoma – Does timing matter?***

O. Alhalabi[1], P. Dao Trong[1], K. Mironov[1], K. Nabiev[1], N. Ghraieb[1], S. Krieg[1], A. Unterberg[1], C. Jungk[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

#### Objective

Surgery for recurrent glioblastoma (GBM) has the potential of prolonging patient survival. However, the impact of the timepoint of re-resection after tumor suspicion on post-surgical survival and neurological deterioration remains unclear.

#### Methods

Patients undergoing first re-resection for recurrent WHO grade 4 IDH-wildtype GBM were analyzed retrospectively. Post-surgical neurological deterioration and post-surgical survival of patients undergoing early surgery (within 3 weeks) after suspected recurrence were compared to those receiving surgery later than 3 weeks. In addition, volumetric analyses were used to determine tumor burden and location.

#### Results

103 consecutive patients (mean age: 59 years; 64 males and 39 females) undergoing first re-resection for recurrent GBM from 2018 to 2022 were included. Gross total resection (GTR) had been achieved in 93 patients (91%) at first diagnosis and was achieved in 96 patients (93%) at repeat surgery. Intraoperative MRI-guided resection was performed in 84 (82%) cases and 5-ALA was applied in 8 (8%) cases, with neuromonitoring utilized in 14 (14%) cases. The median time interval between first and second resection was 341 days (IQR 343 days) while the median time interval between suspected tumor recurrence and re-resection was 20 days (IQR 23 days). Surgery was delayed beyond 3 weeks after suspected recurrence in 49 cases (mean interval 11 in the "early" vs 187 days in the "late" group, $p<0.001$) due to salvage chemotherapy/targeted therapy in 18 cases, suspicion of pseudo-progression in 7 cases and patient preference in 24 cases. Compared to patients receiving "early" repeat surgery, this delay was not associated with a higher rate of immediate (14/54 vs 10/49 patients, $p=0.508$) or permanent (3/54 vs 4/49 patients, $p=0.600$) post-operative neurological deterioration. Median survival after repeat surgery was 220 days and did not significantly differ between early and late surgery (212 in the late vs 243 days in the early group, $p=0.682$). Volumetric analyses revealed no significant differences in tumor volume or localization pertaining to eloquence.

#### Conclusion

Timing of surgery for suspected first recurrence of GBM did not impact on functional outcomes and post-surgical survival. In general, satisfactory rates of postoperative neurological deficits and post-surgical survival in this contemporary cohort of patients with repeat surgery for recurrent GBM could be achieved.

# Tumor – Gliome | Tumour – Gliomas

## P064

### Vor- und Nachteile der Kombinationsbehandlung von GBM-Zellen mit Riluzol und Metformin
*Riluzole and metformin: Positives and negatives of combined treatment in GBM cells*

J. Keul[1], S. Sperling[1], M. Ninkovic[1], V. Rohde[1]

[1]Universitätsmedizin Göttingen, Göttingen, Göttingen, Deutschland

#### Objective

Controlling glucose levels is one of the strategies to influence its deleterious effect on glioblastoma (GBM) progression. Metformin (Met) is a drug widely used in diabetic patients and its cytotoxic activity in GBM is due to a reduction in glucose levels. Riluzole (Ril) is an approved drug for the treatment of amyotrophic lateral sclerosis with a broad spectrum of action including anti-glutamatergic pharmacological properties as well as its involvement in glucose metabolism in GBM. Here we investigated the combined effect on GBM cells.

#### Methods

U87MG cells were treated with Ril (25 µM) and/or Met (1 mM). The expression of the following genes was analysed by quantitative PCR: TFPi2, N-cadherin. Migration was assessed using the xCELLigence system. Prior to the experiment, cells were pre-treated with either 25µM Ril or vehicle for 72 h. Migration rate was expressed as cell index after 5 h co-treatment.

#### Results

The U87MG cells treated with Met showed a significant decrease in the expression of both TFPi2 and N-cadherin (***p), whereas riluzole significantly increased the expression of TFPi2 (***p) and decreased the expression of N-cadherin (**p). In the co-treatment group, the expression of the TFPi gene was significantly decreased compared to riluzole alone, but significantly increased compared to the control group. In addition, a significant increase in migration was observed in Met treated cells (**p), and co-treatment with riluzole further enhanced this effect.

#### Conclusion

A positive effect of co-treatment was observed in the case of TFPi2 expression levels compared to control or metformin alone. As the expression levels of N-cadherin in gliomas increase with pathological glioma grade, a positive effect - significant reduction - was observed with each treatment. A negative effect of the co-treatment was seen in the migration of this cells. Although this study is preliminary and requires further work, it offers another possibility for potential combinatorial treatment of GBM.

# Tumor – Gliome | Tumour – Gliomas

## P065

### Der Nutzen vom intaoperativen MRT in der Resektion beim Glioblastomrezidiv: Eine monozentrische retrospektive Analyse

***The utility of intraoperative MRI in the resection of recurrent GBM: A single-center retrospective analysis***

O. Alhalabi[1], P. Dao Trong[1], N. Ghraieb[1], K. Mironov[1], K. Nabiev[1], S. Krieg[1], A. Unterberg[1], C. Jungk[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

#### Objective

Intraoperative magnetic resonance imaging (iMRI) guidance in the resection of newly diagnosed glioblastoma (GBM) has been shown to be comparable to fluorescence guidance. However, the role of iMRI-guided resection in a recurrent setting remains unclear. In this study, we aimed to examine the utility of iMRI in the resection of recurrent GBM.

#### Methods

Patients undergoing re-resection for the first recurrence of WHO grade 4 IDH-wildtype GBM were retrospectively analyzed. The utility of iMRI (1.5T) guidance with respect to intraoperative decision-making for additional tumor resection and residual nodular contrast enhancing (CE) tumor on early postoperative MRI (poMRI, within 48 hours, 3T) scans was assessed.

#### Results

103 consecutive patients (mean age: 59 years; 64 males and 39 females) undergoing re-resection for first GBM recurrence in the years 2018 to 2022 were included. iMRI-guided resection was performed in 84 (81%) cases and 5-ALA was applied in 8 (8%) cases. In 11 cases (11%), neither was applied. In the 77/84 (92%) of the iMRI group, a gross total resection (GTR)defined as no residual nodular CE tumor was intended . After iMRI, additional resection was carried out in 53/84 cases (63%) while no residual CE tumor was detected 28/84 cases (33%). In the remaining 3 cases, additional resection was not possible due to functional reasons. On poMRI, a GTR was achieved in 63/84 (75%) cases. In 17 cases (20%), residual CE was detected on poMRI (GTR not intended in 3 cases). In 28 cases with intraoperatively assumed GTR, poMRI confirmed GTR in 25 cases (89%, mismatch in 3 cases, 11%), which was higher than in cases with additional intraoperative resection after iMRI (GTR in 42 out of 53 cases, 82%, p=0.07). In the remaining 11/53 cases, residual CE tumor was detected despite additional intraoperative reresection (18%). Hence, achieved GTR was in 63 out of intended 77 patients (81%). Postoperative neurological deficits were noted in 11/53 patients with additional resection (20%) compared to 3/28 patients without additional resection (10%, p=0.126) and were mostly transient (permanent deficits 3/53 and 1/28 patients, respectively). In this cohort, median survival after repeat surgery was 220 days.

#### Conclusion

iMRI provides valuable information on residual CE tumor for intraoperative decision making concerning additional tumor resection in the setting of recurrent GBM. A mismatch between GTR assessed on iMRI and poMRI could be attributed to different magnetic field strengths.

# Tumor – Gliome | Tumour – Gliomas

## P066

### Die Rolle der chirurgischen Re-Resektion für das Überleben beim rezidivierenden Glioblastom
*The role of surgical re-resection on survival in recurrent Glioblastoma*

D. Jankovic[1], S. G. Thavarajasingam[1], A. Dauth[1], F. Lange[1], T. Berenz[1], H. Krenzlin[1], L. Schmidt[1], N. Keric[1], F. Ringel[1]

[1]University Medical Center, Department of Neurosurgery, Mainz, Deutschland

#### Objective

Glioblastoma (GBM) is the most common malignant brain tumor in adults, characterized by a dismal prognosis and near-inevitable recurrence. The management of recurrent GBM is individualized, considering tumor location, patient function, and age. The role of repeated surgical resection in recurrent GBMs is not well-defined. This study aims to to evaluate the impact of repeated resection on progression-free survival (PFS) and overall survival (OS) in recurrent GBMs.

#### Methods

Data acquisition was conducted as a retrospective analysis. Our study included patients diagnosed with recurrent GBM who underwent repeated surgical resection at our department between January 1st, 2016, and December 31st, 2021. Demographic data, tumor size, Eastern Cooperative Oncology Group Performance Status (ECOG), treatment modalities, and extent of resection (classified by RANO criteria) were assessed. The Kaplan-Meier method was used to estimate OS and PFS as a function of time after first and second surgical re-resections.

#### Results

Out of 197 recurrent GBM patients in the study, 86 underwent repeated resection—86 had one, and 20 had two surgical re-resections after initial surgery. The extent of the first repeated resection significantly correlated with overall survival (p=0.014) and progression-free survival (p=0.0073). The median progression-free survival varied: 259 days after complete re-resection, 147 days following subtotal resection, 176.5 days after near-total resection, and 118 days after partial resection. First repeat tumor resection was associated with increased PFS (p=0.0084) and OS (p=0.0023). In contrast, after second relapse, there is no statistically significant difference between second repeated surgery and treatment without surgery for overall survival (p=0.93) and progression-free survival (p=0.18). Multivariate analysis showed that concomitant treatment (OS: p=0.0213; PFS: p=0.00537) and MGMT promoter status (OS: p=0.0165; PFS: p=0.01243) remained statistically significant factors for survival.

#### Conclusion

While our results emphasize the important role of surgery in the treatment of the first recurrent GBM and concomitant treatment with a substantial association with extended overall survival (OS) and progression-free survival (PFS), the implications of subsequent repeated operations, particularly the second and third, remain ambiguous and may be subject to potential influences such as selection bias.

# Tumor – Gliome | Tumour – Gliomas

## P068

### Glioblastom Migration und Invasion wird durch Dextran umhüllte Eisen Oxid Nanopartikel erhöht
*Glioblastoma motility and invasion are increased by dextran coated iron oxide nanoparticles*

C. Petry[1], O. Buchholz[1], I. Vasilikos[1], U. G. Hofmann[1], J. Beck[1], K. Joseph[1], V. Ravi[1]

[1]Universitätsklinikum Freiburg, Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

After decades of stagnation in the treatment of glioblastoma (GB), innovative new treatment modalities are needed. The field of nanomedicine and nanotechnology allows for precise medical intervention for diagnosis and treatment. Despite clinical approval and ongoing clinical trials using dextran coated iron oxide nanoparticles (dIONPs) concerns about potential adverse effects still prevail.Here we explored the effect of dIONPs on GB migration and invasion.

#### Methods

The effect of dIONPs over 15h of exposure on GB cells were tested. Different parameters of migration like total distance traveled or furthest distance from origin were evaluated. Effects on apoptosis were tested at different exposure times to evaluate cytotoxicity. To complement the cell tracking experiments scratch assays were performed to assess potential increases of invasive potential.

#### Results

GB cell tracking revealed that exposure to dIONPs significantly increases their migratory potential. Interestingly we discovered a subpopulation of GB cells with a "high motility" phenotype that consistently exceeds the migratory potential seen in the overall population. Exposure to dIONPs appears to increase the fraction of cells with this "run-away" phenotype. There appears to be a time dependent effect likely linked to cellular uptake, degradation, or chemical reactions. After 3-4 hours of exposure we observed significantly elevated apoptosis compared to the control. Invasion goes beyond simple migration and necessitates directed movement as well as the ability to reshape and interact with the complex extracellular matrix. Here we evaluated directed migratory behavior by scratch assay. This showed that dIONPs also significantly increase the directed migration of GB cells into unchartered territory.

#### Conclusion

These finding are important especially as recurrence from such "run-away" cells are the main cause of death. The use of dIONPs in conjunction with surgery could increase the migratory capabilities of the cells that are left behind.These cells that already have an increased migratory phenotype could see this characteristic increased leading to recurrences in healthy parts of the brain. At least these finding warrant further investigation in adverse effects of exposure to nanoparticles beyond simple cytotoxic assessment.

# P069

## Suizidgentherapie des Glioblastoms mittels des Pseudomonas Exotoxins PE38
## *Suicide gene therapy with Pseudomonas exotoxin PE38 for the treatment of glioblastoma*

S. Michen[1], L. Jilek[1], W. Jugel[1], M. Lange-Osborn[2], G. Schackert[3,4,5,6], I. Y. Eyüpoglu[3,4,5,6], A. Temme[3,4,5,1]

[1]TU Dresden, Medical Faculty and University Hospital Carl Gustav Carus, Department of Neurosurgery, Division of Experimental Neurosurgery/Tumor Immunology, Dresden, Deutschland
[2]University of Missouri, School of Medicine, Department of Molecular Microbiology and Immunology, Columbia, Vereinigte Staaten
[3]German Cancer Consortium (DKTK), Dresden, Deutschland
[4]National Center for Tumor Diseases (NCT/UCC), Dresden, Deutschland
[5]German Cancer Research Center (DKFZ), Dresden, Deutschland
[6]TU Dresden, Medical Faculty and University Hospital Carl Gustav Carus, Department of Neurosurgery, Dresden, Deutschland

### Objective

Glioblastoma (GBM) represent the most common primary adult brain tumors. Despite multimodal treatment, most GBMs ultimately recur. A promising strategy for GBM treatment is suicide gene therapy, employing genes encoding cytotoxic proteins. The truncated form of Pseudomonas exotoxin A, known as PE38, encompasses an enzymatically active C-terminal domain that facilitates ADP-ribosylation and subsequent inactivation of elongation factor 2 (EF2). This molecular cascade inhibits protein synthesis and ultimately causes cell death. In this study, we exploited the ability of PE38 as a suicide gene for the treatment of GBM.

### Methods

To achieve sustained PE38 transgene expression, we flanked its expression cassette with Sleeping Beauty (SB) inverted terminal repeats (ITRs). Simultaneous DNA was introduced mediated by polyethyleneimine (PEI) encoding a hyperactive form of the SB transposase (SB100X). SB100X recognized the ITRs and enabled genomic integration via a cut-and-paste mechanism. To address safety concerns associated with DNA delivery, such as non-specific cytotoxic effects on cells both the transposon and SB100X expression cassettes were flanked by attB and attP recognition sites. This design enabled the use of the bacterial PhiC31 integrase to generate minicircle DNA devoid of bacterial backbones. PE38 protein expression was examined in 293FT-diphtamide 1 knock out (DHP1KO) cells by Western blot analysis. The anti-tumor efficacy of exotoxin PE38 suicide gene therapy was investigated in both permanent (U87-MG, H4) and primary (HT18584, HT16360-1) GBM cell lines, employing comprehensive analyses of cell viability and clonogeneic survival.

### Results

Exotoxin PE38 was successfully expressed in 293FT-DHP1KO cells, as confirmed by Western blot analysis, where the absence of diphthamide, a conserved modification on eEF2, prevented ADP-ribosylation of EF2. Employing exotoxin PE38 suicide gene therapy on GBM cell lines resulted in a substantial reduction in cell viability, reaching up to 80% for the H4 cell line 7 days post-treatment. Moreover, clonogenic survival exhibited a remarkable decrease of up to 99% in both H4 and HT18584 cell lines 14 days after treatment.

### Conclusion

Our findings demonstrate the feasibility of an exotoxin PE38 suicide gene therapy for treating human GBM cells. Further research is essential to address gene delivery and to investigate anti-glioma effects of this therapy in pre-clinical *in vivo* studies.

# P070

## Präoperative Beurteilung des Kurzzeitüberlebens bei Glioblastom: Externe Validierung des SHORT-Scores
## *Preoperative assessment for short-term survival in glioblastoma: External validation of the SHORT score*

I. Ilic[1], A. L. Potthoff[1], N. Schäfer[2], L. Weinhold[3], H. Vatter[1], U. Herrlinger[2], P. Schuss[1,4], V. Borger[1], M. Schneider[1]

[1]Universitätsklinikum Bonn, Klinik mit Poliklinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Klinik und Poliklinik für Neurologie, Sektion Klinische Neuroonkologie, Bonn, Deutschland
[3]Universität Bonn, Institut für Medizinische Biometrie, Informatik und Epidemiologie, Bonn, Deutschland
[4]BG Klinikum Unfallkrankenhaus Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

### Objective

In the context of glioblastoma surgery, assessment of the individual preoperative risk-benefit profile is an essential component of neuro-oncological treatment planning. The SHORT score exploits preoperative variables to forecast short-term survival (STS) in patients with glioblastoma. The aim of this study was to externally validate the SHORT score in patients with surgically treated glioblastoma.

### Methods

Data were collected from patients surgically treated for glioblastoma at a specialized neuro-oncology center. Individualized SHORT scores were calculated and area under the receiver operating characteristic (AUROC) and precision-recall curves (PRC) plus 95% confidence interval (CI) were plotted to evaluate the ability of the SHORT score to indicate short-term survival in glioblastoma patients in an external cohort.

### Results

A cohort of 240 glioblastoma patients was analyzed, where STS < 6 months was noted in 33 patients (14%). Pre-existing arterial hypertension, advanced age, and decreased preoperative Karnofsky Performance Status (KPS) were found to significantly correlate with shorter STS. The SHORT score effectively stratified patients into risk groups (HR, MR, LR), with AUROC for SHORT in this cohort being 0.774, indicating good discriminatory ability.

### Conclusion

The validity of the SHORT score was acceptable and comparable to the values in the referenced study group. This score might be used to preoperatively identify glioblastoma patients at high risk for short-term survival.

# Tumor – Gliome | Tumour – Gliomas

## P071

### Überleben von Patienten mit neu diagnostiziertem Glioblastom: Outcome bei infra- vs. supratentorieller Lokalisation.

***Survival of patients with newly diagnosed glioblastoma: Does cerebellar localization matter?***

Y. Lizunou[1], A. L. Potthoff[1], N. Schäfer[2], A. Waha[3], V. Borger[1], U. Herrlinger[2], H. Vatter[1], P. Schuss[1,4], M. Schneider[1]

[1]Universitätsklinikum Bonn, Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Neurologie, Bonn, Deutschland
[3]Universitätsklinikum Bonn, Neuropathologie, Bonn, Deutschland
[4]BG Klinikum Unfallkrankenhaus Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

#### Objective

Due to the rare incidence of cerebellar glioblastoma, clinical outcome data are scarce. The authors performed propensity score matching between patients with infra- and supratentorial glioblastoma and analyzed their institutional database with regard to potential prognostic differences between cerebellar and supratentorial glioblastoma patients.

#### Methods

Between 2009 and 2020, 8 patients underwent surgery for cerebellar glioblastoma at the author's institution. In order to produce a covariate balance optimization for commonly known prognostic predictors (age, preoperative Karnofsky Performance Scale (KPS), extend of resection (EOR), MGMT-promoter methylation status), a propensity score matching at a ratio of 1:4 between a cohort of patients with infratentorial glioblastoma and a cohort of 205 patients with supratentorial glioblastoma was performed using R. A systematic review of the contemporary literature was performed in order to compile survival data of cerebellar glioblastoma patients.

#### Results

Cerebellar glioblastoma patients exhibited a median overall survival (OS) rate of 18 months (95% confidence interval (CI) 11-25). Compared with this, median OS for the group of 32 individually matched patients with supratentorial glioblastoma was 23 months (95% CI 23 (0-62)) (p = 0.63). A systematic review revealed OS rates for glioblastoma patients between 6 up to 21 months.

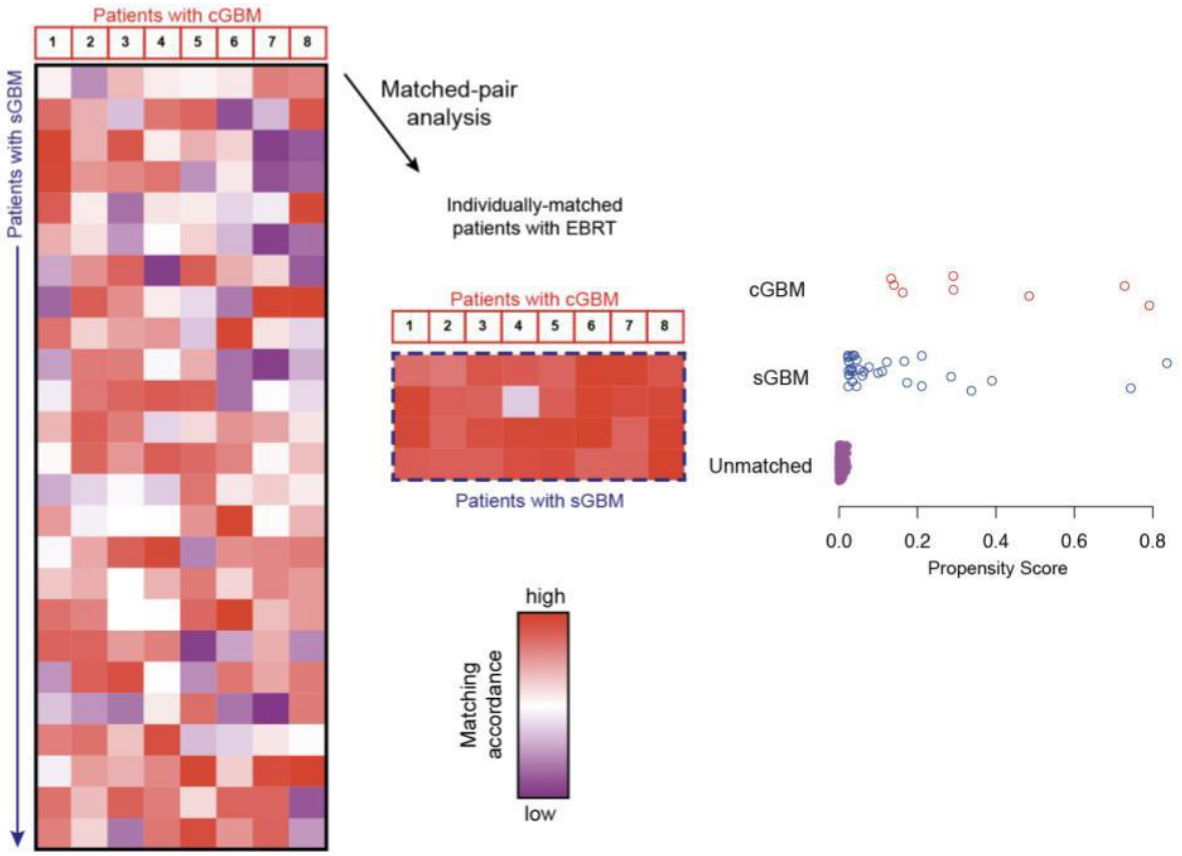
#### Conclusion

The present study suggests that theprognostic value of infra- and supratentorial glioblastoma location following at least STR does not significantly differ. The establishment of large-scale, multicenter databases is needed in order to be capable of adequately addressing this underrepresented subpopulation of glioblastoma patients.

Abb. 1

| | Cerebellar localization n=8 | Supratentorial localization n= 32 | p Value |
|---|---|---|---|
| Number of patients | 8 | 32 | |
| Median age (years, IQR) | 70 (64-76) | 66 (55-74) | 0.22 |
| Median KPS at admission (IQR) | 65 (60-70) | 70 (60-80) | 0,33 |
| EOR (STR/GTR) | 1/7 | 8/24 | 0.45 |
| IDH-Status ( wt/-) | 7/-$^{\Omega}$ | 32/0 | - |
| MGMT-promoter methylation | 5 | 26 | 0.26 |
| Median PFS (mo, 95% CI) | 8 (4-12) | 7 (0-16) | 0,2 |
| Median OS (mo, 95% CI) | 18 (11-25) | 23 (0-62) | 0.63 |

Abb. 2



# Tumor – Metastasen | Tumour – Metastases

## P072

### Asymptomatische vs. symptomatische Hirnmetastasen: operative Behandlungsergebnisse
***Asymptomatic vs. symptomatic brain metastases: Surgical treatment results***

T. F. Ersoy[1], D. Brainman[1], D. Dimov[1], R. Coras[2], M. Simon[1]

[1]Universitätsklinikum OWL Campus Bielefeld-Bethel, Klinik für Neurochirurgie, Bielefeld, Deutschland
[2]Universitätsklinikum Erlangen, Institut für Neuropathologie, Erlangen, Deutschland

#### Objective

Asymptomatic brain metastases (BM) patients are prime candidates for novel systemic therapy options. Treatment results need to be compared to the current standards of local therapy for BM, including surgery. This study details surgical treatment results in asymptomatic vs. symptomatic patients.

#### Methods

We retrospectively analyzed survival and functional outcomes in 328 consecutive patients (365 surgeries) operated for one or more BM 2015-2022, for whom pertinent oncological information was available. Symptom burden was assessed using the presurgical NANO score for neurological deficits, the KPI for functional health status and by occurrence of seizures. Patients with a NANO score 0-1, KPI 90-100% and without seizures were classified as asymptomatic (asymp.), whilst patients with a NANO score ≥4 or a KPI <70% were classified as severely symptomatic (symp.), and all others as moderately symp.

#### Results

52.3% patients harbored a single BM. The primary cancer site was lung in 49.6 and breast in 17.6%. Median OS was 11.5 (95%CI 8.9-14.0) months. 67.6% of the patients had already died at the time of analysis.

Asymp. patients lived significantly longer (medOS: 17.4 (95%CI 10.7-24.1) months; cf. symp.: 8.3 (95%CI 6.2-10.4) months; p<0.001). Complication rates (CTCAE III-V) were much lower for asymp. vs. symp. cases: 4.3 vs. 7.3% surgical (p=NS), 3.4 vs. 10.7% medical (p=0.022), and 0.9 vs. 5.8% persistent neurodeficits (p=0.04). Asymp. patients underwent significantly more often postoperative treatment (radiotherapy: 89.8 vs. 72.3%, p<0.001; systemic treatment: 74.4 vs. 58.9%, p=0.012). When compared to moderately symp. patients, severely symp. cases lived significantly shorter (medOS: 4.1 (95%CI 2.0-6.2) vs. 11.5 (95%CI 7.9-15.1) months; p<0.001), had higher complication rates (surgical: 11.2 vs. 5.2%, medical: 14.6 vs. 8.1%, persistent neurodeficits: 7.9 vs. 4.4%, p=NS) and less intensive postoperative therapy (radiotherapy: 59.8 vs. 80.6%, p=0.001; systemic treatment: 43.8 vs. 68.9%, p<0.001).

#### Conclusion

Our results can serve as a benchmark for surgical treatment of patients with asymptomatic BM who may expect to have systemic therapy options already now or in the near future. We show that survival & functional outcomes worsen significantly with increasing symptom burden. Treatment paradigms deferring surgical BM therapy will thus have to take into account poorer outcomes and worse survival that come with "late" surgery for symp. patients after failure of primary systemic treatment.

# P073

## Die Zytokinantwort im Liquor zerebrospinalis nach Resektion von zerebralen Metastasen mit intraoperativer Bestrahlung.

***Cytokine profiling in cerebrospinal fluid after intraoperative radiation of cerebral metastases***

P. Krauss[1], Z. Mielewczyk[2], K. H. Kahl[3], T. Mögele[2], B. Märkl[2], F. Liesche-Starnecker[2], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland
[2]Universitätsklinikum Augsburg, Pathologie, Augsburg, Deutschland
[3]Universitätsklinikum Augsburg, Strahlentherapie, Augsburg, Deutschland

### Objective

Intraoperative radiation therapy (IORT) is an ascending treatment approach which provides targeted radiation, reduced local recurrence and induction of an anti-tumor effect by activating an immune response. Aim of our study is to characterize the immunological signature represented by the cytokine profile in the cerebrospinal fluid (CSF) after IORT of cerebral metastases.

### Methods

We analyzed the cytokine patterns in 37 CSF samples obtained from 10 patients with tumor resection and IORT. Samples were taken at four time points: 1. intraoperatively, before tumor resection and IORT, 2. intraoperatively, after tumor resection, before IORT, 3. intraoperatively, after tumor resection and IORT, 4. ~24 hours postoperatively from drainage. Samples were tested using a multiplex immunoassay (CodePlex Secretome - Human Innate Immune Panel provided by IsoPlexis) according to the manufacturer"s instructions. Levels of EGF, GM-CSF, Granzyme B, IFN-γ, IL-1β, IL-4, IL-6, IL-7, IL-8, IL-10, IL-15, IP-10, MCP-1, MIP-1α, MIP-1β, PDGF-BB, sCD137, TNF-α and VEGF were measured and quantified using IsoSpeak software. The Wilcoxon-Test was used for statistical analysis.

### Results

An increase of signal intensity was observed for 16 of the 19 analyzed cytokines (84%), of which 7 (37%) displayed significant differences between baseline and postoperative time points: IL-1β, IL-6, IL-8, IP-10, MCP-1, MIP-1β and VEGF. Except for IP-10, a gradual increase for the four time points was seen for these cytokines.

### Conclusion

Our study allows first conclusions about changes in the cytokine profile of cerebrospinal fluid after IORT of cerebral metastases. The results indicate that IL-1β, IL-6, IL-8, IP-10, MCP-1, MIP-1β and VEGF are involved in the inflammatory response induced by exposure to ionizing radiation of the tumor bed during surgery. The results are limited since no control group was tested, yet. Currently, we are setting up such a control group which included patients with resection of cerebral metastases without IORT.

# P074

## Resektion bei Patienten mit Hirnmetastasen und schlechtem Karnofsky Performance Status - eine Überlebensanalyse.

***Enhancing outcomes: Neurosurgical resection in brain metastasis patients with poor Karnofsky performance score – A comprehensive survival analysis.***

M. Goldberg[1], M. G. Mondragon-Soto[2], G. Altawalbeh[1], L. Baumgart[3], J. Gempt[3], D. Bernhardt[4,5], S. E. Combs[4,5,6], B. Meyer[1], A. K. Aftahy[1]

[1]Department of Neurosurgery, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[2]National Institute of Neurology and Neurosurgery, Department of Neurosurgery, Mexico City, Mexiko
[3]Department of Neurosurgery, University Medical Center Hamburg-Eppendorf, Hamburg, Deutschland
[4]Department of Radiation Oncology, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[5]German Cancer Consortium (DKTK), München, Deutschland
[6]Institute of Innovative Radiotherapy (iRT), Department of Radiation Sciences (DRS), Helmholtz Zentrum Munich, München, Deutschland

### Objective

A reduced Karnofsky performance score (KPS) often leads to the discontinuation of surgical and adjuvant therapy. This study aimed to examine the clinical and treatment outcomes of patients with KPS < 70 after neurosurgical resection and identify prognostic factors associated with better survival.

### Methods

Patients with a preoperative KPS < 70 who underwent surgical resection for newly diagnosed brain metastases (BM) between 2007 and 2020 were retrospectively analyzed. The KPS, age, sex, tumor localization, cumulative tumor volume, number of lesions, extent of resection, prognostic assessment scores, adjuvant radiotherapy and systemic therapy, and presence of disease progression were analyzed. Univariate and multivariate logistic regression analyses were performed to determine the factors associated with better survival. Survival > 3 months was considered favorable and ≤ 3 months as poor.

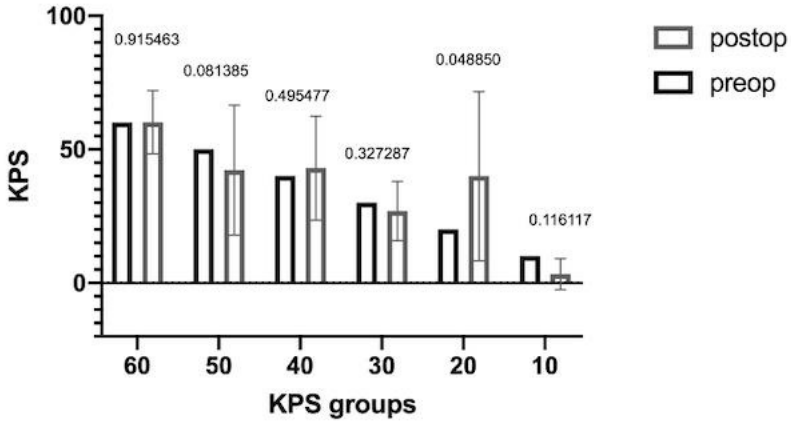
### Results

A total of 140 patients were identified, with a median overall survival of 5.6 months (range 0-58). There was a significant improvement in KPS after surgery in patients with a preoperative KPS of 20% (p = 0.048). In the other groups, no significant changes in KPS were observed. Adjuvant radiotherapy was associated with better survival (44 [84.6%] vs. 32 [36.4%]; hazard ratio [HR], 0.0363; confidence interval [CI], 0.197–0.670, p = 0.00199). Adjuvant chemotherapy and immunotherapy resulted in prolonged survival (24 [46.2%] vs. 12 [13.6%]; HR, 0.474; CI, 0.263–0.854, p = 0.013]. Systemic disease progression was associated with poor survival (36 [50%] vs. 71 [80.7%]; HR, 5.975; CI, 2.610–13.677, p < 0.001].

### Conclusion

Neurosurgical resection is an appropriate treatment modality for patients with low KPS. Surgery may improve functional status and facilitate further tumor-specific treatment. Combined treatment with adjuvant radiotherapy and systemic therapy was associated with improved survival in this cohort of patients. Systemic tumor progression has been identified as an independent factor for a poor prognosis.

Abb. 1


100
50
0
KPS
0.915463
0.081385
0.495477
0.327287
0.048850
0.116117
60
50
40
30
20
10
KPS groups
postop
preop

# P075

## Immunphänotypisierung von Patienten mit Hirnmetastasen zeigt eine deutliche Depletion und Erschöpfung des CD4-T-Zell-Repertoires in Blut und Knochenmark

***Immune phenotyping of brain metastasis patients identifies a distinct depletion and exhaustion of the CD4 T cell repertoire in blood and bone marrow***

M. Reetz[1], A. Ryba[1], K. Fita[1], J. Gempt[1], M. Westphal[1], K. Lamszus[1], E. Tolosa[2], C. Maire[1], M. Mohme[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik für Neurochirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Institut für Immunologie, Hamburg, Deutschland

### Objective

Brain metastases are the most rapidly emerging entity in neuro-oncology. Given the decisive role of immunotherapy, the immune crosstalk between the blood circulation and the brain tumor requires deeper investigation, especially in light of recent data showing that T cells might be trap in the bone marrow in the course of brain metastasis.

### Methods

Using a cohort of 40 patients with brain metastasis, we analyzed the immune signature in the blood circulation and bone marrow using flow cytometry. We investigated the phenotype and differentiation status of T cells as well as the general immune cell composition.

### Results

Our results show a global decrease of the proportion of CD3+ T cells in the peripheral blood of patients with brain tumor when compared to healthy donors. In particular, the CD4+ T cells were more affect from the presence of brain tumors than the CD8, with a significant decrease of Tregs, and Th1 and Th2 helper cell populations. The proportion of naïve CD4 T cells with low expression of CXCR3 and CD127 is decreased in tumor, while a subpopulation of naïve as well as central memory CD4CM with high expression of PD1 is increased. Additionally, we noticed an increase of the proportion of B cells in the tumor patients" blood together with a decrease of non-classical CD86+ monocytes. The NK population was also affected with a significant depletion of mature NK CD57+ in the periphery in patients with brain tumors. In the bone marrow, we found an increase of the proportion of senescent CD4CM CD57+, while the proportion of CD4CM CXCR3+ was significantly decreased in patients with NSCLC brain metastasis.

### Conclusion

Taken together, our data shows that brain metastases deeply affect the phenotype and abundance of the CD4 T cell repertoire, thus interfering with the primary T cell population orchestrating the tumor-specific immune response.

# Tumor – Metastasen | Tumour – Metastases

## P076

### Neurochirurgisches Management von multiplen Hirnmetastasen: Ergebnisse, Komplikationen und Überlebensraten in einer retrospektiven Analyse

***Neurosurgical management of multiple brain metastases: Outcomes, complications, and survival rates in a retrospective analysis***

S. Niedermeyer[1], M. Schmutzer-Sondergeld[1], J. Weller[1], S. Katzendobler[1], C. Schichor[1], V. Stöcklein[1], N. Thon[1]

[1]LMU Klinikum, Neurochirurgische Klinik und Poliklinik, München, Deutschland

#### Objective

This study investigates the outcomes of microsurgical resection of multiple brain metastasis (BMs).

#### Methods

Clinical data of patients undergoing resection of ≥2 BMs in a single surgery between January 2018 and May 2023 were retrospectively analyzed. Surgical indications adhered to established criteria for salvage therapy post-radiation or when significant mass effect precluded radiation. Patients were stratified based on the Radiation Therapy Oncology Group (RTOG) recursive partitioning analysis (RPA) derived prognostic classes. Postoperative neurological and functional outcomes, along with perioperative complications, were evaluated.

#### Results

A total of 47 patients, with a median age of 61 years (IQR 48-69), underwent 73 craniotomies (median 2 ; range 1-3) for resection of 104 metastases. RPA class distribution was 17% for class 1, 70.2% for class 2 and 12.8% for class 3. Karnofsky Performance Scale (KPS) scores were improved in 44.7% of patients, remained unchanged in 48.9%, and worsened in 6.4% after surgery. The Wilcoxon matched-pairs signed rank test revealed a significant overall improvement in postoperative vs. preoperative KPS score medians (p=0.0004). Perioperative complications were observed in 25.5%, with Dindo & Clavien grade III & IV complications in 19.2%, necessitating surgical intervention. Complications were permanent in 6.4% of patients, and transient 19.1%. Their occurrence was independent of age (p=0.325), number of craniotomies (p=0.1) or eloquent location (p=0.63). Complications were associated with a longer ICU stay (p<0.0001), but not with worsening KPS score at discharge (p=0.159) or at 3 months follow-up (p=0.405). Twelve-month survival rates were 85%, 77%, and 50% for RPA classes 1, 2, and 3, respectively (log rank test, p=0.2).

#### Conclusion

Surgical resection of multiple brain metastases results in stabilization or functional improvement in the majority of patients, enabling continued systemic disease treatment. Although complications occurred in a significant number of patients, they were predominantly transient and not associated to KPS at discharge or at 3 months follow-up.

# P077

## Die Potenziale der intraoperativen 3-Tesla-Magnetresonanztomographie bei der Resektion von Hirnmetastasen
*Navigating brain metastases: Unveiling the potential of 3-Tesla intraoperative MRI*

G. Altawalbeh[1], M. Goldberg[1], M. G. Mondragon-Soto[2], C. Negwer[1], A. Wagner[1], J. Gempt[3], B. Meyer [1], A. Kaywan Aftahy [1,]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]National Institute of Neurology and Neurosurgery, Department of Neurosurgery, Mexico City, Deutschland
[3]Department of Neurosurgery, University Medical Center Hamburg-Eppendorf, 20246 Hamburg, Germany

### Objective

Intraoperative magnetic resonance imaging (iMRI) has witnessed significant growth in the realm of neurosurgery, particularly in glioma surgery, enhancing image-guided neuronavigation and optimizing extent of resection (EOR). Despite its extensive use in gliomas, its utility in brain metastases (BM) remains underexplored. This study examines the impact of iMRI in resecting BM.

### Methods

A retrospective study involved 25 patients with BM undergoing 3-Tesla iMRI-assisted resection between 2018 and 2022. Volumetric measurements of BM were conducted with pre-, intra-, and postoperative MRI. Karnofsky-Index, ECOG-Score, and neurological status were assessed. Local recurrences and in-brain progression were monitored through follow-up MRI at 3 and 6 months postoperatively.

### Results

In this cohort (n=25, mean age 63.6 years), the mean surgical duration was 219.9 minutes and mean iMRI duration was 61.7 minutes. Indications for iMRI were primarily associated with preoperative imaging suggesting an unclear entity, often suspicious for glioma. Gross total resection was achieved in in 21 cases (84%). Continued resection was pursued after iMRI in 6 cases (24%), resulting in improved EOR to 100% in 5 cases. Neurological status postoperatively remained stable in 60%, improved in 24%, and worsened in 16%. No wound healing problems or postoperative complications occurred. Among the 13 Patients who underwent follow-up MRI 3 months postoperatively, one patient showed local recurrence in the site of resection and 7 patients showed in-brain Progression. In the 8 patients with a 6-month follow-up MRI, two showed local recurrence, while 3 exhibited in-brain progression.

### Conclusion

This analysis of 3-Tesla iMRI's impact on brain metastases outcomes affirms its safety and feasibility in the neurosurgical workflow. Real-time imaging precision aids in informed decision-making, contributing to improved patient outcomes including the enhancement of the EOR. While suggesting potential benefits, larger clinical trials are essential to refine indications for iMRI in BM, guiding neurosurgeons toward more informed decision-making.

# P078

## Neutrophile als Immuntargets für die Therapie von Hirnmetastasen
*Neutrophils as immune targets for the therapy of brain metastases*

L. Cook[1], F. Conrad[1], E. Eikmeier[1], A. Grote[2], C. Nimsky[2], J. Bartsch[2]

[1]Philipps-Universität Marburg, Neurochirurgie, Marburg, Deutschland
[2]Philipps-Universität Marburg, Klinik für Neurochirurgie, Marburg, Deutschland

### Objective

With a frequency of 20 to 40 %, brain metastases represent the majority of malignant brain tumors in adults. The development of metastases is the greatest obstacle to long-term patient survival. A detailed understanding of the mechanisms involved in the metastatic process is crucial to improve available treatment options. During metastasis of primary tumor cells, immune cells, in particular neutrophil granulocytes are recruited to the metastatic site. The interaction of tumor and immune cells, especially neutrophils, in metastasis formation with a specific focus on proteolysis function is subject to this study.

### Methods

Immunostaining for neutrophil marker, proteases, and protease-associated proteins was performed in a total of 10 patients with brain metastases from breast cancer who underwent resection at the Neurosurgery Clinic of Marburg University Hospital. In addition, primary neutrophil granulocytes were isolated from buffy coats of healthy donors and co-cultured with the breast cancer cell lines MB-231 and MCF-7 as well as the lung cancer cell lines A549 and H1299. Protein and mRNA expression levels of EMT and tumor progression markers and proteases of the co-cultured tumor cells were tested and compared with those of the control cells.

### Results

Quantitative analysis of immunostaining revealed a high abundance of neutrophils (range: 2.6-8.8 % positive for MPO) in brain metastasis tissue of mamma carcinoma patients. Among the detected neutrophils, there were both ADAM8-negative as well as ADAM8-positive neutrophils present suggesting that ADAM8 represents a specific subset of immunosuppressive neutrophils associated with increased angiogenesis. To prove for this, co-cultures of breast (MB-231, MCF-7) and lung cancer (H1299, A549) cell lines with primary neutrophils were performed and showed elevated expression levels of VEGFA in all cell lines except for the non-metastatic MCF-7 cell line (1.5-1.9-fold, $p<0.05$) in tumor cells, suggesting that functionally, neutrophils can contribute to angiogenesis in the metastatic cascade.

### Conclusion

Our data suggest that neutrophils and their release of proteases and secreted VEGF could play a crucial role in the metastatic cascade. However, the exact mechanism and the potential of drug targeting to affect metastasis needs to be further elucidated.

# P079

## Patientinnen mit resezierten intrakraniellen Metastasen eines Mammakarzinoms zeigen unterschiedliche Rezidivmuster in Abhängigkeit von Hormonrezeptor- und HER2-Status

***Patients with resected intracranial breast cancer metastases show differential recurrence patterns depending on hormone receptor and HER2 status***

J. Weller[1], S. Katzendobler[1], F. Thiele[1], P. Harter[2], S. Schönecker[3], C. Schichor[1], N. Thon[1,4], V. Stöcklein[1,4]

[1]LMU Klinikum, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Klinikum der Ludwig-Maximilians-Universität München, Zentrum für Neuropathologie und Prionforschung, München, Deutschland
[3]LMU Klinikum, Klinik und Poliklinik für Strahlentherapie und Radioonkologie, München, Deutschland
[4]Deutsches Krebsforschungszentrum (DKFZ), Deutsches Konsortium für Translationale Krebsforschung (DKTK), Partnerstandort München, München, Deutschland

### Objective

Up to 25% of patients with advanced breast cancer develop brain metastases. Treatment strategy is based on radiation or, in case of a space-occupying lesion, resection. It has been described that breast cancer brain metastases show differential recurrence rates after radiation depending on hormone receptor (HR) and human epidermal growth receptor 2 (HER2) status. It is unknown whether this is also the case after resection. It was therefore the aim of our study to investigate whether recurrence rates after microsurgical resection of breast cancer brain metastases also differ according to HR and HER2 status.

### Methods

The database at our institution was retrospectively screened for patients who underwent resection of intracranial breast cancer metastases between 2013 and 2023. Clinical, histopathological data including hormone receptor status and HER status, and radiological data were analyzed. Local recurrence was recorded if there was new contrast enhancement on follow-up MRI at the site of the previous surgery and distant recurrence was recorded if there was new contrast enhancement anywhere else in the brain.

### Results

67 patients were identified. 16/67 (24%) patients had hormone receptor positive (HR+)/HER2 negative metastases, 32/66 (48%) had HER2+ metastases and 19/67 (28%) had triple negative (TN) metastases. Mean follow-up was 704 days. During follow-up, 40/67 patients (60%) developed intracranial recurrence. Overall PFS was shortest in patients with TN metastases (median 170 days) as compared to patients with HER2+ (419 days) and HR+/HER2- (1152 days) tumors. Freedom from local progression was also shortest in patients with TN metastases (p=0.0004) as was freedom from distant progression (p=0.0029). Median overall survival was 409 days in patients with TN metastases (HER2+: 1120 days, HR+/HER2-: 1527 days).

### Conclusion

Our data suggest that intracranial breast cancer metastases show differential tumor biology following resection depending on HR and HER2 status. TN metastases showed earlier overall, distant and local progression. This indicates that more aggressive adjuvant treatment could be warranted following resection in patients with TN brain metastases.

# P080

## Etablierung eines Fluoreszenz-Multiplexing Verfahrens zur Charakterisierung des Tumormikromilieus in zerebralen Melanommetastasen

***Implementation of a multiplexed tissue imaging protocol for characterization of the tumor microenvironment in melanoma brain metastases***

A. N. J. Sagerer[1], D. Westphal[2], M. Meinhardt[3], A. Schulz[2], F. Meier[2], I. Y. Eyüpoglu[1], G. Schackert[1], T. Juratli[1]

[1]Klinik und Poliklinik für Neurochirurgie, Universitätsklinikum und Medizinische Fakultät Carl Gustav Carus, Dresden, Deutschland
[2]Klinik und Poliklinik für Dermatologie, Universitätsklinikum und Medizinische Fakultät Carl Gustav Carus, Dresden, Deutschland
[3]Institut für Pathologie, Neuropathologie, Universitätsklinikum und Medizinische Fakultät Carl Gustav Carus, Dresden, Deutschland

### Objective

Melanoma-specific genetic changes are being identified for targeted therapy. Unfortunately, patients receiving such therapies often develop resistance and experience recurrence. Current data suggest that the tumor-specific microenvironment has a decisive influence on therapy resistance. We therefore established a multiplexed immunofluorescence staining procedure to precisely characterize the tumor microenvironment in melanoma brain metastases (BM).

### Methods

Co-detection by indexing (CODEX) technology relies on DNA-conjugated antibodies and the cyclic addition and removal of complementary fluorescently labeled DNA probes and has been used so far to simultaneously visualize up to 100 biomarkers in situ. It enables a deep view into the single-cell spatial relationships in tissues and is intended to spur discovery in disease and therapeutic design. Hence, CODEX was provided by Akoya Biosciences. To quickly handle a larger scale of samples, a tissue microarray (TMA) was created both of tumor bulk as well as positive and negative surgical margins.

### Results

At first, a panel of yet 30 antibodies were conjugated with its definite DNA oligonucleotide sequence (reporter). On our part, these antibodies were previously validated on conventional IHC using normal and gliotic brain along with tonsil tissue, including CD molecules (e.g. CD4, CD8, CD20, CD31, CD68), signal transducing antibodies (e.g. AKT, ERK, EGFR, IGFR and their phosphorylated isoforms) as well as tumor (e.g. HMB-45, Ki67, Melan-A) and neuronal (e.g. GFAP, NeuN, Olig2, PSD-95) markers. Subsequently, TMAs of different BM composition were generated (25 cores (1.5 mm), per slide 6x4 samples + 1 positive control). Within only a single working day TMAs were prepared and CODEX staining protocol fully assembled (single step staining to preserve sample integrity). CODEX run (3 reporter dyes imaged with complimentary barcodes) was performed overnight truly smooth. Lastly, analysis of spatial information has been received via QuPath (open source).

### Conclusion

Once individually designed, multiplex fluorescence imaging platform is an easy and especially in case of TMAs fast-performing tool to gain insight into the tumor microenvironment of small sample volumes in particular. For the prediction of possible therapy resistance distinct further studies are warranted to define the potential of high throughput multiplexed imaging in a clinical routine.

# P081

## SNP-Array-Analysen von Hirnmetastasen bei kolorektalem Karzinom mit metachronen Leber- und Lungenmetastasen

***SNP array analyses of brain metastases in colorectal cancer with metachronous liver and lung metastases***

C. Sander[1], V. P. Brandt[1,2], M. Wallenborn[1,2], R. Koschny[3], W. Müller[4], L. Holland[2], J. Meixensberger[1], U. Nestler[1], H. Holland[2]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland
[2]University Leipzig, Saxonian Incubator for Clinical Translation (SIKT), Leipzig, Deutschland
[3]Ruprecht-Karls-University Heidelberg, Interdisciplinary Endoscopy Center (IEZ), Department of Gastroenterology and Hepatology, Heidelberg, Deutschland
[4]University Leipzig, Paul Flechsig Institute of Neuropathology, Leipzig, Deutschland

### Objective

Brain metastases (BM) occur rarely and at a late stage in colorectal cancer (CRC). They are associated with an extremely poor prognosis. Chromosomal aberrations of CRC are heterogeneous, further knowledge of the genetic phenotype of brain metastases is very limited.

### Methods

We examined 32 patients with cerebral metastatic colorectal cancer between 2012 and 2023. We performed chromosomal analysis using SNP array (OncoScan FFPE Assay Kit, ThermoFisher Scientific) in four patients with CRC, metachronous liver metastases (LM) and BM.

### Results

On average, the patients developed a brain metastasis 50 months after first diagnosis. Metastases were localized supratentorially in 40.6%, infratentorially in 21.9% and supra- and infratentorially in 37.5% of the cases. On average, patients died 4.4 months after manifestation of the brain metastases at 66 years. Further lung metastases were present in 80.9% of cases and liver metastases in 64.3% of cases. Beside 189 chromosomal aberrations, we detected 5 copy neutral Loss of Heterozygosity (cn-LOH) regions in the primaries, 4 cn-LOH regions in LM and 23 cn-LOH regions in BM. We identified 902 cancer genes located within the cn-LOH regions of the brain metastases, like NOTCH1 and RUNX1, involved in the RUNX3 pathway.

### Conclusion

The high number of cn-LOH aberrations in brain metastases indicates that cn-LOHs could be involved in the carcinogenesis of the cerebral seeding phenotype. Currently, we look for chromosomal aberrations occurring in the same patient, each in brain metastasis, lung metastasis and in the primary rectal cancer.

# P082

## Psychoonkologische Belastungsfaktoren bei Patienten mit Hirnmetastasen
*Psycho-oncological burden in patients with brain metastases*

T. Araceli[1], A. Haj[1], C. Doenitz[1], E. M. Stoerr[1], N. O. Schmidt[1], M. Proescholdt[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland

### Objective

The development of brain metastases (BM) can significantly increase the psycho-oncological burden in cancer patients, requiring timely intervention. In addition, this aspect may negatively affect the course of the disease and treatment outcome. However, screening for psycho-oncological distress is not generally implicated in clinical routine. We, therefore, analyzed the extent of psychological distress in a prospectively recruited patient population with BM receiving surgical resection. In particular, we wanted to identify clinical characteristics which are associated with a high need for psycho-oncological intervention.

### Methods

We screened 353 patients (169 female, 184 male) with a median age of 62.5 years (range: 26.3 – 86.2 years) who were planned to undergo surgical resection of one or several BM. Patients presented with multiple metastases in 50.4%, singular in 38.8%, and solitary in 10.8%. The majority were treated for metachronous metastases (63.2%), the median preoperative Karnofsky Index (KPI) was 80 (range: 30 – 100), the most frequent primary tumor was lung cancer (38.8%), followed by melanoma (15.1%) and breast cancer (12.5%). Psycho-oncological screening was performed on the day of admission using the Hornheider screening instrument (HSI) in 92.9% and the distress thermometer (DT) in the remaining 7.1% of all patients.

### Results

Most patients (72.8%) filled out the screening questionnaire. Those patients who failed to complete the questionnaire were significantly older ($p = 0.0018$), presented more frequently with metachronous BM (60.6 vs. 35.4%, $p = 0.044$), and showed a significantly poorer KPI ($p = 0.0002$). Based on the threshold values of the questionnaires, 59.3% of all patients showed a significant psycho-oncological burden requiring immediate intervention. Univariate analysis demonstrated that female gender ($p = 0.009$), synchronous BM ($p = 0.042$), presurgical aphasia ($p = 0.042$), lower KPI ($p = 0.031$), and tumors in eloquent location ($p = 0.022$) were significantly associated with high psycho-oncological burden. Multivariate analysis revealed female gender ($p = 0.017$) and synchronous BM ($p = 0.045$) as independent factors associated with a high need for psycho-oncological support.

### Conclusion

Our results demonstrate that the majority of BM patients present with a high degree of psycho-oncological distress. Female gender and synchronous BM presentation are independently associated with a need for psycho-oncological intervention.

Abb. 1

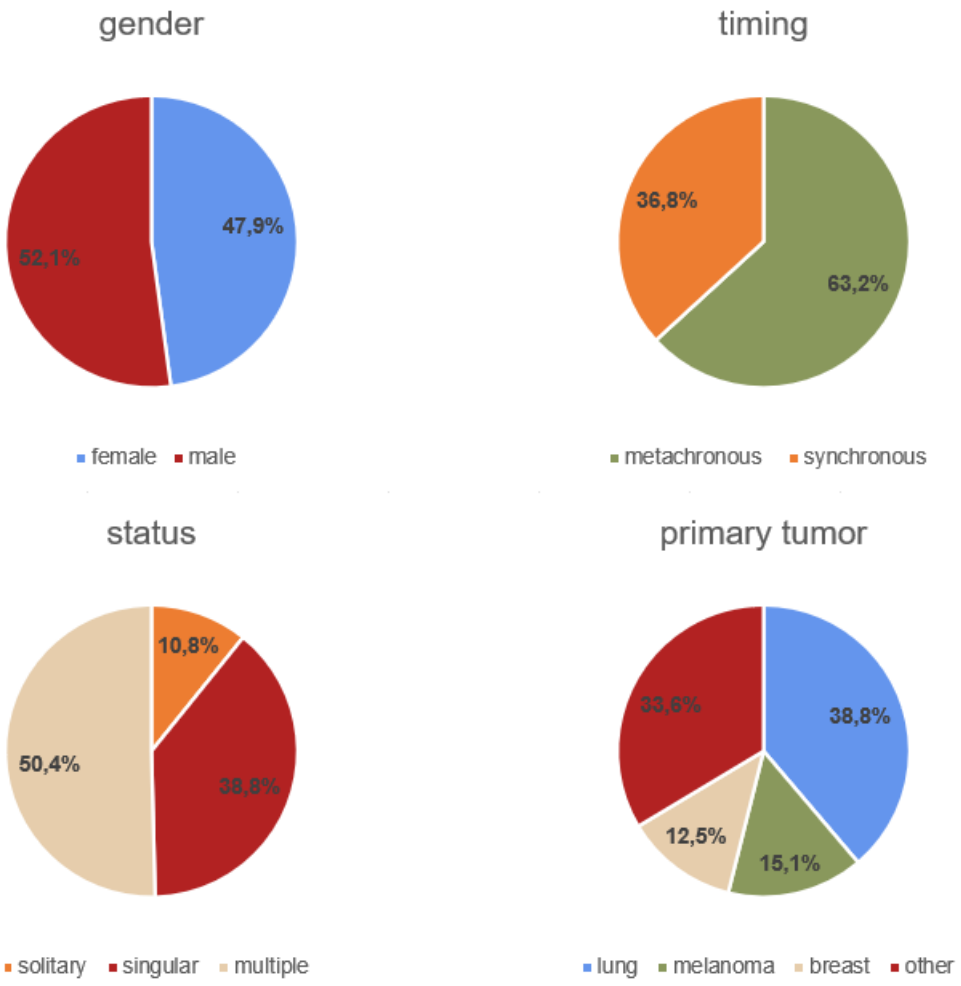
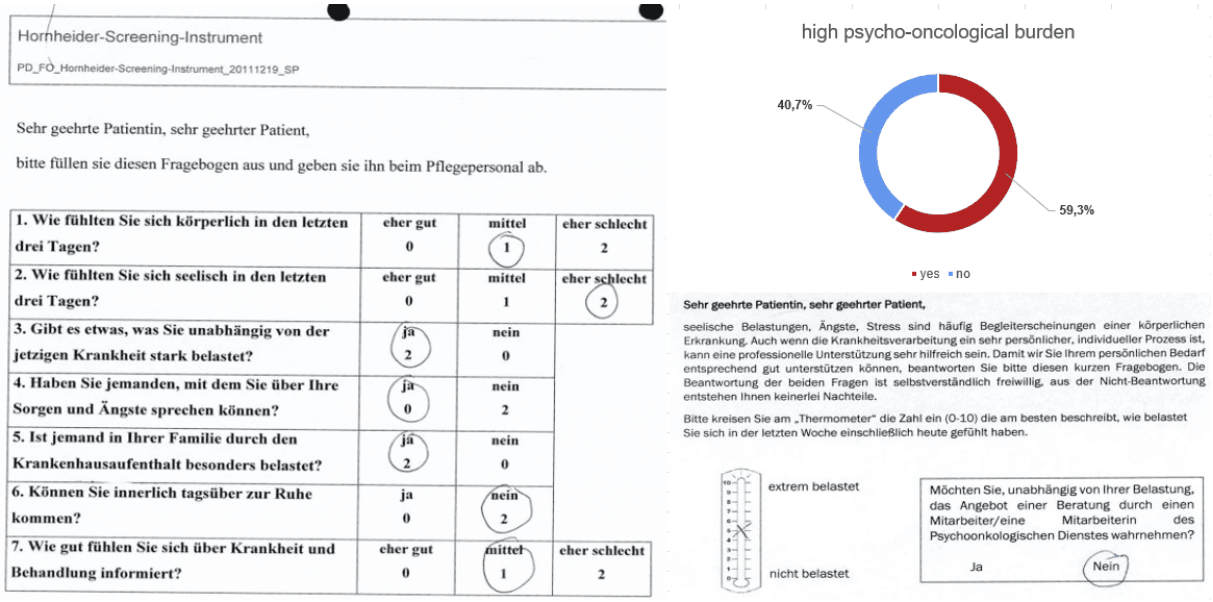



Abb. 2



Hornheider-Screening-Instrument

PD_FO_Hornheider-Screening-Instrument_20111219_SP

Sehr geehrte Patientin, sehr geehrter Patient,

bitte füllen sie diesen Fragebogen aus und geben sie ihn beim Pflegepersonal ab.

| | | | |
|---|---|---|---|
| 1. Wie fühlten Sie sich körperlich in den letzten drei Tagen? | eher gut 0 | mittel (1) | eher schlecht 2 |
| 2. Wie fühlten Sie sich seelisch in den letzten drei Tagen? | eher gut 0 | mittel 1 | eher schlecht (2) |
| 3. Gibt es etwas, was Sie unabhängig von der jetzigen Krankheit stark belastet? | (ja) 2 | nein 0 | |
| 4. Haben Sie jemanden, mit dem Sie über Ihre Sorgen und Ängste sprechen können? | (ja) 0 | nein 2 | |
| 5. Ist jemand in Ihrer Familie durch den Krankenhausaufenthalt besonders belastet? | (ja) 2 | nein 0 | |
| 6. Können Sie innerlich tagsüber zur Ruhe kommen? | ja 0 | (nein) 2 | |
| 7. Wie gut fühlen Sie sich über Krankheit und Behandlung informiert? | eher gut 0 | (mittel) 1 | eher schlecht 2 |

high psycho-oncological burden

40,7%

59,3%

yes no

Sehr geehrte Patientin, sehr geehrter Patient,

seelische Belastungen, Ängste, Stress sind häufig Begleiterscheinungen einer körperlichen Erkrankung. Auch wenn die Krankheitsverarbeitung ein sehr persönlicher, individueller Prozess ist, kann eine professionelle Unterstützung sehr hilfreich sein. Damit wir Sie Ihrem persönlichen Bedarf entsprechend gut unterstützen können, beantworten Sie bitte diesen kurzen Fragebogen. Die Beantwortung der beiden Fragen ist selbstverständlich freiwillig, aus der Nicht-Beantwortung entstehen Ihnen keinerlei Nachteile.

Bitte kreisen Sie am „Thermometer" die Zahl ein (0-10) die am besten beschreibt, wie belastet Sie sich in der letzten Woche einschließlich heute gefühlt haben.

extrem belastet

nicht belastet

Möchten Sie, unabhängig von Ihrer Belastung, das Angebot einer Beratung durch einen Mitarbeiter/eine Mitarbeiterin des Psychoonkologischen Dienstes wahrnehmen?

Ja (Nein)

# P084

## Klinische Charakterisierung einer Kohorte von Krebspatienten mit metastasierter Erkrankung und spinaler Meningeosis neoplastica: eine deskriptive retrospektive Single-Center-Studie

***Clinical characterization of a cohort of metastatic cancer patients with spinal leptomeningeal disease: A descriptive retrospective single-center study***

Z. Shaked[1], C. Eitner[1], S. Murad[1], C. Jelgersma[1], A. Früh[1,2], A. Wetzel-Yalelis[1], A. Radbruch[3], J. S. Onken[1,2,4,5], M. Misch[1,4], P. Vajkoczy[1,4], L. Wessels[1], D. Wasilewski[1,4,5]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, Berlin Institute of Health (BIH) Charité, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Institut für Neuropathologie, Berlin, Deutschland
[4]Charité – Universitätsmedizin Berlin, Charité Comprehensive Cancer Center, Berlin, Deutschland
[5]German Cancer Consortium (DKTK), Berlin, Deutschland

### Objective

Despite affecting approximately 5% of metastatic cancer patients, data on leptomeningeal disease (LMD) is limited. One particularly understudied subcohort of LMD patients are those with spinal LMD (sLMD). Our study aims to characterize sLMD patients in terms of course of disease, therapies and outocomes.

### Methods

Patients with sLMD treated at the Charité University Hospital between 2015-2023 with both cranial and spinal imaging within 28 days from diagnosis were included. Medical records were reviewed for clinical, histopathological and radiological characteristics. Kaplan-Meier curves were computed for overall survival (OS).

### Results

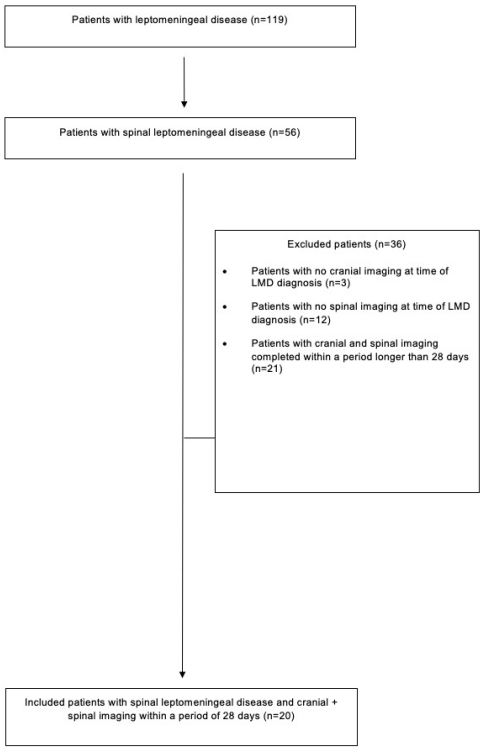
Twenty patients, with a median age of 54.59 [IQR: 44.30-68.85], were included. Breast (30%), lung (20%) and melanoma (20%) were the most common underlying primary entities. Median time from primary disease diagnosis to LMD diagnosis was 2.20 years [IQR: 1.62-4.93]. Before LMD diagnosis, 60% of patients received local and 95% received systemic therapy. LMD diagnosis was confirmed in 65% of cases through imaging and in 35% through imaging and cytology. At diagnosis, 90% of patients had concurrent cranial and spinal LMD. Vertebral or intraspinal metastases occured in 40% of patients. Of those, 37.5% were diagnosed prior, 50% simultaneously and 12.5% after the LMD. Most patients with spinal or intraspinal metastases (62.5%) underwent spinal surgery, 2 prior and 3 after sLMD diagnosis. Eighty percent underwent a single spine surgery, whereas one patient underwent 5. These procedures included but were not limited to metastasis resection, hemilaminectomy and spondylodesis. Only 20% of patients had follow-up spinal imaging, with a median of 3.5 studies [IQR: 3-4]. Eighty-five percent of patients had ≥1 brain metastasis in the course of their disease, with 64.7% undergoing ≥1 resection. After sLMD diagnosis, 65% of patients received local and 60% received systemic therapy, including chemotherapy (75%, of those 66.67% intrathecal methotrexate and 33.33% other), targeted therapy (TTx)(60%) and checkpoint inhibition (20%). The median OS was 2.5 months [IQR: 1.23-8.23]. A good Karnofsky score, presence of a targetable mutation and administration of TTx after LMD diagnosis were positive prognostic factors.

### Conclusion

Our study demonstrates the clinical challenges, heterogeneous treatment regimens and poor prognosis associated with sLMD, emphasizing the need to study such cohorts in multicenter studies to improve diagnosis, management and outcomes for future patients.

Abb. 1

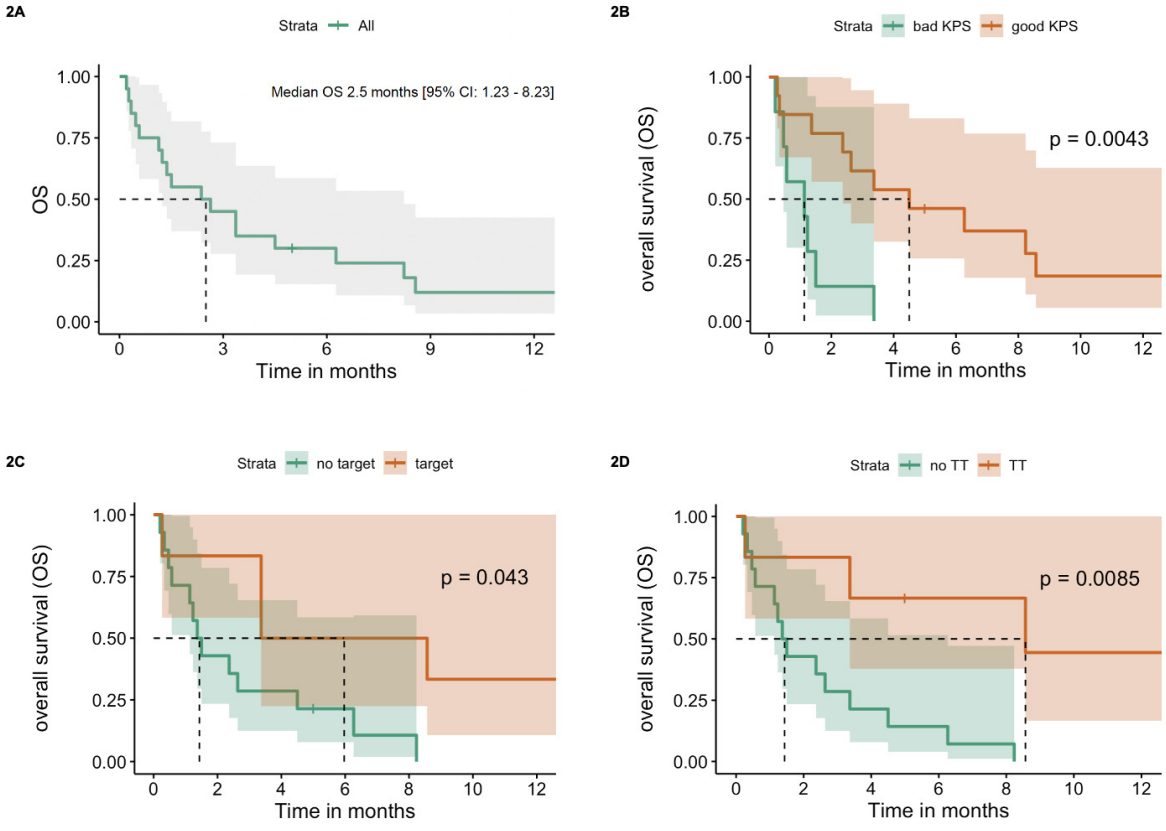
1A




1B

| Variable | n = 20 |
|---|---|
| **Age (years), median (IQR)** | 54.59 (44.30 – 68.85) |
| **Sex, n (%)** | |
| Female | 10.00 (50) |
| Male | 10.00 (50) |
| **Tumor entity, n (%)** | |
| Breast cancer | 6.00 (30) |
| Lung cancer | 4.00 (20) |
| Melanoma | 4.00 (20) |
| Other | 6.00 (30) |
| **Presence of a targetable mutation, n (%)** | |
| No | 14.00 (70) |
| Yes | 6.00 (30) |
| **Time from diagnosis of primary tumor to diagnosis of LMD, median in years (IQR)** | 2.20 (1.62 – 4.93) |
| **Modality of LMD diagnosis, n (%)** | |
| Cranial and spinal imaging | 13.00 (65) |
| Cranial and spinal imaging and CSF cytology | 7.00 (35) |
| **Concurrent cranial and spinal LMD, n (%)** | |
| No | 2.00 (10) |
| Yes | 18.00 (90) |
| **KPS at time of LMD diagnosis, n (%)** | |
| Bad KPS (≤70%) | 7.00 (35) |
| Good KPS (>70%) | 13.00 (65) |
| **Spinal MRI follow-up, n (%)** | |
| No | 16.00 (80) |
| Yes | 4.00 (20) |
| **Occurrence of spinal or intradural metastasis in clinical course, n (%)** | |
| No | 12.00 (60) |
| Yes | 8.00 (40) |
| **Spine surgery, n (%)** | |
| No | 15.00 (75) |
| Before LMD diagnosis | |
| 5 surgeries, including intraspinal and spinal metastasis resections, spondylodesis, corpectomy and decompression of spinal canal | 1.00 (5) |
| Kyphoplasty and vertebral body replacement | 1.00 (5) |
| After LMD diagnosis | |
| Extended interlaminar fenestration | 1.00 (5) |
| Dorsal spondylodesis | 1.00 (5) |
| Hemilaminectomy | 1.00 (5) |

Abb. 2



# P085

## Die *temporal muscle thickness* (TMT) im Vergleich zu funktionellen Skalen als prognostischer Parameter bei Patient:innen mit Hirnmetastasen

***Temporal muscle thickness compared to functional scales as a prognostic parameter in patients with brain metastases***

J. Klingenschmid[1], N. Pichler[1], A. Krigers[1], C. Thomé[1], C. Freyschlag[1]

[1]Medizinische Universität Innsbruck, Klinik für Neurochirurgie, Innsbruck, Österreich

### Objective

Metastatic brain tumors are the most common malignant intracranial growths in adults. While Karnofsky Performance Status (KPS) and Clinical Frailty Scale (CFS) are recognized for their substantial influence on overall survival (OS), temporal muscle thickness (TMT) has been suggested as a potentially valuable new parameter for prognostic estimation.

### Methods

We included patients who underwent surgical resection for 1 - 3 brain metastases at our institution. TMT was measured from preoperative MRI scans following a standardized protocol.

### Results

Among 199 patients, the mean TMT was 7.5 mm (95% CI 7.3 – 7.7), and the mean OS during the follow-up period was 31.3 months (95% CI 24.2 – 38.3). There was no significant correlation between TMT and preoperative or follow-up CFS and KPS scores. However, CFS and KPS were significantly correlated with OS ($p < 0.001$ for each), while TMT did not exhibit such associations. CFS demonstrated superior prognostic value when compared to KPS.

### Conclusion

Temporal muscle thickness did not demonstrate a significant impact on overall survival or patient performance, in contrast to the clinical scales (KPS and CFS), which exhibited a strong correlation with OS. Given its superiority over KPS, we strongly recommend using CFS to estimate overall survival in patients with brain metastases.

# Tumor – Metastasen | Tumour – Metastases

## P086

### Die Resektion von malignen Radionekrosen führt zu einer lokalen Kontrolle und Verbesserung der Symptome
*Resection of malignant radionecrosis results in local control and improvement of symptoms*

L. Schmidt[1], N. Schakat[1], A. Dauth[1], D. Jankovic[1], C. Sommer[1], F. Ringel[1], H. Krenzlin[1], N. Keric[1]

[1]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Institut für Neuropathologie, Mainz, Deutschland

#### Objective

Stereotactic radiosurgery combined with or without surgical resection is a common treatment modality for intracranial malignancies. Typical complication includes occurrence of radionecrosis (RN) with an incidence of up to 25%. Despite pharmacologic therapy, a subset of RN is progressive and requires surgical resection. The aim of this study is to evaluate the clinical outcome of surgical resection of RN.

#### Methods

A single-center retrospective study was performed including all patients who underwent surgery for intracerebral radionecrosis between 2018 and 2022, if radionecrosis with or without additional tumor cells was pathologically confirmed. Demographic and clinical data were assessed for outcome analysis.

#### Results

During this period, 56 patients underwent surgery for suspected RN. Of these, 9 underwent biopsy and 47 resection. Median age was 58 (53-64) years and 29 (52%) were female. 39 (70%) patients had brain metastasis (NSCLC 21, breast cancer 6, melanoma 2, gastrointestinal adenocarcinoma 2, other 8) and 17 (30%) patients had high grade glioma (glioblastoma 10, oligodendroglioma 5, other 2). 45% of patients were asymptomatic, 34% had focal deficits, 17% headaches, 2% seizures and 2% confusion or mood changes, 3 patients (5%) received prior corticosteroid treatment. Previous resection of CNS lesions was performed in 34 patients (61%), with 15 patients undergoing repeat surgeries (27%). Of all patients who underwent RN resection, 16 (28%) were subsequently treated with corticosteroids and 31 (56%) received no further treatment. Bevacizumab was used after prior corticosteroid treatment in two cases. Clinical status improved from preoperative to discharge (mean KPS 75±15.1 vs 80±14.7, p=0.09) and to 6-month follow-up (mean KPS 75±15.1 vs 84.7±12.6 p=0.001). The rate of local control at 6 months after surgery was 80% (95%CI 68.2 - 93.8%). Twelve-month survival was 62.3% (95%CI 46.8 - 82.9%). The 6-month local control rate did not differ between primary tumors (75.4% vs 92.8% p=0.16), adjuvant therapy (85.2% vs 77% p=0.95) presence of viable tumor cells (68.6% vs 88.1% p=0.051). Patients suffering from systemic cancer received more frequent adjuvant corticosteroids (31.9% vs 2.1% p= 0.027). We observed no complications from adjuvant treatment.

#### Conclusion

Resection of progressive radionecrosis is a feasible treatment option and should be considered to achieve local control. Resection leads to clinical improvement and reduces the need for further medical treatment.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P087

### Funktionelle Verbesserung bei Überlebenden mit schlechtem Ausgang bei der Entlassung nach aneurysmatischer Subarachnoidalblutung: eine gepoolte Analyse

***Functional improvement in survivors with poor outcome at discharge after aneurysmal subarachnoid hemorrhage: A pooled analysis***

M. Said[1], M. Gümüs[2], M. Darkwah Oppong[2], P. Dömer[1], S. Helgers[1], P. Dammann[2], K. H. Wrede[2], J. Woitzik[1], U. Sure[2], R. Jabbarli[2]

[1]Evangelisches Krankenhaus Oldenburg, Neurochirurgie und Wirbelsäulenchirurgie, Oldenburg, Deutschland
[2]Universitätsklinikum Essen, Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) carries a substantial risk of poor outcome with long-term functional limitations. However, in some cases improvement is possible despite poor neurological condition at discharge. In this pooled analysis, we observed the improvements in neurological status in aSAH patients surviving the acute phase with a poor condition (modified Rankin Scale [mRS] = 4 – 5).

#### Methods

From a pooled database of two German university hospitals with aSAH (n=1171), the sub-cohort of survivors with poor condition at discharge was selected (n=454). Baseline demographic, clinical and radiographic parameters and outcome-relevant adverse events during aSAH were collected. The probability of favorable outcome (mRS≤3) and functional independency (mRS≤2) at 6-months follow-up were endpoints of the study. Univariate and multivariate analyses were performed.

#### Results

After excluding cases lost to follow-up (n=71; 15.6%), 6-months mRS data were available in 383 aSAH individuals with poor outcome at discharge. 176 patients (46%) presented with favorable outcome at 6 months and 113 individuals (29.5%) gained functional independency. In the final step of the backward conditional multivariate regression analysis, older age (>65 years, aOR=4.21, p<0.0001), 3rd ventricle ratio (>0.072, aOR=2.18, p=0.021), World Federation of Neurosurgical Societies (WFNS) grade =4-5 at admission (aOR=2.17, p=0.013), need for decompressive craniectomy (aOR=2.97, p=0.001), and mRS=5 at discharge (aOR=16.61, p<0.0001) were independently associated with a risk of unfavorable 6-months outcome. Furthermore, older age (>65 years, aOR=3.62, p=0.002), higher Hijdra sum score (>17, aOR=3.05, p=0.002), decompressive craniectomy (aOR=5.54, p<0.0001), cerebral infarcts (aOR=2.15, p=0.014) and mRS=5 at discharge (aOR=10.26, p<0.0001) were significant predictors of persistent functional dependency 6 months after aSAH.

#### Conclusion

About half of aSAH survivors in poor neurological condition at discharge reach favorable functional outcome at 6 months, with over a quarter of patients improving to functional independency. Baseline characteristics, certain adverse events and neurological condition at discharge predestinate the chances for neurological improvement in the further course.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P088

### Karotissiphon-Verkalkungen und das funktionelle Outcome nach aneurysmatischer Subarachnoidalblutung.
### *Impact of carotid siphon calcification on the course and outcome of patients with aneurysmal subarachnoid hemorrhage*

A. Engel[1], S. Li[1], L. Rauschenbach[1], M. Gümüs[1], A. N. Santos[1], M. Darkwah Oppong[1], Y. Li[2], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland
[2]Universitätsklinikum Essen, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Essen, Deutschland

#### Objective

Carotid siphon calcification (CSC) serves as a marker of atherosclerosis and therefore may influence the outcome after subarachnoid hemorrhage (aSAH) among other known factors. The impact of CSC on neurological outcome and vasospasm after aSAH was analyzed.

#### Methods

716 consecutive patients with aSAH (mean age 54.95±13.85 years) treated between December 2004 to June 2016 in our central European tertiary care center were included. For each side, CSC was recorded using the Woodcock scale (0-3 points) on a computed tomography (CT)-scan. Study endpoints included an unfavorable outcome at 6 months post-aSAH (modified Rankin scale≥ 4) and angiographic vasospasm. The associations were adjusted for the severity of aSAH, aneurysm and patient characteristics and secondary complications.

#### Results

Severe CSC (grade 3) independently increased the risk of an unfavorable outcome (aOR 4.06; 95% CI 1.98 – 8.33; **p < 0.001**). In coil occluded aneurysms the unfavorable outcome could only be predicted by severe CSC in patients without aspirin intake (aOR 5.47; 95% CI 2.38 – 12.54; **p < 0.001**) but not in patients with aspirin intake after the coiling (aOR 0.84; 95% CI 0.59 – 4.21; p = 0.603). Increasing grades of CSC were associated with lower rates of vasospasm in the middle cerebral artery (aOR 0.76; 95% CI 0.61 – 0.93; **p = 0.009**), the anterior cerebral artery (aOR 0.75; 95% CI 0.61 – 0.92; **p = 0.005**).

#### Conclusion

Severe CSC predicts an unfavorable outcome after aSAH. Vasospasm was prevented by higher grades of CSC, likely by an increased arterial stiffness. In coil occluded patients with severe CSC an unfavorable outcome was prevented by aspirin intake in line with previous findings.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P089

### Eine longitudinale Charakterisierung der zellulären Immunantwort in der Gegenwart und Abwesenheit einer sekundären Hirnschädigung bei Subarachnoidalblutungen

***Longitudinal characterization of the cellular immune response in the presence and absence of secondary brain injury in subarachnoid hemorrhage***

N. Schwendinger[1], K. Akeret[1], R. M. Buzzi[2], B. Thomson[3], E. Dürst[3], N. Schulthess[3], L. Baselgia[3], K. Hansen[3], E. Colombo[1], A. Grob[1], L. Egli[1], F. Vallelian[2], L. Regli[1], D. J. Schaer[2], M. Hugelshofer[1]

[1]Universitätsspital Zürich, Neurochirurgie, Zürich, Schweiz
[2]Universitätsspital Zürich, Innere Medizin, Zürich, Schweiz
[3]Universität, Zürich, Schweiz

#### Objective

Secondary brain injury occurs four to 14 days after a subarachnoid hemorrhage (SAH). This delayed onset potentially allows for disease modulation and outcome improvement in patients. To enhance our understanding of the pathophysiology of secondary brain injury, we characterized the cellular immune response by longitudinal RNA-single-cell sequencing. We mapped cellular phenotypes to clinical endpoints.

#### Methods

Patients who were 18 years or older at the time of hospital admission and who had a confirmed aneurysmal subarachnoid hemorrhage and a cerebrospinal fluid (CSF) diversion were included in the study. CSF samples of patients were collected at three different time points and subjected to a leukocyte isolation protocol. Timepoint one was defined as day three to five post-SAH, timepoint two as day six to eight post-SAH, and timepoint three as day nine to eleven post-SAH. The obtained cells were processed using the 10x Genomics Chromium Single Cell 3" v3.1 Reagent Kit instruction guide (10x Genomics). Further, the 3' Gene Expression libraries for each sample were pooled at an equimolar amount and sequenced on an Illumina NovaSeq 6000 system with a sequencing depth of 50000 reads per cell. (workflow depicted in Fig.1) The computational analysis was performed with R (R version 4.2.1) using the Seurat package (version 4.3.0).

#### Results

To our knowledge, we have created the biggest RNA-single-cell data set on CSF-derived leukocytes.

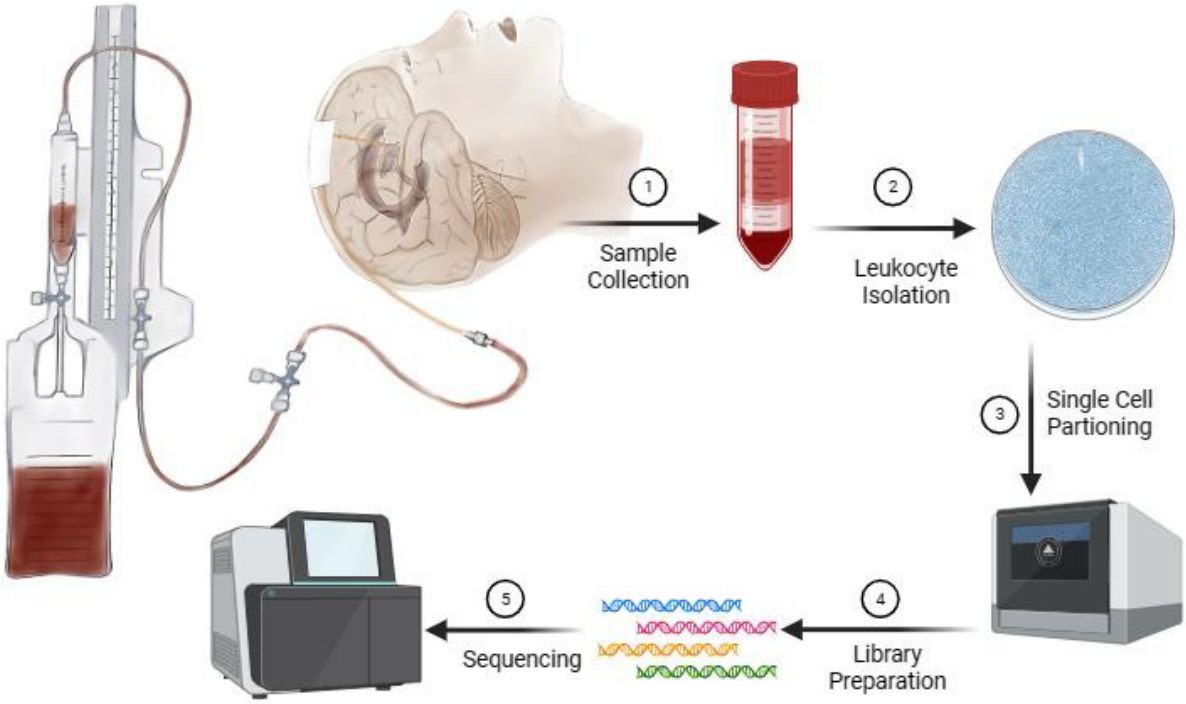
We identified all major leukocyte subsets like T-cells, B cells, myeloid dendritic cells, monocytes, and neutrophils within the CSF of our aSAH cohort (celltypes depicted in Fig.2).

Outcome variables stratified patients according to the presence/absence of secondary brain injury and the presence/absence of a ventriculoperitoneal shunt three months after the initial bleeding. We identified significantly differentially expressed genes between either of the groups using a negative binomial model.

#### Conclusion

Characterizing the cellular immune response after aneurysmal subarachnoid hemorrhage is critical to understanding the pathophysiological course of the disease. Cell composition and cellular phenotypes within the CSF allow us to conclude about potentially modifiable adaptive processes. Further, this work enhances our knowledge about protective immune responses and those promoting SAH-SBI and shunt dependency.

Abb. 1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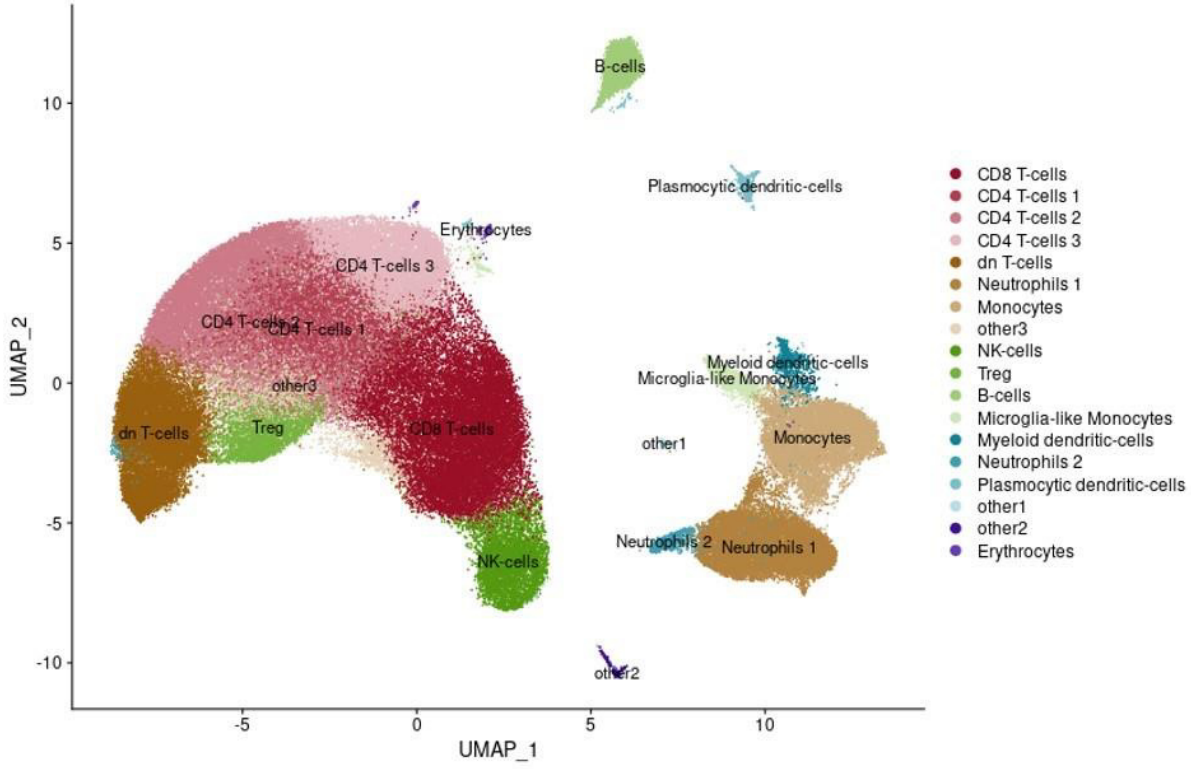
Sample
Collection
2
Leukocyte
Isolation
3
Single Cell
Partioning
4
Library
Preparation
5
Sequencing

Abb. 2


B-cells
Plasmocytic dendritic-cells
Erythrocytes
CD4 T-cells 3
CD4 T-cells 2
CD4 T-cells 1
other3
dn T-cells
Treg
CD8 T-cells
NK-cells
Myeloid dendritic-cells
Microglia-like Monocytes
other1
Monocytes
Neutrophils 2
Neutrophils 1
other2
UMAP_1
UMAP_2
CD8 T-cells
CD4 T-cells 1
CD4 T-cells 2
CD4 T-cells 3
dn T-cells
Neutrophils 1
Monocytes
other3
NK-cells
Treg
B-cells
Microglia-like Monocytes
Myeloid dendritic-cells
Neutrophils 2
Plasmocytic dendritic-cells
other1
other2
Erythrocytes

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P090

### Reevaluation der Risikofaktoren für schlechtes Outcome bei hochgradigen aSABs: Verbesserung der Behandlungsentscheidungsfindung

***Reevaluation of risk factors for poor outcome among poor-grade aneurysmal subarachnoid hemorrhage: Enhancing treatment decision-making***

M. Darkwah Oppong[1], S. Li[1], A. Engel[1], A. N. Santos[1], L. Rauschenbach[1], O. Gembruch[1], H. H. Gull[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

#### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) is a cerebrovascular disease associated with significant morbidity and mortality. WFNS grades IV and V are designated as poor-grade aSAH (PGASAH), and are known for an exceptional grim prognosis. To identify individuals who can benefit from further treatment despite PGASAH, we conducted a comprehensive analysis of potential risk factors for poor outcome in this aSAH-subgroup, considering factors available at admission and during the hospital stay.

#### Methods

We utilized an institutional aSAH database covering a 13.5-year period, encompassing over 900 patients. Eligible participants for this study included all patients with PGASAH scheduled for aneurysm treatment, with available data on 6-month follow-up outcomes.The primary endpoint was defined as a poor outcome at the 6-month follow-up defined as the modified Rankin scale>2. We analyzed over 100 potential risk factors, including admission parameters, premorbid conditions, lab results, aSAH-specific parameters, and complications of aSAH, evaluating their influence on the primary endpoint through univariate analysis(UVA). All significant parameters were then included in a two-step multivariate analysis(MVA), first analyzing different subgroups and subsequently incorporating all significant parameters into a final MVA analysis.

#### Results

A total of 348 patients were eligible for the final analysis. The majority were female(64.9%), with a median age of 55.1 years. In the UVA, we identified 19 potential risk factors. After the second MVA step, we identified age >55 years(p=0.002,aOR=2.44), premorbid cardiac valve disease(p=0.004,aOR=6.50), anisocoria at admission (p=0.025, aOR=2.64), early(<=72h post-aSAH,p<0.001,aOR=5.56) and delayed(>72h,p<0.001,aOR=5.09) cerebral infarction in the follow-up computed tomography scan(s) as independent risk factors for poor outcomes among PGASAH patients. The risk of a poor outcome gradually increased with the accumulation of the three baseline risk factors(cardiac valve diseases,age,anisocoria), resulting in a 50% risk of poor outcome in patients with zero and a 100% risk for patients with all three baseline risk factors.

#### Conclusion

Despite PGASAH, younger patients without premorbid cardiac valve disease and without anisocoria have a 50% chance of achieving a functional independency 6 months post-aSAH. Knowledge of PGASAH-specific risk factors may enhance counseling for relatives and facilitate informed treatment decisions in this aSAH sub-population.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P091

### Remote ischemic preconditioning zur Vermeidung von Delayed Cerebral Ischemia durch Vasospasmen in der Behandlung von Patienten mit aneurysmatischer Subarachnoidalblutung

***Remote ischemic preconditioning to prevent delayed cerebral ischemia due to vasospasm in the treatment of patients with aneurysmal subarachnoid hemorrhage***

T. Bottenschein[1], A. Wagner[1], C. Albrecht[1], M. Wostrack[1], C. Maegerlein[2], B. Meyer[1], J. Gempt[1,3]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Abteilung für diagnostische und interventionelle Neuroradiologie, München, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgische Klinik, Hamburg, Deutschland

#### Objective

This study investigates the effect of remote ischemic preconditioning (RIPC) in patients after aneurysmal subarachnoid haemorrhage (aSAH) with vasospasm. The hypothesis of the study was that RIPC would reduce the cerebral impact of vasospasm in terms of new ischemic areas, leading to an improvement in functional outcome and a reduction in mortality among these patients.

#### Methods

In a prospective, randomized, controlled and rater-blinded study, patients were assigned to an intervention or a control group. Recruitment took place at the Klinikum rechts der Isar between 11/19 and 09/23. The RIPC intervention involved three inflations of a blood pressure cuff on the upper arm for at least 20 mmHg above the patient's systolic blood pressure for five minutes each, followed by five minutes of reperfusion each time. This was performed on 10 consecutive days within the first 14 days after the initial bleeding event. The primary endpoint of this study was a cerebral CT scan at the end of the intervention to diagnose new areas of cerebral infarction.

#### Results

60 patients were included in the analysis, 29 in the intervention group and 31 in the control group. The average age for the entire cohort was 62.0 years without statistically significant difference between the two groups. The analysis showed that RIPC does not appear to have any influence on the initial occurrence of symptomatic vasospasms, as measured by the occurrence of a delayed cerebral ischemia (DCI). In the subgroup of patients with an accelerated flow of over 200 cm/s in the transcranial Doppler examination (TCD), the intervention group trended to have a lower occurrence of new infarct areas in the cerebral CT scan, although statistically insignificant.

#### Conclusion

RIPC does not appear to have any influence on the initial occurrence of vasospasms and the development of delayed cerebral ischemia (DCI). The subgroup of patients with increased flow accelerations in the TCD measurement may exhibit some benefit by RIPC.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P092

### Versorgung spontaner Subarachnoidalblutungen: Ergebnisse einer Umfrage in der EANS
*Management of spontaneous subarachnoid hemorrhage: Results of an EANS survey*

C. Wolfert[1], P. Krauss[1], M. Colosimo[1], B. Sommer[1], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Klinik für Neurochirurgie, Augsburg, Deutschland

#### Objective

Based on the current guidelines, there is no clear consensus on best clinical management modalities concerning cerebral vasospasm prophylaxis (CVP) and follow-up imaging for perimesencephalic non aneurysmal subarachnoid hemorrhage (NASAH).

The aim of this survey evaluates the incidence of NASAH patients treated annually as well as the estimated complication rate.

#### Methods

The survey was distributed through the Vascular Section of the European Association of Neurosurgical Societies (EANS) and conducted on an online platform. Three clinical vignettes of NASAH with the initial CT-scans were distributed, questioning the in-hospital treatment including initial observation, blood pressure management, CVP and the need for digital subtraction angiography (DSA). The case vignettes are depicted in picture 1.

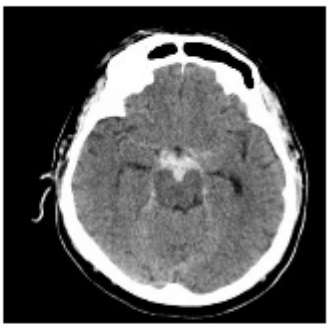
#### Results

32 questionnaires were answered from eighteen different countries. Most questionnaires were filled out by departments located in Italy (n=6; 18.8%) and Greece (n=4; 12.5%), followed by the United Kingdom (n=3; 9.4%). Most answers were provided from employees of University Hospitals (n=27; 84.4%). Nearly half of the departments reported an annual caseload of more than 2000 patients (n=14; 43.7%), whereof the remaining 18 reported annual caseloads less than 2000 patients (56.3%). Up to five NASAH cases per year were reported by 10 (31.3%), another 12 (37.4%) treat more than 20 cases in the same time period. In case of one negative DSA, a second one is performed in most of the centers (n=25; 78.1%). With regard to the three different case studies, most centers admit their patients (case 1) to the regular ward (n=17, 51.5%), while only 9 (27.3%) in the third case. Non-invasive blood pressure management is performed in 24 (72.7%) in the first case, compared to 18 (54.5%) in the third. In the third case, most centers perform a CVP (n=15; 45.5%), in comparison to 8 (24.2%) in the first case.

#### Conclusion

This study confirms that, in most centers, the initial bleeding severity seen on the native CT scan influences the further treatment. However, clear intercontinental differences cannot be worked out based on these low numbers.

Abb. 1

| Case 1 | Case 2 | Case 3 |
| --- | --- | --- |
|  |  |  |
| 38-year-old female, thunderclap headache, GCS 15, lumbar puncture positive for SAB Negative DSA | 51-year-old male, headache for 2 days, GCS 15 Negative DSA | 53-year-old male, thunderclap headache, emesis, GCS 15 Negative DSA |

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P093

### Komplikationen und VR-basierte Identifizierung von Risikofaktoren bei Patienten mit frühen autologen Kranioplastiken

***Complications and VR-based identification of risk factors in patients with early autologous cranioplasties***

S. Zawy Alsofy[1,2], M. Nakamura[2,3], T. Fortmann[1,2], E. Wilbers[1,2], M. Lewitz[1,2], A. Salma[4], C. Ewelt[1,5], I. Sakellaropoulou[1], R. Stroop[2]

[1]St. Barbara-Klinik Hamm-Hessen, Neurochirurgie, Hamm, Deutschland
[2]Witten/Herdecke University, Department of Medicine, Faculty of Health, Witten, Deutschland
[3]Academic Hospital Koeln-Merheim, Neurochirurgie, Köln, Deutschland
[4]St. Rita's Neuroscience Institute, Department of Neurosurgery, Lima, OH, Vereinigte Staaten
[5]Universitätsklinikum Münster, Neurochirurgie, Münster, Deutschland

#### Objective

Cranioplasty (CP) of autologous bone flap after decompressive craniectomy (DC) is known to be associated with a high complication rate, particularly bone flap resorption (BFR). In a retrospective study, we used a novel virtual reality (VR) visualisation technique to identify and evaluate risk factors associated with CP.

#### Methods

Twenty-five patients underwent early autologous CP. All complications were recorded. Cranial computed tomography scans were visualised via the VR software to access the fitting accuracy of the bone flap (bone flap size, gap width at trepanation cutting edge, extent of osteoclastic extension).

#### Results

An overall complication rate of 44% was seen, and BFR was the most common (36%). Only "osteoclastic extension of trepanation" (p=.04) was a significant risk factor for BFR. The factors "indication for DC" (p=.09) and "size of bone flap" (p=.09) had a tendency towards influencing the rate of BFR, while "age" (p=.68), "time interval between DC and CP" (p=1.00), and "gap width" (p=.50) were not considered to influence the BFR rate.

#### Conclusion

DC and subsequent CP is a complication-prone procedure. Therefore, it is relevant to identify and quantify probable risk factors for the most common complications, such as BFR. Here, we found that the extent of osteoclastic extension may impair the patient"s healing process. Our investigation was made considerably easier by using the novel VR visualisation technique, which allows parallax free measurements of distances in 3D space.

Abb. 1

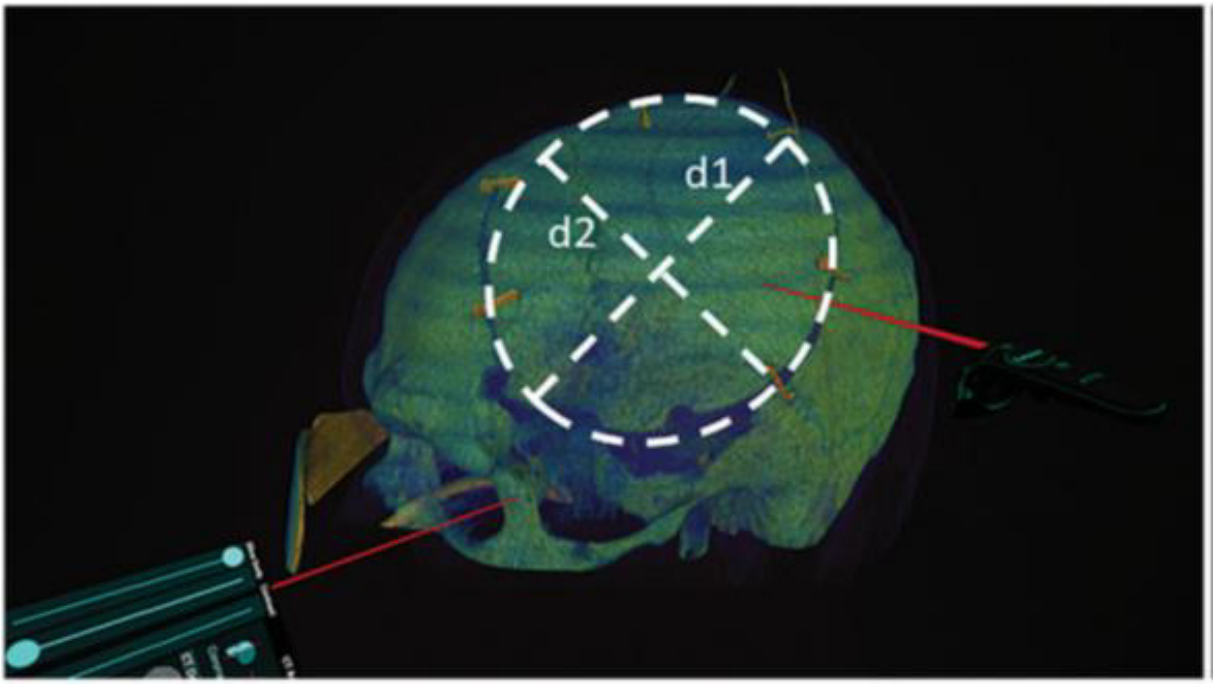
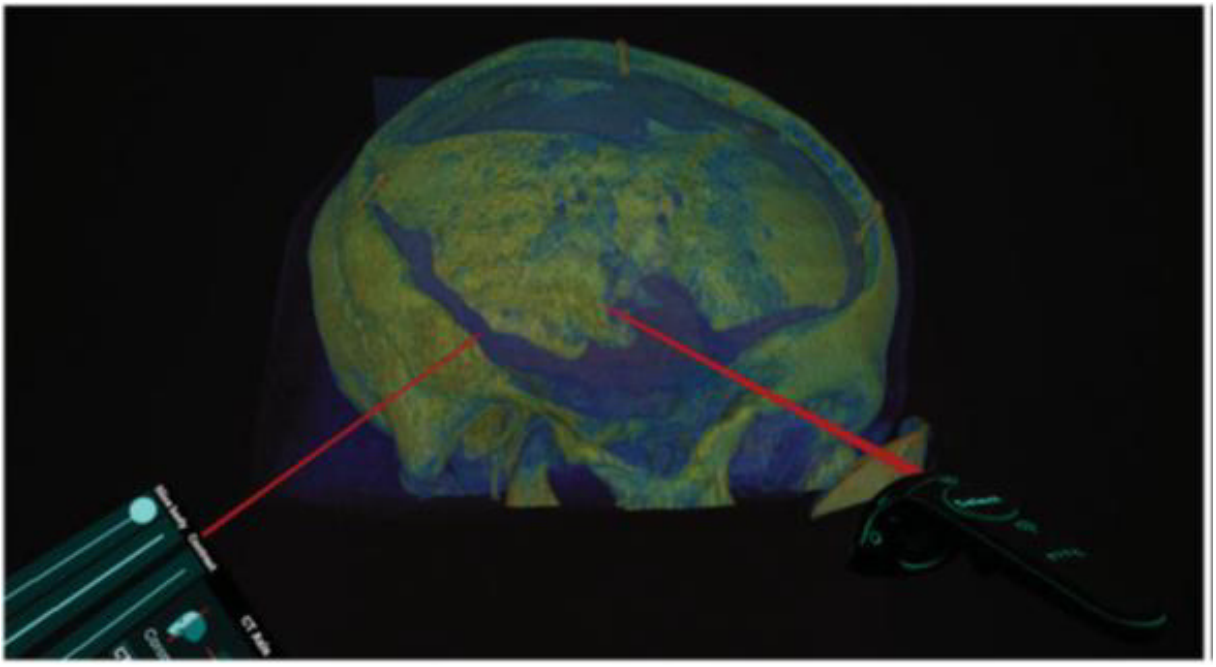



Abb. 2



# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P094

### Subarachnoidalblutung und Temporalmuskeldicke als Surrogatmarker für Sarkopenie: Ein möglicher und leicht zugänglicher prognostischer CT-Marker für den Krankheitsverlauf und das neurologische Outcome.

***Subarachnoid Hemorrhage and Temporal Muscle Thickness as a surrogate marker for sarcopenia: A possible and easily accessible prognostic CT-marker for patient's course of disease and neurological outcome***

E. Mohajerani[1], M. Gümüs[1], T. F. Dinger[1], C. Rieß[1], M. Darkwah Oppong[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Neurochirurgie, Essen, Deutschland

#### Objective

Sarcopenia has already been investigated as a prognostic marker for many different cancerous and non-cancerous diseases to prognosticate the clinical course. Temporal muscle thickness (TMT), as a representative of sarcopenia, and therefore also as a possible marker for clinical outcome, has gained increasing interest in recent years. The aim of this retrospective study was to investigate the association between TMT and the neurological outcome of patients with aneurysmal subarachnoid hemorrhage (aSAH).

#### Methods

A retrospective database consisting of all consecutive aSAH cases treated from 01/2003 to 06/2016 was used. The initial computed tomography examinations were used to calculate the mean TMT values. Primary endpoints included in-hospital mortality, development of cerebral infarcts and unfavorable outcome at 6 months defined as modified Rankin Scale >3. Secondary endpoints included occurrence of angiographic vasospasm, intracranial hypertension (>20mmHg) and systemic infections during aSAH. Univariate analyses were conducted and multivariate analyses were performed on significant findings.

#### Results

The mean TMT value of the final cohort (n=937) was 7.49mm ±1.68mm. Of the baseline characteristics, a significant relationship with TMT mean value was found for age ($p < 0.0001$), sex ($p < 0.0001$), obesity ($p = 0.001$) and uricemia/gout ($p = 0.026$). In the final multivariate analysis, the following aSAH endpoints/adverse events were independently associated with TMT: in-hospital mortality ($p = 0.035$, adjusted odds ratio [aOR] 0.86 per-mm-increase, 95% confidence interval [CI] 0.75-0.99), unfavorable outcome at 6 months ($p = 0.018$, aOR 0.86, 95% CI 0.76-0.98), intracranial hypertension ($p = 0.002$, aOR, 1.17, 95% CI 1.06-1.29) and the occurrence of angiographic vasospasm ($p = 0.011$, aOR, 0.87, 95% CI 0.78-0.97).

#### Conclusion

In this study, we found significant correlations between TMT mean value and the clinical course/outcome of patients affected by aSAH. Further studies in different patient populations are needed to validate the clinical relevance and prognostic value of TMT for aSAH patients.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P095

### Hausinterner 3D Druck von patientenspezifischen Polyetheretherketon (PEEK) Implantaten zur Deckung von großen Schädeldachdefekten - technisches Konzept und klinische Anwendung.

***In house 3D-printing of patient specific cranioplastic Polyetheretherketone (PEEK) implants for large skull defects – technical concept and clinical implementation***

J. Pöppe[1], M. Spendel[1], W. Wurm[2], S. Enzinger[3], C. J. Griessenauer[1]

[1]Uniklinikum Salzburg, Universitätsklinik für Neurochirurgie, Salzburg, Österreich
[2]Salzburger Landeskliniken, Abteilung für Medizin- u. Informationstechnologie, Salzburg, Österreich
[3]Uniklinikum Salzburg, Klinik für Mund-, Kiefer-, und Gesichtschirurgie, Salzburg, Österreich

#### Objective

3D printing is commonly used to aid implant molding with Polymethylmethacrylate for cranioplastic surgery of large skull defects. 3D printing of cranial implants itself has not been implemented in a clinical setting yet, mainly due to medico-legal concerns and missing of an implant ready printing material. With a 3D printer developed for printing medical applications and implant-grade Polyetheretherketone (PEEK) filament commercially available, we established a novel workflow in compliance with the European Union Medical Device Regulation (EU MDR) to 3D print PEEK implants for cranioplastic surgery at the point of care.

#### Methods

A design and 3D printing process in accordance with the EU MDR under the health institution exemption (Article 5.5, Regulation (EU) 2017/745) was developed: Implants are digitally designed (Geomagic Freeform 1.0, 3D Systems) upon pre- and post-craniectomy cranial CT scans by trained 3D printing experts from the department of medical engineering at our institution. Implants are then 3D printed on a medical 3D printer (3D Systems EXT 220 MED) with implant-grade PEEK filament (Vestakeep i4 3DF, Evonik Industries) using the Fused Filament Fabrication process. After post-processing and steam sterilization, implantation for reconstruction of the cranial skull can be performed.

#### Results

The first cranioplastic surgery with a 3D printed PEEK implant in a patient with a large fronto-temporo-parietal skull defect after traumatic brain injury with consecutive decompressive craniectomy was performed at our institution. No intra- or postoperative complications occurred. Postoperative cranial CT scans showed optimal reconstruction of pre-craniectomy skull shape. The esthetic result was promising and satisfactory to the patient.

#### Conclusion

This is the first published 3D printing workflow to facilitate 3D printing of patient specific cranial PEEK implants for the reconstruction of large skull defects directly at the point of care. Clinical implementation of the concept has been successfully performed. This marks an innovative technological and medico-legal advancement in the field of patient specific cranial implants, with the hospital infrastructure delivering additive manufacturing of patient specific customized skull implants. With the described 3D printing workflow cranioplastic implants – equivalent to Computer Animated Design implants – can be designed, produced and implanted at the point of care in accordance with medical device regulations.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P096

### Outcome nach einer späten Kranioplastik. Eine retrospektive Studie.
*Outcome after late Cranioplasty: A single-center retrospective study*

H. Asoglu[1], T. Lampmann[1], M. Hamed[1], H. Vatter[1], J. Weller[2], A. L. Potthoff[1], M. Schneider[1], M. Banat[1], V. Borger[1], F. A. Schildberg[3]

[1]Universitätsklinikum Bonn, Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Neurologie, Bonn, Deutschland
[3]Universitätsklinikum Bonn, Orthopädie und Unfallchirurgie, Bonn, Deutschland

#### Objective

The best time for cranioplasty (CP) after decompressive craniectomy (DC) is controversial and there are no authoritative guidelines yet. Both complications as well as outcome may depend on the timing of CP. The aim of this singe-center study was to evaluate the impact of late CP on procedural safety as well as on patient outcome.

#### Methods

All patients receiving CP at a tertiary university medical center between 01/2015 and 12/2022 were included retrospectively. Patients" conditions were assessed according to the modified Rankin scale (mRS) prior CP and 6 months after. Baseline characteristics, indication for DC, time from DC to CP, and postoperative complications according to the Landriel Ibañez Classification were analyzed.

#### Results

CP was performed in 271 patients who previously underwent DC due to traumatic brain injury (25.5%), ischemic stroke (29.5%), aneurysmal subarachnoid hemorrhage (26.9%), or intracerebral hemorrhage (18.1%). The median interval between DC and CP was 143 days (interquartile range 112–184 days). Receiver operating characteristic analysis revealed a cut-off of 149 days, where CP performed within 149 days after DC led to an improvement on mRS after CP (p=0.001). In multivariate analysis, additional rehabilitation after and better mRS before CP were independently associated with improvement of outcome. Rate of complications was similar between early and late CP (24.8% and 25.4%, respectively, p=0.562).

#### Conclusion

Late cranioplasty is a safe procedure. Outcome was improved when additional rehabilitation was performed after cranioplasty and was not associated with timing of cranioplasty.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P097

### Patientenspezifische Schädeldachplastiken aus titanverstärktem Calciumphosphat bei komplikativen Kranioplastiepatienten

***Patient specific titanium reinforced calcium-phosphate implants as rescue cranioplasty material in complicative cases***

P. Naser[1,2,3], F. Zacharias[1,2], H. Giese[1], S. Krieg[1,2], A. Unterberg[1,2], A. Younsi[1,2]

[1]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Medical Faculty, Heidelberg, Deutschland
[3]German Cancer Research Center (DKFZ), AI Health Innovation Cluster, Heidelberg, Deutschland

#### Objective

Cranioplasty (CP), the restoration of cranial integrity is routinely performed both following decompressive hemicraniectomy, and also as the final step of most intracranial operations. Complications can be severe with wound infections damaging the autologous bone and surrounding tissue typically requiring explantation. Eventually, these patients present for repeat CP to restore cranial integrity. In recent years, patient specific implants using titanium reinforced Calcium Phosphate (Ca-P PSI) have increasingly been utilized. This study aims to assess their applicability for repeat CP in complicative cases.

#### Methods

A single center retrospective analysis of all complicative cases treated with a Ca-P PSI as a repeat CP between 2020 and 2022 was performed. Demographic, perioperative and long-term follow-up data on the patients were collected and are presented descriptively.

#### Results

We identified 15 patients (six male, nine female) implanted with a Ca-P PSI for repeat CP from 2016 to 2022. The cranial operations prior to the initial CP (CP1) were predominantly tumor excisions (n=9) and took place between 1991 and 2019. The first complication was noted on average 15 months after CP1. Reasons for explantation of the initial CP were mostly infections (n=13), though one CSF fistula and one epidural hematoma were noted. The first repeat CP (CP2) was performed in 12 cases using a Ca-P PSI. In four of those cases, a skin expander was utilized prior to CP2 and 12 of those patients were administered antibiotics postoperatively. In three patients, CP2 was performed using a material other than Ca-P. Complications requiring re-explantation were noted on average seven years after CP2 in those cases but in all, another CP (CP3) was attempted (2 Ca-P, 1 PMMA). The PMMA-implanted patient developed another wound infection and was finally treated with a Ca-P PSI (CP4) 11 months after explantation of the PMMA plastic. Overall, during a mean follow-up of 2.1 ± 0.6 years, four patients developed significant complications after CP with a Ca-P PSI, leading to explantation and definitive treatment with a myocutaneous flap.

#### Conclusion

Our data suggest that Ca-P PSI can be an asset for repeat CP in complicative cases. A possible reason could be osseous integration of the this material, yielding a physiological microenvironment potentially resilient to infections. However, further studies are warranted to elucidate the underlying mechanisms and develop guidelines for repeat CP.

# Vaskuläre Neurochirurgie – Verschiedenes 2 | Vascular Neurosurgery – Various 2

## P098

### Essentielle Hypertonie bei einem 16-jährigen Mädchen, das durch mikrovaskuläre Dekompression behandelt wurde

*Essential hypertension in a 16-year old girl treated by microvascular decompression*

M. Middelkamp[1], P. S. Steffens[2], V. Vogelsang[2], R. Schild[2], J. Gempt[1], A. C. Muntau[2], L. Dührsen[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Klinik und Poliklinik für Kinder- und Jugendmedizin, Hamburg, Deutschland

#### Objective

Hypertension in children, while less prevalent than in adults, is a clinically significant and increasingly acknowledged health issue. Characterised by elevated blood pressure levels, paediatric hypertension can have immediate and long-term consequences on a child's health, leading to organ damage, particularly to the heart, kidneys, and blood vessels, despite it being often asymptomatic. The etiology of hypertension in children is multifactorial and can involve genetic predisposition, obesity, sedentary behaviour, and specific medical disorders. Identifying and managing the condition early on is crucial in minimizing consequent health complications. In the late 1970s it was postulated neurovascular compression (NVC) of the ventrolateral medulla might play a role in the development of essential hypertension. Subsequently, limited research, encompassing both clinical and experimental studies, has delved into this potential cause and its corresponding treatment. Despite compelling anatomical/physiological evidence supporting the idea that compression of the root entry/exit zone (REZ) of the ninth and tenth cranial nerves (CN IX–X) and the adjacent ventrolateral medulla, predominantly on the left side, may be implicated in systemic arterial hypertension.

#### Methods

Various studies have employed MRI to identify compressive vessels associated with hypertension, revealing a heightened prevalence of vascular contact or compression at the ventrolateral medulla in hypertensive individuals compared to those with normal blood pressure. The surgical procedure involved micro-vascular decompression (MVD) at the ventrolateral medulla and CN IX–X REZ as a therapeutic intervention for the condition. Vascular nerve contacts on CN X and IX were identified and carefully dissected, with the nerves padded using a teflon sponge.

#### Results

Following microvascular decompression of the left glossopharyngeal and vagus nerves, blood pressure values significantly decreased to normalized levels. Antihypertensive therapy was discontinued, and subsequent blood pressure measurements remained within the normotensive range.

#### Conclusion

Neurovascular compression may contribute to treatment-resistant hypertension, and microvascular decompression surgery appears to be an effective option for achieving blood pressure control. However, further research is needed to better understand the role of neurovascular abnormalities in hypertension and to optimize treatment strategies for this patient population.

Abb. 1

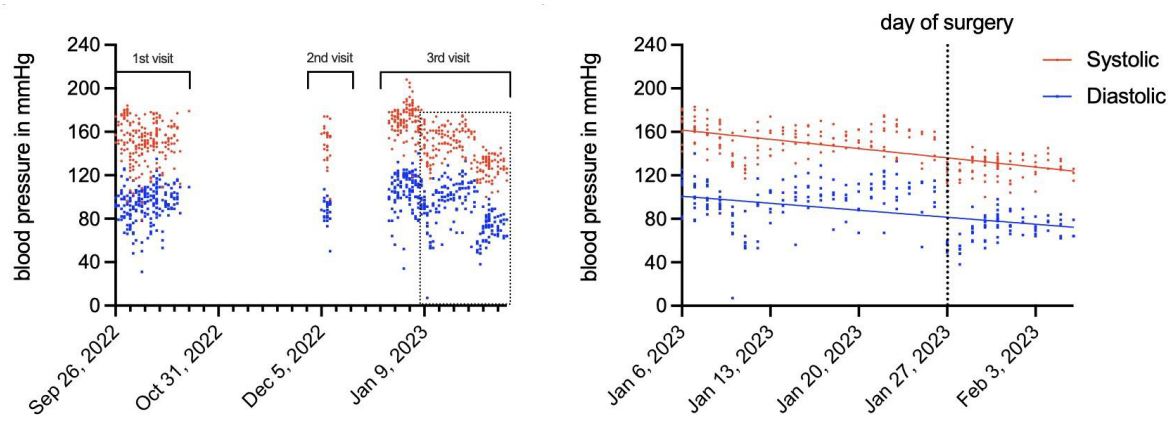
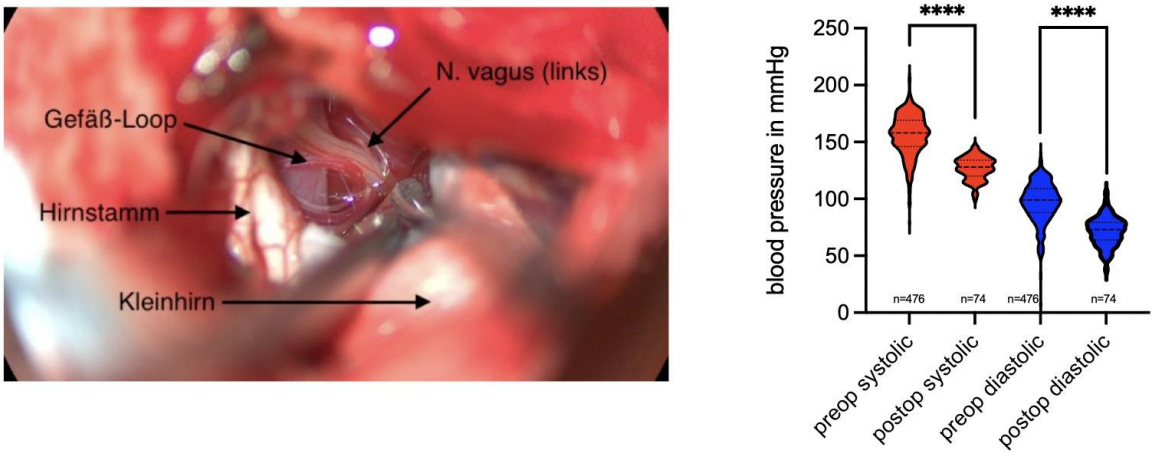

blood pressure in mmHg
240
200
160
120
80
40
0
1st visit
2nd visit
3rd visit
Sep 26, 2022
Oct 31, 2022
Dec 5, 2022
Jan 9, 2023
day of surgery
Systolic
Diastolic
Jan 6, 2023
Jan 13, 2023
Jan 20, 2023
Jan 27, 2023
Feb 3, 2023

Abb. 2


N. vagus (links)
Gefäß-Loop
Hirnstamm
Kleinhirn
blood pressure in mmHg
250
200
150
100
50
0
****
****
n=476
n=74
n=476
n=74
preop systolic
postop systolic
preop diastolic
postop diastolic

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P099

### Analyse des immunologischen Mikromilieus von Chordomen
### *Analysis of the immune microenvironment of chordomas*

Z. Wang[1], A. Unterberg[1], A. von Deimling[2], S. Krieg[1], C. Herold-Mende[1], R. Warta[1]

[1]Universitätsklinikum Heidelberg, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Heidelberg, Deutschland

### Objective

Chordoma has a high recurrence rate due to low sensitivity to conventional chemotherapy and radiotherapy. Therefore, objective of this study was to explore potential markers for prognosis and immunotherapy of chordoma.

### Methods

Cryopreserved tumor samples of 53 chordoma patients were included to perform immunofluorescence (IF) staining of tumor-associated macrophages (TAM-general: *CD68+*, M2-like: *CD163+*), tumor-infiltrating T lymphocytes (TIL-general: *CD3+*, cytotoxic: *CD8+*, regulatory: *FoxP3+*), and tumor cells (*pan-cytokeratin+*). The localization and quantity of infiltrating cells has been assessed by tissue cytometry on entire tissue-sections using the semi-automated analysis software, StrataQuest.

### Results

Our study sample consisted of 25 primary (47%) and 28 recurrent tumors (53%) derived of 28 male patients (53%). 37 tumors were located in the clivus (70%), while 15 tumors infiltrated the soft-tissue (28%), and 34 patients received postoperative radiotherapy (64%). The median age was 40 years (range: 2-77) with a median progression-free survival (PFS) of 14 months (range: 0-176). IF staining revealed a highly variable presence of infiltrating immune cells with median frequencies of 3.67 TAMs / total cell count (0.34-25.55), 2.29 M2-like TAMs (0.13-11.03), 6.28 TILs (1.34-31.29), 1.26 cytotoxic T cells (0.18-8.35), and 0.16 regulatory T cells (0.04-0.85). Interestingly, higher infiltration levels of TAMs or cytotoxic T cells were associated with a better PFS. Moreover, a higher intratumoral TAM infiltration was significantly associated with an increased OS in the group of newly diagnosed chordomas. The unexpected impact of TAM infiltration on survival may indicate a novel immunoregulatory mechanism in chordoma and require more in-depth analysis.

### Conclusion

The association of high TAM infiltration and prolonged PFS indicates that chordoma patients might benefit from immune-activating therapies and seem to have a less immunosuppressive tumor microenvironment.

# P100

## Medikamentenscreening in Ependymomorganoiden identifiziert HDAC, Anthrazykline und Proteasominhibitoren als potentielle Therapeutika

***Automated drug screening in ependymoma organoids identifies HDAC, anthracyclines, and proteasome inhibitors as potential therapeutic candidates***

Y. Pan[1], G. Jungwirth[1], J. Cao[1], R. Warta[1], A. Abdollahi[2], S. Krieg[1], A. Unterberg[1], C. Herold-Mende[1]

[1]Ruprecht-Karls-University Heidelberg, Division of Experimental Neurosurgery, Department of Neurosurgery, Heidelberg, Deutschland
[2]Ruprecht-Karls-University Heidelberg, Department of Radiation Oncology, Heidelberg, Deutschland

### Objective

Ependymoma is a rare tumor arising from brain or spinal ependymal cells. Due to limited treatment options besides surgery and radiotherapy, the management of ependymoma remains challenging. This study aims to establish a novel *ex vivo* model and to find effective systemic drugs for the treatment of ependymoma.

### Methods

Tumor Organoids (TOs) were generated by the reaggregation of single cell suspensions from freshly resected ependymoma tissue. Live/dead staining and ATP-based CellTiterGlo3D were used to assess the viability. To perform the high-throughput drug screening, TOs were generated from a spinal *NF2*-mutated ependymoma. The robotic liquid handler Hamilton Microlab STAR ® was used to screen 179 FDA-approved antineoplastic drugs (NCI AOD XI) in the range of 10 nmol/l to 30 µmol/l. A multi-step approach was employed to generate dose-response curves for all drugs.

### Results

TOs reaggregated within 2-3 days to dense mini-tumors resulting in a reduced diameter by 50% independent of the seeded cell number. TOs primarily comprised viable cells, whereas dead cells were mainly located on the outside. Half-maximum inhibitory concentrations (IC50) were obtained for 34% (n=61/179) of the drugs, the remaining drugs showed no efficacy up to 30 µmol/l. To assess if potential therapeutic concentrations were reached, IC50 values were compared to the peak serum drug concentrations (Cmax). By using this approach, 11.7% of the drugs (n=21/179) can be classified as sensitive (Cmax/IC50 ratio > 1). Of those, the drug classes HDAC inhibitors (Belinostat and Romidepsin), anthracyclines (Doxorubicin and Epirubicin), and the proteasome inhibitor Carfilzomib demonstrated the highest Cmax/IC50 ratios, suggesting that therapeutic drug levels can be achieved.

### Conclusion

Taken together, we generated standardized ependymoma TOs and identified HDAC, anthracyclines, and proteasome inhibitors as therapeutic candidates for ependymoma. Our findings may help guide the clinical decision-making for the systemic treatment of ependymoma in the future.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P101

### Charakterisierung des Immunzellinfiltrats im Vestibularisschwannom
### *Characterization of immune cell infiltrate in vestibular schwannoma*

A. L. Becker[1], C. H. Klause[1], P. Morgner[1], C. Strauss[1], C. Scheller[1], C. Ostalecki[2], S. Leisz[1]

[1]Martin-Luther-Universität Halle-Wittenberg, Klinik für Neurochirurgie, Halle, Deutschland
[2]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Klinik für Dermatologie, Erlangen, Deutschland

#### Objective

Vestibular schwannoma (VS) is the most common benign tumor in the cerebellopontine angle. Macrophage infiltration has been suggested to influence disease progression in our preliminary studies. In comparison, the infiltration of other immune cells in the VS is not well investigated. Therefore, the aim of this study was to characterize the immune cell infiltrate quantitatively and topologically in the VS.

#### Methods

Cryosections of five tumor samples from VS patients with different tumor volume were examined. The abundance of 18 immune cell markers and two tumor markers were detected using multi-epitope ligand cartography, which can be used to stain over 100 antigens on a tissue section. The microscopic images were subsequently analyzed using ImageJ and CellProfiler software.

#### Results

In addition to $S100B^+$ and $CD56^+$ VS tumor cells, numerous $CD68^+$ and $CD163^+$ macrophages were visualized in the image sections. $CD14^+$, $CD16^+$, and $CD40^+$ macrophages were also detected in the histological sections. Double positive cells were shown for CD3 and CD4 as well as CD3 and CD8, representing T helper cells and cytotoxic T cells. In addition to these T cell markers, $CD80^+$, $CD86^+$, and $CTLA4^+$ cells were also identified, which might play a role in immune escape by tumor cells. Furthermore, detection of cells that were stained with antibodies against PD1 and PDL1 were observed.

#### Conclusion

From the fluorescence microscopic images, it can be concluded that more distinct immune cells are found in the VS than previously known. In addition to tumor-associated macrophages, proinflammatory and immature macrophages, T helper cells and cytotoxic T cells were detected. Likewise, the results indicate that immune cells may influence each other in activity and function. Thus may contribute to the development and proliferation of VS. Overall, these new findings offer the possibility to establish new diagnostic and therapeutic options in VS.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P102

### Klinische und molekulare Merkmale von primären spinalen epiduralen Lymphomen
*Clinical and molecular features of primary spinal epidural lymphomas*

V. Stöcklein[1,2], L. Adolph[2,3], V. Passerini[2,3], M. Heide[3], P. Karschnia[1], S. Zausinger[1], M. von Bergwelt-Baildon[2,3], J. Tonn[1,2], S. Stöcklein[4], M. Rudelius[5], N. Thon[1,2], C. Schichor[1], O. Weigert[2,3]

[1]LMU Klinikum, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Deutsches Krebsforschungszentrum (DKFZ), Deutsches Konsortium für Translationale Krebsforschung (DKTK), Partnerstandort München, München, Deutschland
[3]LMU Klinikum, Medizinische Klinik, München, Deutschland
[4]LMU Klinikum, Klinik und Poliklinik für Radiologie, München, Deutschland
[5]Klinikum der Ludwig-Maximilians-Universität München, Pathologisches Institut, München, Deutschland

#### Objective

Primary spinal epidural lymphoma (PSEL) is a rare group of non-Hodgkin lymphomas that originates in the spinal epidural space and lack additional manifestations at the time of diagnosis. Here we report clinical, histopathological and molecular characteristics of PSEL.

#### Methods

Patients with PSEL were identified by searching our institutional database. Clinical and histopathological data were extracted. Furthermore, formalin-fixed and paraffin-embedded (FFPE) specimens were used for extraction of genomic DNA (gDNA) and RNA. We performed targeted DNA sequencing of recurrently mutated genes for all patients with sufficient yield and quality of gDNA and digital multiplexed gene expression profiling for all patients with sufficient yield and quality of RNA.

#### Results

13 PSEL patients were identified. All patients underwent laminectomy of the cervical (n=1), thoracic (n=7) or lumbosacral spine (n=5) and resection of the epidural mass. Median age was 66 years. Seven patients were male and 6 female. Median follow-up was 70 months. Histopathological analysis showed indolent (follicular lymphoma (FL; n=4) and marginal zone lymphoma (n=3)) and aggressive morphology (diffuse large B cell lymphoma (n=5) and Burkitt lymphoma (n=1)). 10/13 patients received adjuvant radiotherapy and 9/13 received chemotherapy. Despite systemic treatment, 2 of 6 patients with aggressive PSEL died during follow-up and one patient relapsed after 23 months. In contrast, all patients with indolent PSEL were still alive at last follow up with one patient relapsing after 129 months. FFPE specimens were available for 10/13 cases. Targeted DNA sequencing (n=8) and gene expression data (GED; n=10) showed similarity with expression profiles of nodal lymphomas of corresponding histology. Comparison of GED from PSEL FL with data derived from nodal FL showed higher similarity with advanced stage; gene set enrichment analysis showed higher expression of genes involved in inflammation, angiogenesis and extracellular matrix organization.

#### Conclusion

We present a comprehensive analysis of a patient group with an extremely rare spinal tumor. Despite their initially localized presentation, PSEL with aggressive histologies exhibited remarkable poor outcomes. Molecular analysis revealed similarities between PSEL and their nodal counterparts, with activated pathways likely supporting lymphoma growth within this extranodal site.

# P103

## Vergleich unterschiedlicher radiologischer Wachstumsmessungen von Vestibularisschwannomen basierend auf der Expression des Proliferationsmarkers MIB1

***Comparison of different radiographic growth measurements of vestibular schwannomas based on the expression of the proliferation marker MIB1***

L. Dörner[1], V. Goncalves[2], E. M. Suhm[1], V. Ries[1], J. Schittenhelm[3], M. Tatagiba[1], F. Behling[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]University of Porto, Faculty of Medicine, Porto, Portugal
[3]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland

### Objective

The growth of vestibular schwannomas is a decisive feature on follow-up imaging to help with the treatment decisions. Radiographic growth can be measured by different means ranging from changes in CPA diameter to volumetric growth and percentual volumetric growth. A correlation of radiographic growth with the tumor cell proliferation on a cellular level has not yet been compared.

### Methods

The radiographic growth of 207 vestibular schwannomas that were surgically treated in the authors" center was measured by different methods (change in CPA diameter over time, percentual change in CPA diameter over time, volumetric change over time, percentual volumetric change over time). The results were measured against the expression of the proliferation marker MIB1 in the preserved tumor tissue.

### Results

In general, the proliferative activity measured by MIB1 in vestibular schwannomas is low with a mean immunopositivity of 1.34% of tumor cells, ranging from 0.45 to 3.20%. A statistically significant correlation was seen with percentual change in CPA diameter and percentual volumetric growth ($p=0.0056$ and $p=0.0062$, respectively). Absolute change in CPA diameter or tumor volume over time did not correlation with MIB1 expression.

### Conclusion

Percentual change in CPA diameter and tumor volume are both correlated with MIB1 expression.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P104

### Evaluation von vestibulären Symptomen bei Patienten mit Vestibularisschwannom nach robotisch geführter stereotaktischer Radiochirurgie mit dem Dizziness Handicap Inventory (DHI)

***Evaluation of vestibular symptoms in patients with vestibular schwannoma after robotic-guided stereotactic radiosurgery using the Dizziness Handicap Inventory (DHI)***

D. Rueß[1], S. Vojacek[1], D. Ludyga[1], K. Jablonska[1], M. Kocher[1], M. I. Ruge[1]

[1]Universitätsklinikum Köln, Klinik für Strahlentherapie, Köln, Deutschland

#### Objective

Vestibular symptoms (Vsym) can severely affect the daily life of patients with vestibular schwannomas (VS). Nevertheless, in available studies investigating outcome after radiosurgery (SRS) with valid objective data addressing Vsym beyond subjective patient reports are scarce. To objectively evaluate the incidence of vestibular symptoms we introduced the standardized questionnaire Dizziness Handicap Inventory (DHI).

#### Methods

For this retrospective single center investigation we included all patients who received Cyberknife® SRS for newly diagnosed unilateral VS between 2012 and 2022 and with a minimum of three follow-up (FU) visits. Besides clinical investigation, the incidence of Vsym before and after treatment was recorded by using the DHI. The results were correlated with tumor-, patient-, and treatment related characteristics.

#### Results

We identified 105 patients with a median age of 60 years (range: 29-82) and a median follow-up of 37 months (range: 10-103). Mean tumor volume was 1.4 cm3 ± 1.4 ml (range: 0.08-7.1). A mean marginal dose of 13 Gy ± 0.2 (range: 12-13) was administered. Tumor control was 100%. The mean DHI-score before treatment was 28.7 ± 24 (range:0-92). In about 10% of the patients (n=11) a deterioration of > 10 points DHI score was found at LFU. In multivariate analysis, neither tumor volume (p=0.227), age (p=0.634), nor radiation dose were significantly associated with the deterioration of DHI.

In contrast 16% of the patients (n=17) showed an improvement of >10 points DHI. Overall, there was no statistically significant difference between mean DHI score before and after treatment.

#### Conclusion

The DHI has proven to be a feasible and reliable instrument for measuring Vsym after SRS. However, the incidence of Vsym after SRS was found to be independent of the usual tumor-, patient- and treatment-related factors. In how far the dose exposure of the structures of the vestibular apparatus could play a role should be further analyzed and correlated with DHI in detail.

# P105

## Bestimmung des Mehrwerts von Kontrastmitteln bei der radiomikgestützten Klassifizierung von Astrozytomen anhand von Niedrigdosis-CT-Navigationsdaten

***Determining the added value of contrast agents in the radiomics-based classification of astrocytomas using low-dose CT navigation data***

M. Musigmann[1], M. Bilgin[1], S. Bilgin[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

### Objective

The correct differentiation of low-grade and anaplastic astrocytomas is of great importance for further therapy planning in the context of personalized medicine. The aim of our study is to investigate the achievable accuracy in the non-invasive discrimination of these tumor types using radiomics and machine learning based on low-dose CT images. We determine the added value of contrast agents for this important diagnostic task.

### Methods

Our study cohort includes 190 patients with low-grade and anaplastic astrocytomas and available low-dose CT images. The images were obtained with dual energy CT scanners. Segmentation of the contrast-enhancing parts of the tumor on the contrast enhanced CT images as well as segmentation of the hypodense tumor parts on the native CT images was semi-automatically performed with the 3D Slicer software and utilizing the Segmentation Wizard plugin by two readers. A total of 107 radiomic features were extracted by hand-delineated regions of interest from the CT images of each patient. Three conventional machine learning algorithms and a neural network were tested to discriminate the two astrocytoma types and to analyze the added value of the contrast agent.

### Results

We achieved our best results in distinguishing the astrocytoma types using Lasso regression for feature preselection and subsequent model development. Six radiomic and clinical features were found to be particularly important. Using independent test data, our 6-feature Lasso regression model achieved an AUC of 90.8%, an accuracy of 86.1%, a sensitivity of 75.7% and a specificity of 91.5%. The mean prediction error rate based on the native CT images was only slightly higher than the mean prediction error based on the contrast-enhanced CT images. The administration of a contrast agent did not lead to a significant improvement in prediction accuracy for low-grade astrocytomas. In contrast, however, the accuracy was significantly increased in anaplastic astrocytomas. Here, the prediction error was 34.2% when using native CT images, but only 16.9% when using a contrast agent.

### Conclusion

Our results show that low-grade and anaplastic astrocytomas can be distinguished non-invasively with high accuracy using machine learning based on low-dose CT images. Even with native CT images and only a few radiomic features, comparatively accurate predictions can already be made. In the case of anaplastic astrocytomas, however, the administration of a contrast agent results in a considerable added value.

# P106

## Charakteristika von Riesen-Vestibularisschwannomen.
## *Factors associated with giant vestibular schwannoma size*

L. Dörner[1], V. Goncalves[2], E. M. Suhm[1], V. Ries[1], J. Schittenhelm[3], M. Tatagiba[1], F. Behling[1]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]University of Porto, Faculty of Medicine, Porto, Portugal
[3]Eberhard-Karls University Tübingen, Department of Neuropathology, Tübingen, Deutschland

### Objective

The size of vestibular schwannomas shows marked variations, ranging from small intrameatal lesions to giant tumors that compress multiple structures of the cerebellopontine angle (CPA). Giant vestibular schwannomas are defined by a CPA diameter of at least 40 mm and factors that are associated with giant size at clinical presentation are still poorly understood.

### Methods

A retrospective analysis of 907 sporadic vestibular schwannomas that were treated at our center were analyzed for clinical and immunohistochemical factors that are associated with giant tumor size. Age, gender, tumor status (primary vs. recurrent tumor), prior radiotherapy, volumetric tumor size, and immunohistochemical markers of proliferation (MIB1), lymphocyte infiltration (CD3 and CD8) and macrophage infiltration (CD68 and CD163) were analyzed.

### Results

Overall, 36 of 907 tumors (4.0%) were giant vestibular schwannomas and were associated with cyst formation ($p<0.0001$) and higher expression scores for macrophage marker CD163 ($p<0.0001$). There were no differences in age, gender, prior radiotherapy, recurrent tumor status, MIB1 expression, CD68, CD3 and CD8 expression. In the multivariate nominal logistic regression cyst formation and higher CD163 expression were associated with giant size.

### Conclusion

Giant vestibular schwannomas are associated with cystic growth and show an increased infiltration with CD163 positive macrophages

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P107

### Systematische Übersichtsarbeit zur Lebensqualität von PatientInnen mit Schwannomatose
*Exploring the quality of life in Schwannomatosis: A systematic review*

A. C. Lawson McLean[1,2], C. Senft[1], A. Demetriades[3], S. Rosahl[2]

[1]Universitätsklinikum Jena, Jena, Deutschland
[2]Helios Klinikum Erfurt, Klinik für Neurochirurgie, Erfurt, Deutschland
[3]University Hospital, Edinburgh, Vereinigtes Königreich

### Objective

Schwannomatoses, rare genetic disorders leading to multiple tumors of the central and/or peripheral nervous system, have undergone a conceptual shift due to recent molecular insights. This revised framework summarizes nf2-related schwannomatosis (NF2-SWN) and other variants, emphasizing their destinction from neurofibromatosis 1. Patients with schwannomatosis exhibit diverse symptoms impacting their quality of life (QoL). This systematic review aims to analyze existing literature on QoL in patients with schwannomatosis.

### Methods

A thorough search of databases (PubMed, MEDLINE, Scopus) until August 2023, using keywords like "neurofibromatosis 2," "schwannomatosis," "quality of life," and "patient-reported outcomes." Inclusion criteria covered studies evaluating QoL, using validated tools. Case reports and reviews were excluded.

### Results

The initial search yielded a total of 224 articles, from which duplicates were removed. Following the screening process, 32 articles emerged as fitting for final analysis. These studies employed a wide variety of assessment tools, including the SF-36 (n=7), PHQ-9 (n=8), and the disease-specific questionnaire NFTI-QoL (n=13). Findings revealed limitations in social interactions, outlook on life, and physical functioning in patients with NF2-SWN, while non-NF2-SWN patients mainly had QoL limitations due to pain.

### Conclusion

This systematic review provides a comprehensive overview of QoL in schwannomatosis. The outcomes underscore the importance of a holistic approach to patient care, necessitating attention not only to tumor management but also the strategic enhancement of overall well-being and QoL for affected individuals. Given the wide variety of assessmemnt tools, a consensus for a standardized test battery would be desirable.

# P108

## Langzeit-Management intrakranieller Epidermoidzysten - die Balance zwischen Resektionsausmaß und Funktionserhalt

***Long-term management of intracranial epidermoid cysts – Balancing extent of resection and functional preservation***

M. Omer[1], J. M. Nakagawa[1], C. Scheiwe[1], J. Beck[1], J. Grauvogel[1], C. Steiert[1]

[1]University of Freiburg, Neurosurgery, Freiburg i. Br., Deutschland

### Objective

Epidermoid cysts represent about 1% of all intracranial neoplasms. Surgical treatment of these rare benign lesions can be challenging due to capsular membranes adhering to critical neurovascular structures, particularly as they are frequently widespread and deep-seated. Their tendency for recurrence necessitates meticulous surgical intervention, balancing radicality and the risk of neurological morbidity. The current study focuses on correlating surgical outcomes with the extent of resection and recurrence rates during long-term follow-up.

### Methods

The monocenter retrospective study involved patients being operated for epidermoid cysts between 2000 and 2021. A detailed analysis of their clinical, surgical, and neuroradiological data was performed, with special interest on long-term symptom development and changes in imaging.

### Results

The study included 55 patients (56.4% male) with epidermoid cysts located predominantly in the cerebellopontine angle/prepontine cistern (75.3%), beside supratentorial and fourth ventricular lesions. The mean age at surgery was 44.3 years. The most common symptoms were dizziness and trigeminal nerve affection (29% each), followed by hearing difficulties/loss, headaches, and gait disturbances (27% each). Postoperative MR imaging showed remnants of restricted diffusion < 10 mm in 28%, and remnants > 10 mm in 7% of cases (non-total removal). Progression on imaging after non-total removal was found in 64.0%, whereas recurrence after total removal was detected in 20.5%. The rate of immediate postoperative symptom improvement was similar after total and non-total removal (12.6% vs. 10.5%), and after one year, the rate of symptom improvement was higher after total removal (41.7% vs. 28.0%). The rate of new, though mostly transient, cranial nerve deficits after surgery was similar in both groups (total vs. non-total removal: CN III, VI or VI: 15.4 vs. 20%, CN VII: 15.4 vs. 8%, CN VIII: 5.1 vs. 0%, CN IX, X, XI or XII: 10.2 vs. 16%), as were general, usually minor surgical complications (total vs. non-total removal: 20.5 vs. 16%).

### Conclusion

A more radical resection without remnants of restricted diffusion on postoperative imaging was associated with a higher rate of long-term symptom improvement and less recurrence. However, functional preservation should remain priority in the surgical management of epidermoid cysts. Long-term follow-up is always mandatory, as recurrences were regularly observed even after total removal.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P109

### Erhöhte 68Ga-DOTATATE-Aufnahme in der PET/CT-Bildgebung von solitären fibrösen Tumoren: eine Fallserie
*Increased 68Ga-DOTATATE Uptake in PET/CT Imaging of solitary fibrous tumors: A case series*

A. Biczok[1], T. Greve[1], P. Harter[2], N. Albert[2], C. Schichor[3]

[1]Klinikum der Ludwig-Maximilians-Universität München, Neurochirurgie, München, Deutschland
[2]Klinikum der Ludwig-Maximilians-Universität München, Nuklearnedizin, München, Deutschland
[3]Klinikum der Ludwig-Maximilians-Universität München, Neurochirurgie, München, Deutschland

#### Objective

Solitary fibrous tumor (SFT) represents a rare type of meningeal tumor, constituting approximately 1% of all intracranial tumors. Despite being predominantly considered benign, local tumor recurrence and distant metastasis occur in 40-50%. The most effective approach involves maximal safe resection, potentially complemented by radiotherapy (RT). [68Ga]-DOTATATE, a somatostatin analog PET radiotracer, has proven beneficial in delineating the volume of meningiomas, including transosseous tumor growth, as well as in distinguishing between tumor and treatment related changes. However, there remains a lack of comprehensive information regarding the uptake of this PET radiotracer in SFTs.

#### Methods

In this retrospective analysis we included patients undergoing surgical resection SFTs at our institution between 2000 and 2020. Tumors were classified according to the WHO classification (edition 2021). Patients with known SFT receiving [68Ga]-DOTATATE PET/CT imaging were included. Uptake intensity (SUVmax) of SFT was assessed.

#### Results

Three of 21 patients with diagnosed malignant SFT received [68Ga]-DOTATATE PET/CT during their follow-up period. A 33-year-old male patient underwent surgical resection and RT for a malignant SFT in 2008 and 2012. Three years later, MRI detected a suspect recurrent lesion distant to the surgical cavity. [68Ga]-DOTATATE PET/CT was obtained in order to evaluate the presence of distant metastases, which showed a high uptake intensity (SUVmax: 5,48). The lesion was treated with CyberKnife radiosurgery. A 38-year-old man was surgically treated for malignant SFT in 2015. He underwent postoperative [68Ga]-DOTATATE PET/CT, which showed a tumor remnant adjacent to the surgical cavity with a high uptake intensity (SUVmax: 5,4). The patient received RT, and showed no recurrence or distant metastatic disease. A 49-year-old male patient with a previous history of surgically treated metastatic (osseus, hepatic and pulmonal) intracranial malignant SFT, received [68Ga]-DOTATATE PET/CT imaging for resection planning of a recurrent intracranial tumor. Tracer uptake intensity was moderate (SUVmax: 3.0). Histopathological report confirmed recurrence of SFT (MIB-1 of 15%). Due to progressive systemic disease the patient died in the course of the following year.

#### Conclusion

[68Ga]-DOTATATE PET/CT imaging may serve as a promising imaging tool for treatment planning, discrimination of post treatment related chances and residual or recurrent tumor or for disease monitoring.

# P110

## Molekulare Unterschiede zwischen lang- und kurzzeitüberlebenden Patienten mit Glioblastom
*Molecular differences in long- and short-time survivors of GBM patients*

L. Hönikl[1], V. M. Butenschön[1], J. Gempt[1], N. Pfarr[2], C. Delbridge[2], B. Meyer[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgische Klinik und Poliklinik, München, Deutschland
[2]Institut für Pathologie, Technische Universität München, Klinikum rechts der Isar, München, Deutschland

### Objective

Glioblastoma (GBM) is a highly aggressive brain tumor. Despite maximal multimodal tumor therapy, the overall survival is still poor (15 months after diagnosis). Regardless of standard molecular diagnostics, there are cases with extremely short (<9 months, short-term survivors, STS) and long-term GBM patients (>36 months, long-term survivors, LTS). An understanding of the underlying molecular mechanisms is still missing.

### Methods

This is a single-center retrospective analysis of 206 GBM tumor patients with an overall survival of < 9 months and >36 months. All patients receiving tumor therapy per the Stupp protocol in-house were included. Molecular analyses were performed with TSP 500 next-generation sequencing.

### Results

206 GBM patients were included (57 STS, 125 ITS, 24 LTS). LTS had younger (median 60 years) and more female (54%) patients than ITS and STS do. We found no significant difference between the tumor heterogeneity in all groups (TMB, MSI). TERT promotor mutations are more frequent in LTS 63%, vs. 54% ITS and 53% STS (p=0.7080). Pathogenic TP53 mutations are also slightly more frequent in LTS 13% than in ITS 6% and STS 5% p=0.4746). LTS presented more NF1 likely pathologic mutations (21%) than ITS (18%) and STS (5%) do (p=0.0037).

### Conclusion

In summary, the molecular analysis of GBM patients, for those with STS and LTS, reveals the critical role of TERT promotor. Further minor differences were seen, but no distinct biomarker could be identified. Other studies and proteomic analyses are needed.

# Tumor – Verschiedenes 1 | Tumour – Various 1

## P111

### Intraorbitales retrobulbäres Speicheldrüsenchoristom: Präsentation eines einzigartigen Falles und Analyse der Literatur

***Intraconal retrobulbar salivary gland choristoma: Presentation of a unique case and review of the literature***

L. Ritter[1], T. Eibl[1], A. Liebert[1], C. Blechschmidt[2], M. Traxdorf[3], K. M. Schebesch[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Klinik für Neurochirurgie, Nürnberg, Deutschland
[2]Klinikum Nürnberg, Paracelsus Medizinische Universität, Institut für Pathologie, Nürnberg, Deutschland
[3]Klinikum Nürnberg, Paracelsus Medizinische Universität, Klinik für Hals-Nasen-Ohrenheilkunde, Nürnberg, Deutschland

#### Objective

A choristoma is defined as the accumulation of normal tissue in an abnormal location. Salivary gland choristomas are a rare entity that is most frequently described in the middle ear. However, there are a few reported cases of salivary gland choristomas in other locations like the pituitary gland and the optic nerve dural sheath. To the best of our knowledge, we present the first case of a patient with an intraconal salivary gland choristoma. A brief, but comprehensive review of literature is offered, additionally.

#### Methods

A 19-year-old male patient presented with disturbance of ocular motility, ptosis, and exophthalmos of the right eye. The subsequent imaging by MRI demonstrated an intraconal lesion that infiltrated the lateral and the medial rectal muscle of the right eye. The lesion showed intensive Gadolinium enhancement in T1 weighted sequence and the FLAIR sequence showed no intracranial edema. The interdisciplinary neuro-oncologic tumor board recommended a biopsy and partial removal of the lesion.

#### Results

Partial resection of the choristoma was successfully performed via lateral orbitotomy. No new neurological or visual deficits occurred postoperatively. During the two-week follow-up examination, the exophthalmos had completely regressed and the patient only reported a slight retrobulbar pressure sensation. The histopathological examination of the tissue revealed seromucous glandular tissue.

#### Conclusion

Salivary gland choristomas have been occasionally described intracranially before, but this is the first case of an intraconal accumulation of salivary gland tissue. Partial resection was achieved, resulting in complete recovery of the ophthalmologic symptoms.

# P112

## Die Rolle des postoperativen Blutdruckmanagements bei frühen postoperativen Nachblutungen bei Patienten nach Wachcraniotomien für intrakranielle Gliome

***The role of postoperative blood pressure management in early postoperative hemorrhage in awake craniotomy glioma patients***

M. Demetz[1], A. Krigers[1], R. Uribe-Pacheco[1], D. Pinggera[1], C. Thomé[1], J. Kerschbaumer[1], C. Freyschlag[1]

[1]Universitätsklinik für Neurochirurgie Medizinische Universität Innsbruck, Innsbruck, Österreich

### Objective

Awake surgery is widely used to maximize the extent of resection and neuro-oncological outcome in eloquent gliomas. Postoperative hemorrhage can severely deteriorate the patients" neurological outcome. Higher postoperative blood pressure can increase the risk of postoperative hemorrhage, but optimal blood pressure management is still debatable. The aim of this study was to investigate the role of postoperative blood pressure and other common radiological and epidemiological features with the incidence of postoperative hemorrhage.

### Methods

In this retrospective analysis, we included all patients who underwent awake surgery between 2010 and 2023 at our institution. We assessed the blood pressure both intra- and postoperatively as well as the heart rate for the first 12 hours. We compared a cohort with postoperative hemorrhage, who required further treatment (surgical revision or intravenous antihypertensive therapy), with a cohort with no postoperative hemorrhage.

### Results

We included 48 patients with a median age of 39 years. 23 patients (48%) showed signs of a hemorrhage on early postoperative MRI, of whom 9 (19%) required further treatment, which was surgery in 2 cases and conservative therapy in 7 cases.

Patients with postoperative hemorrhage showed significantly higher postoperative systolic blood pressure during the hours 3-12 ($p<0.05$) as well as intraoperatively during the hours 1-5 ($p<0.05$). No significant impact of both intra- and postoperative heart rate could be shown. No significant influence on postoperative hemorrhage could be shown for the residual tumor volume.

In ROC and Youden Test, a significant impact of systolic blood pressure over 140 mmHg during early the postoperative course on the occurrence of postoperative hemorrhage could be shown ($p<0.05$).

At 3 months follow-up, no significant difference in Karnofsky Performance Score between the two cohorts could be shown.

### Conclusion

Postoperative hemorrhage is a serious complication in awake surgery glioma patients. However, with early treatment, no significant difference in Performance scores at follow-up could be found. To avoid postoperative hemorrhage, treating physicians should aim at a strict systolic blood pressure of under 140 mmHg both intraoperatively as well as for the early postoperative course.

# P113

## Welchen Einfluss hat der Diagnostikprozess bei Patienten mit primärem ZNS-Lymphom?
*Primary central nervous system lymphoma: What is the impact of the diagnostic process?*

S. Quach[1,2], L. Lehner[3], A. Khan[2], K. Müller[3], N. Thon[2], L. von Baumgarten[2]

[1]Evangelisches Klinikum Bethel, Universitätsklinik für Neurochirurgie, Bielefeld, Deutschland
[2]Klinikum der Ludwig-Maximilians-Universität München, Klinik mit Poliklinik für Neurochirurgie, München, Deutschland
[3]Klinikum der Ludwig-Maximilians-Universität München, Klinik und Poliklinik für Neurologie, München, Deutschland

### Objective

Patients with primary central nervous system lymphoma (PCNSL) suffer from a poor prognosis due to an aggressively fast growing tumor. Diagnosis can be obtained by lumbar puncture, biopsy or resection. Our study aimed to evaluate the impact of diagnostic delay on overall survival and progression-free survival.

### Methods

One hundred twenty-five patients with newly diagnosed PCNSL between 2008 and 2021 were retrosepctively analyzed. The prognostic value of diagnostic and therapeutic delay as well as patient characteristics was studied with uni- and multivariate analyses.

### Results

Three patients could be diagnosed by lumbar puncture, 116 by stereotactic biopsy and 6 by open tumor resection. No re-biopsy due to inconclusive histopathology prolonged diagnostic delay. Patients with a diagnostic waiting time of less than the median of 12 days survived significantly longer (149 vs 54 months, p=0.010). Progression-free survival also tended to be longer (15 vs 11 months, p=0.168). In a multivariate analysis, though, only Karnofsky performance status, renal function, and methotrexate-based chemotherapy in combination with autologous stem cell transplantation retained statistical significance.

### Conclusion

A good clinical performance status, renal function and an aggressive chemotherapeutic treatment are the main prognostic factors in patients with PCNSL.

# P114

## Die perkutane endoskopische Behandlung thorakaler Bandscheibenvorfälle: Die modifizierte "inside out" Technik allein oder in Kombination mit der "outside in" Vorgehensweise - Technische Aspekte und klinische Ergebnisse

***Percutaneous endoscopic treatment of thoracic disc herniation: The modified "inside out" technique alone or in combination with the "outside in" maneuver – Technical aspects and clinical results***

T. Lübbers[1], A. Schomaker[1]

[1]Klinikum Leer, Wirbelsäulenchirurgie, Leer, Deutschland

### Objective

Percutaneous endoscopic disc surgery evolved on two major surgical principles: Inside out and outside in. Higher rates of dural tears, increased mechanical stress on the myelon and higher bleeding complications are more frequently associated with the outside in procedure compared to the inside out surgery. Our goal: To apply a modified inside out maneuver in symptomatic thoracic disc herniation.

### Methods

Retrospective analysis of a prospective case control study. Either transforaminal or posterolateral access was used and in the latter approach the "foraminal retreat" maneuver was connected. An access optimized endoscopic system was introduced and burrs were used in case of a calcified disc prolapse. In all cases the surgery started with the inside out maneuver and in whom accurate approach to the disc herniation was impossible, we had to perform the outside in maneuver in addition.

### Results

In a cohort of 29 patients we surgically treated 16 female and 13male patients from Th5/6 to Th12/L1 (Abb.1).Overall 9 pat. showed calcification of the disc herniation and in 24 pat. the inside out maneuver was carried out alone (Abb.2), while in the remaining 5 pat. additional outside in procedure was necessary. VAS decreased from 8.4 to 2.9 and the satisfaction rate (MacNab) was 65% for excellent and good outcome at the latest follow- up after 27 month (2- 67 month). The complications: One pneumothorax, one spondylodiscitis (after inside out and outside in surgery),insufficient decompression in 2 pat. We did not detect any dural tear, neurological deterioration or recurrent herniation during the follow-up period.

### Conclusion

In our cohort more than 80% of hard or soft thoracic disc herniation could be treated in the modified inside out maneuver alone. This is a result of a detailed preop. individual planning, combined with the use of special scopes and instruments in a high sophisticated surgical procedure. However, the close relationship between the low complication rates of full-endoscopic spinal cases and surgical experience should always be kept in mind.

Abb. 1

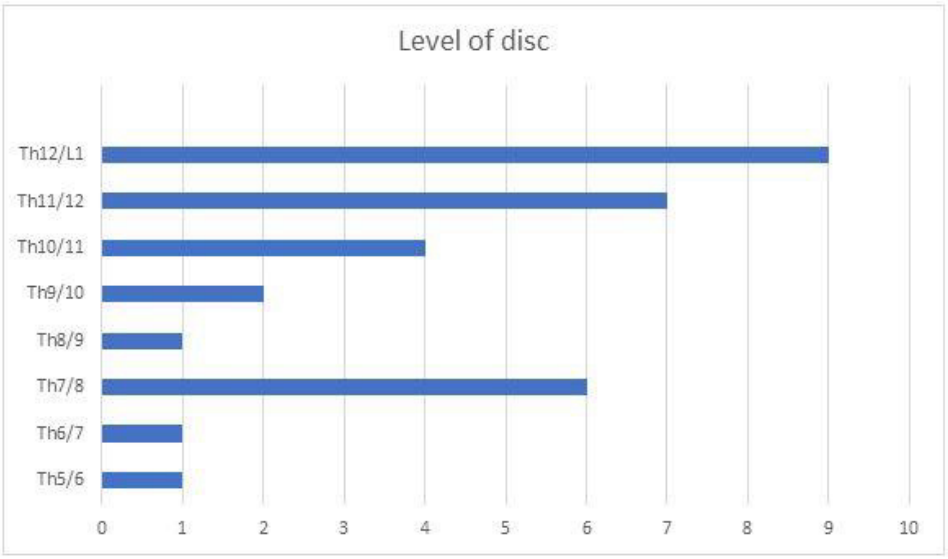



Abb. 2

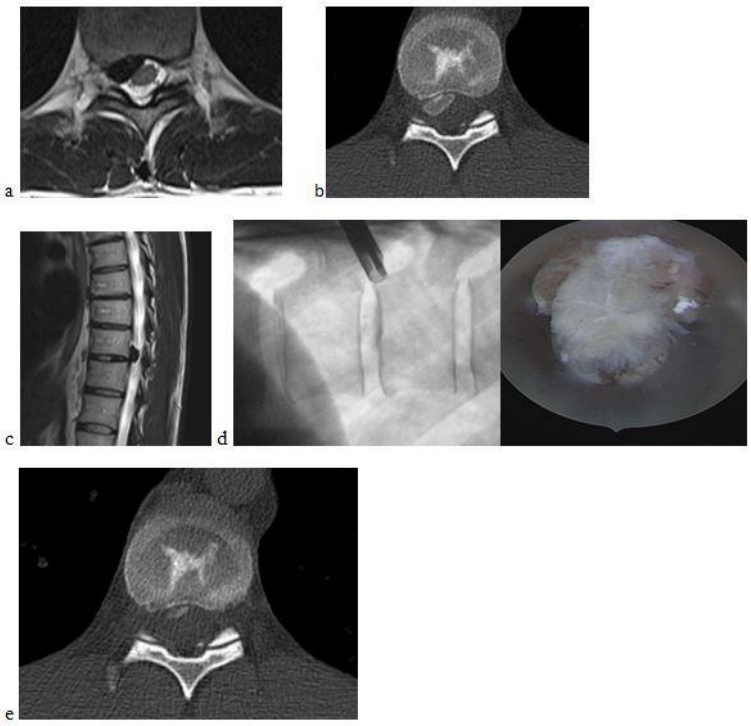



Abb.2: Centrolateral calcified disc hernation Th10/11 in a 39 year old male patient, (a) preop axial MRI, (b) axial CT scan and (c) sagittal MRI. (d) intraoperative exposure of the disc herniation in the foramen. (e) axial CT scan after the decompression

# P116

## Risikofaktoren einer Schraubenfehlplatzierung unter Verwendung einer iCT-bildgestützten Navigation: eine Serie von 1471 Schrauben

***Risk factors of screw misplacement by using intraoperative computed tomography image-guided navigation: A series of 1471 screws***

B. Stemmer[1], P. Baptist[1], S. Ertl[1], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Klinik für Neurochirurgie, Augsburg, Deutschland

### Objective

The aim of this study was to identify potential risk factors for screw misplacement after using an intraoperative computed tomography (iCT) guided navigation for Screw insertion.

### Methods

A retrospective analysis of all patients following iCT navigated spinal pedicle screw placement between October 2015 and March 2022 was performed. Navigated drilling of the pedicle was followed by screw placement (with and without via K-wire). Screw position was checked by a further iCT scan . Screw position was assesed according to the Gertzbein-Robbins classification and the rates of screws actually revised intraoperatively were calculated.

### Results

256 consecutive patients were identified (50,39% male, 49,61% female). A total of 1471 Screws were implanted. Median age was 67 years. The all-over revision rate was 4,49%. Screws were placed in all spinal regions. Degenerative spine disease was the most common diagnosis (43,44%). No significant differences in revision rates were found for gender and age. Lumbar spine (6,25%), thoracic spine (5,86%), tumor (6,40%) and infection (7,98%) diagnosis were associated with highest revision rate. We also found significantly increased revision rates for overweight (BMI 25 to 30) and obesity (BMI > 30) at 4,17% and 7,38%.

### Conclusion

The all-over revision rate was 4,49%. The highest revision rates were observed for tumor (6,40 %), infection patients (7,98 %), lumbar spine (6,25 %) and thoracic spine (5,86 %). Overweight and obesity also seems to be a significant risk factor for screw misplacement (BMI<25: 0,46%; BMI 25 to 30: 4,17%; BMI>30: 7,38%). None of the patients suffered from any neurovascular damage. No secondary operation to revise the misplaced screws was required.

# P117

## Radiologische Evaluation der anatomischen Möglichkeit zur Implantation von Pedikelschrauben im Bereich des kraniozervikalen Übergangs sowie der mittleren Halswirbelsäule

***Radiological evaluation of anatomical feasibility for pedicle screw implantation in the Cranio-cervical junction and middle cervical spine***

L. Weiser[1], L. Wübbeke[1], S. Höller[1], J. Roch[1], F. Klockner[1], K. Jäckle[1], W. Lehmann[1]

[1]Universitätsmedizin Göttingen, Klinik für Unfallchirurgie, Orthopädie und Plastische Chirurgie, Göttingen, Deutschland

### Objective

The presence of instabilities in the cranio-cervical junction, as well as in the upper and middle sections of the cervical spine, may potentially require dorsal spinal stabilization. The stability of the construct plays a crucial role in the success of the treatment outcome. In clinical practice, massa-lateralis screws are typically implanted both in the C1 region and in the middle cervical spine. The aim of this study was to determine the anatomical feasibility of placing pedicle screws in the C1 and middle cervical spine areas in order to assess the clinical relevance of this type of screw placement.

### Methods

In this retrospective data analysis, a total of 210 patients who underwent CT examination of the cervical spine at the University Medical Center Göttingen (UMG) were included. The pedicle height and width of the first cervical vertebra (Fig. 1) as well as the third to fifth cervical vertebrae were measured bilaterally and standardized. The primary endpoint was a pedicle height and width of more than 4 mm. Furthermore, gender- and age-specific differences in pedicle height and width were analyzed as secondary endpoints.

### Results

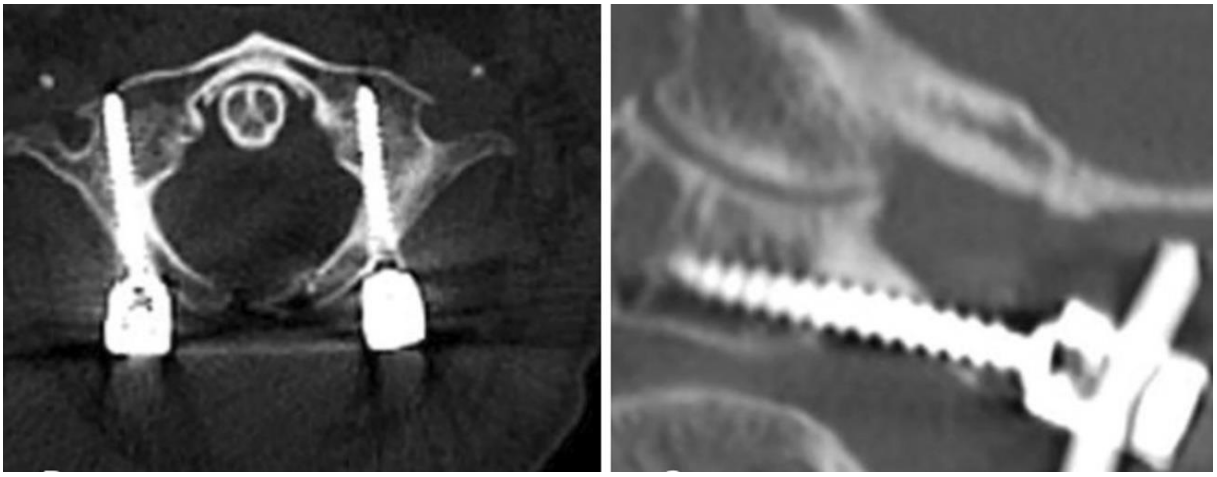
The pedicle height of the first cervical vertebral body was greater than 4 mm in 55.2% of patients on the right side (4.10 mm ± 0.94) and in 46.7% on the left side (3.91 mm ± 0.97). For the third to fifth cervical vertebral bodies, in most patients (77.1% to 100%), both the pedicle height and width were greater than 4 mm. A significant gender difference was observed in terms of the pedicle height of the first cervical vertebral body, as in female patients, the required pedicle height of more than 4 mm was achieved only in 39.5% and 29.1% of cases, respectively. No age-specific differences were found.

### Conclusion

The results suggest that the pedicle height of the first cervical vertebral body is sufficiently large in about half of the cases to place a biomechanically more stable pedicle screw with a lower risk of bleeding (Fig. 2). In the area of the middle cervical spine, instrumentation using pedicle screws can be performed in most patients, although not all pedicles can always be instrumented with a traditional pedicle screw.

Abb. 1


Abb. 2



# P118

## C1-Ringosteosynthese als sichere und effektive Behandlungsmethode bei C1-Frakturen.
## *C1-Ring Osteosynthesis as a safe and effective method for C1 fractures*

M. Goldberg[1], F. Bader[2], M. Wostrack[1], B. Meyer[1], N. Lange[1]

[1]Department of Neurosurgery, School of Medicine, Klinikum rechts der Isar, Technical University Munich, München, Deutschland
[2]School of Dentistry, Ludwig-Maximilian University of Munich, München, Deutschland

### Objective

C1 fractures are traditionally treated with C1–2 fixation and fusion because they are thought to provide a better level of stability. However, this surgical treatment is associated with a reduced range of motion. C1 ring osteosynthesis is an alternative technique that provides adequate fracture healing while preserving the range of motion. We aimed to describe the clinical and radiological outcomes of patients with C1 fractures treated with C1 osteosynthesis.

### Methods

This retrospective single-center study included all patients with C1 fractures who underwent C1-ring osteosynthesis surgery during 2007–2023. Lateral mass displacement (LMD), atlantodental interval (ADI), hospital stay, surgical duration, and surgical complications were analyzed.

### Results

38 patients were identified. 30 patients received C1 ringosetheosynthesis alone, 8 cases were in association with polytrauma and multiple surgeries including other spondylodesis in cervical spine (17 female, 21 male, age 57.3 ± 23.7). 3 patients had Gehweiler type 1 fracture, 25 Gehweiler type 3, 10 Gehweiler type 4. The mean operation time was 94 ± 17 min. Mean hospital stay was 18.2 ±7.6. Injury of the vertebral artery was documented during 4 surgeries (10%); screw malposition requiring revision was observed in 1 patient (3%) and pulmonary embolism in 1 patient (1%). There was no neurological deterioration after surgery (0%). All patients reported relief of pain shortly after surgery. ADI was significantly reduced after surgery (2.1 ± 1.2 vs 1.45 ± 1.0 p= 0.002674). LMD bilateral as well as unilateral was significantly reduced as well (LMD bilateral 5.5 ± 2.5 vs 4.2 ± 2.6 p=0.045909, LMD unilateral 3.6 ± 1.6 vs 2.5 ± 1.4, p=0.000063).

### Conclusion

Based on this analysis, C1 ring osteosynthesis is a safe and feasible procedure for treating C1 fractures. Radiographic and clinical parameters were significantly improved, while complication rates were comparable to those of other methods.

# P119

## Vom Abstract zur Veröffentlichung in einem PubMed-gelisteten Journal: Auswertung der vergangenen Jahrestagungen der Deutschen Wirbelsäulengesellschaft (DWG) 2017, 2018, 2019 und 2022

***From abstract to publication in a PubMed-indexed journal: Evaluation of the German Spine Society's (DWG) past annual meetings 2017, 2018, 2019 and 2022***

J. On[1], T. Pantel[1], S. Häckel[2,3], V. Hubertus[2], S. Ille[4], M. Kalbitz[5], J. Keller[6], J. H. Klingler[7], J. S. Onken[2], H. Schmidt[8], A. Younsi[4], S. Zwingenberger[9], P. Vajkoczy[2], M. Mohme[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik für Neurochirurgie, Hamburg, Deutschland
[2]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[3]Universitätsspital Basel, Klinik für Orthopädische Chirurgie und Traumatologie, Basel, Schweiz
[4]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[5]Universitätsklinikum Erlangen, Klinik für Unfallchirurgie und Orthopädie, Erlangen, Deutschland
[6]Universitätsklinikum Hamburg-Eppendorf, Klinik für Unfallchirurgie und Orthopädie, Hamburg, Deutschland
[7]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[8]Charité – Universitätsmedizin Berlin, Julius Wolff Institute, Berlin, Deutschland
[9]Universitätsklinikum Carl Gustav Carus Dresden, Dresden, Deutschland

### Objective

The discussion of the latest academic findings in the context of scientific presentations is the central purpose of the annual meeting of the German Spine Society (DWG). This study aimed to assess the publication rate of abstracts presented at DWG annual meetings from 2017 to 2019 and in 2022 in peer-reviewed, Pubmed-indexed journals. Additionally, it sought to identify factors contributing to higher publication rates.

### Methods

We reviewed all accepted oral and poster presentations of the DWG meetings (2017-2019 and 2022). Subsequently, we performed a PubMed database query to determine the publication rate until 12/2023. We analyzed the time to publication, type of research (retro- vs. prospective; clinical vs experimental) and the area of research to analyze the current landscape of spine research in the DWG.

### Results

A total of 729 scientific abstracts were presented at the four annual conferences analyzed. The overall publication rate was 34.8% (n=254): 27.1% (2017), 46.2% (2018), 35.4% (2019) and 30.0% (2022). In 8.5% (n=62), articles were already published before the congress presentation, otherwise the average time to publication was 36.6 months. Basic research and experimental studies represented 19.3% of abstracts, with a publication rate of 37.4%. The following research fields were represented as following: spinal cord injury (24.7% of abstracts), biomechanics (13.1%), spinal oncology (7.5%) and bone & cartilage (3.8%). Overall, 70.6% of abstracts were clinical studies.

### Conclusion

The 34.8% publication rate of abstracts at the reviewed DWG annual meetings in PubMed-indexed journals not only underscores the scholarly impact of the submissions and the conference but also highlights areas for further advancement in the scientific scope of the DWG.

# Spinal – Verschiedenes 2 | Spinal – Various 2

## P120

### Risikobewertung der Wundinfektion bei der posterioren zervikalen Dekompression: Die Rolle der lokalen Fettdicke

***Assessing surgical site infection risks in posterior cervical decompression: The role of local fat thickness***

J. Farzullayev[1], B. Younes[1], D. Mielke[1], V. Rohde[1], A. Tammam[1]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland

#### Objective

Background: Local subcutaneous fat thickness has been identified as a significant predictor for the risk of surgical site infection (SSI) in lumbar spine procedures. Emerging research suggests its potential relevance in posterior cervical spine surgery as well. This study aims to further explore the connection, focusing on the comparative impact of Body Mass Index (BMI) and localized fat thickness at the C5 level on the risk of SSIs.

#### Methods

Methods: This study undertakes a detailed retrospective review of patients undergoing posterior cervical decompression from 2015 to 2021. Exclusions were made for minors and individuals who received posterior cervical instrumentation. Measurements of localized nuchal and fat thickness at the C5 level were taken. Patient charts provided data on demographics, BMI, diabetic status, smoking history, previous surgical history, the extent of surgery (number of operated levels), and duration of hospital stay. A combination of univariate and multivariate analysis was employed to identify significant predictors of SSIs.

#### Results

Results: From the 346 patients who qualified for the study, 20 (5.8%) experienced SSIs. Those with SSIs generally had higher BMIs (median 29 vs. 27, p=0.032), greater nuchal fat thickness (median 27mm vs. 23mm, p=0.012), and more extensive surgeries (75% had multiple levels operated compared to 55% in the non-SSI cohort, p=0.006). Additionally, occurrence of SSI resulted in a prolonged hospital stay (median 12 days vs. 7 days, p≤0.001). However, in multivariate logistic regression, nuchal fat thickness was not a significant predictor, whereas BMI and the number of operated levels were confirmed as substantial predictors of SSI (OR=1.095, CI: 1.005 to 1.192, p= 0.038 and OR=2.089, CI: 1.3 to 3.357, p= 0.002 respectively).

#### Conclusion

Conclusion: This research indicates that contrary to initial assumptions, localized fat thickness at the C5 level is not a significant predictive factor for SSI post posterior cervical decompression. Instead, it underscores the importance of BMI and the extent of surgical intervention as considerable, quantifiable risk factors for SSIs. These findings can guide more effective preoperative assessments and targeted interventions to mitigate SSI risks in posterior cervical decompression surgeries.

# P121

## Die Verwendung Iodophor-beschichteter Inzisionsfolien veringert die Rate an postoperativen Wundinfekten nach Wirbelsäulenoperationen: eine Untersuchung von 2279 Patienten

***Iodophor-impregnated adhesive incision draping reduces the rate of surgical side infection in spine surgery: Study in 2279 patients***

A. Gencer[1], C. Schichor[1], J. Tonn[1], S. Siller[1,2]

[1]LMU University Hospital of the Ludwig-Maximilians-University Munich, Neurosurgical Clinic, München, Deutschland
[2]University Hospital Regensburg, Neurosurgical Clinic, Regensburg, Deutschland

### Objective

Surgical site infection (SSI) is a potentially devastating complication of spine surgery. While iodine-impregnated adhesive incise drapes are widely used during surgeries for reducing surgical site contamination, evidence is still scarce if this can reduce the rate of SSI in spine surgery.

### Methods

All patients who had been surgically treated in our high-volume tertiary-care neurosurgical university spine center between January 2018 and December 2021 were retrospectively evaluated and devided into a cohort treated before ("control cohort") and after ("study cohort") introduction of iodophor-impregnated adhesive incision drapes in our institute. Epidemiological aspects, baseline characteristics, operative records and rate/characteristics of postoperative SSI were analyzed and compared between both cohorts.

### Results

A total of 2279 patients were included with a mean age of 60 years and a slight predomination of the male gender (male/female: 1.2/1). Baseline patients" findings as well as surgical characteristics including indication, localization, procedure and duration of surgery did not significantly differ between the 1125 patients of the "control cohort" and the 1154 patients of the "study cohort". The rate for SSI was 0.5% (11/2279) in the overall cohort with a predomination of early postoperative SSI involving the deeper wound layers. Uni- and multivariate analysis showed that the use of a iodophor-impregnated adhesive incision drape (compared to no adhesive drape) was the only factor significantly associated with a lower risk of postoperative SSI. The rate of SSI was indeeded significantly lower in the "study cohort" with use of iodophor-impregnated adhesive incision drapes compared to the "control cohort" without use of incision drapes (0.2% vs. 0.8%; p=0.036). While germs of the skin microbiome (like *Staphylococcus epidermidis* or *aureus*) were predominantly prevalent in both cohorts, faecal germs (like *Enterococcus species* or *Enterobacter cloacae)* were only found in the "control cohort" and not in the "study cohort" using iodophor-impregnated adhesive incision drapes.

### Conclusion

The use of iodophor-impregnated adhesive incision drapes in spine surgery can help to lower the rate of postoperative SSI and aid to reduce the risk for faecal germ infections.

# P122

## Oberflächliche Wundinfekte nach intrakutaner Hautnaht und Klammernaht bei nicht instrumentierten spinalen Eingriffen: eine multizentrische, randomisierte, prospektive Studie

***Wound healing after intracutaneous vs. staple-assisted skin closure in lumbar, non-instrumented spine surgery: A multicenter prospective randomized trial***

A. Romagna[1], J. Lehmberg[1], C. J. Griessenauer[2], E. Shiban[3], A. Rezai[2], C. Schwartz[2]

[1]München Klinik Bogenhausen, Neurochirurgie, München, Deutschland
[2]Paracelsus Medizinische Privatuniversität (PMU), Neurochirurgie, Salzburg, Österreich
[3]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland

### Objective

Superficial surgical site infection (SSSI) is a major problem in spine surgery. Intracutaneous sutures and staple-assisted closure are two widely used surgical techniques for skin closure. Yet, their comparative impact on wound healing and infection rates is underexplored. Our goal was to address this gap and compare wound healing between these two techniques.

### Methods

This study was a multicenter international prospective randomized trial. Patient data were prospectively collected at three large academic centers, patients who underwent non-instrumented lumbar primary spine surgery were included. Patients were intraoperatively randomized to either intracutaneous suture or staple-assisted closure cohorts. The primary endpoint was SSSI within 30 days after surgery according to the wound infection Centers for Disease Control and Prevention (CDC) classification system.

### Results

Of 207 patients, 110 were randomized to intracutaneous sutures and 97 to staple-assisted closure. Both groups were homogenous with respect to epidemiological as well as surgical parameters. Two patients (one of each group) suffered from an A1 wound infection at the 30-day follow up. Median skin closure time was faster in the staple-assisted closure group (198 minutes vs. 13 seconds, $p<0{,}001$).

### Conclusion

This study showed an overall low superficial surgical site infection rate in both patient cohorts in primary non instrumented spine surgery.

# P123

## Atlantoaxiale Instabilität im Zeitalter der degenerativen Arthrosen: operatives Vorgehen und klinischer Outcome in 36 Patienten

***Atlantoaxial instability in the era of non-inflammatory degenerative arthrosis: Surgical strategy and clinical outcome in 36 patients***

R. Liang[1], B. Meyer[1], V. M. Butenschön[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland

### Objective

While rheumatoid arthritis is a well-recognized cause of C1-2 instability, more recent research shows that instability can arise from severe degenerative arthrosis, independent of any autoimmune or inflammatory influences. Therefore, this study aims to analyze the surgical approach and clinical outcome in patients with atlantoaxial instability attributed to non-inflammatory degenerative arthrosis.

### Methods

A retrospective review was conducted on patients who underwent C1-2 stabilization for symptoms and radiographical signs of C1-2 instability with retrodental pannus strictly of degenerative origin in our neurosurgical department from January 2012 to December 2021. Radiological parameters, surgical details, and clinical follow-up data were analyzed.

### Results

Among 36 included patients (mean age: 72 years), C1-2 fixation was performed. In 61% of cases, C1 laminectomy for myelopathy symptoms were performed. The median mJOA score improved from 14/18 preoperatively to 15/18 post-surgery and 16/18 at a median 3-month follow-up. Clinically, 71% showed improvement, 29% remained stable, and 9.7% deteriorated. The mean preoperative atlantodental distance was 2mm. The overall complication rate was 8.6%, with minor incidents like asymptomatic vertebral artery injuries and one case of CSF leakage.

### Conclusion

Surgical intervention for C1-C2 fixation yielded favorable outcomes in non-inflammatory atlantoaxial instability cases, showcasing notable improvements in neck pain and myelopathy symptoms.

# P124

## Unterschiedliche Behandlungsstrategien bei pyogener Spondylodiszitis: Eine Umfrage der EANS-Sektion Wirbelsäule zeigt heterogene Therapieansätze auf

***Variability in treatment strategies for spinal infections: A survey of the EANS Spine Section revealing heterogeneous therapeutic approaches***

A. Kramer[1], S. G. Thavarajasingam[1], J. Neuhoff[2], B. Davies[3], A. Demetriades[4], E. Shiban[5], F. Ringel[1]

[1]Universitätsmedizin Mainz, Klinik mit Poliklinik für Neurochirurgie, Mainz, Deutschland
[2]Berufsgenossenschaftliche Unfallklinik Frankfurt am Main, Wirbelsäulenchirurgie und Neurotraumatologie, Frankfurt a. M., Deutschland
[3]Cambridge University Hospital, Department of Academic Neurosurgery, Cambridge, Vereinigtes Königreich
[4]Edinburgh University Hospitals, Department of Neurosurgery, Edinburgh, Vereinigtes Königreich
[5]Universitätsklinikum Augsburg, Neurochirurgie, Augsburg, Deutschland

### Objective

Spondylodiscitis cases are increasing in Europe, with no clear consensus on the best treatment method. This study aims to investigate the current treatment preferences for primary spondylodiscitis across Europe.

### Methods

An online survey, circulated via the EANS Spine Section, presented seven case vignettes of spondylodiscitis to spinal neurosurgeons. The survey included general management questions and specific treatment scenarios. Analysis was conducted using R (version 4.0.4), with the Index of Qualitative Variability (IQV) used to measure response variability.

### Results

Of the 130 respondents, 86.9% were board-certified and 13.1% were neurosurgeons in training, averaging 11 years in practice. Most conducted 50-100 spinal surgeries yearly, with 66.7% specializing in this area. Factors like pronounced neurological deficits due to epidural empyema (95.4%), mild neurological deficits (72.3%), and difficulty identifying pathogens (80%) swayed many towards surgery. Conversely, vertebral deformities prompted 60%-66.2% towards surgery, whereas age and comorbidities had minimal influence (5.4% and 9.2%, respectively). Case vignettes showed a general preference for conservative treatment, with significant statistical backing ($p<0.05$). IQV values ranged from 0.88 to 0.99, indicating low consensus across questions. Notably, the average IQV varied greatly by country (0.15 – 0.85).

### Conclusion

The study uncovers notable variability in spondylodiscitis treatment approaches among European neurosurgeons, with a general inclination towards conservative treatment. The varied strategies within and between countries underscore the need for evidence-based guidelines and consensus in managing this serious condition.

Abb. 1

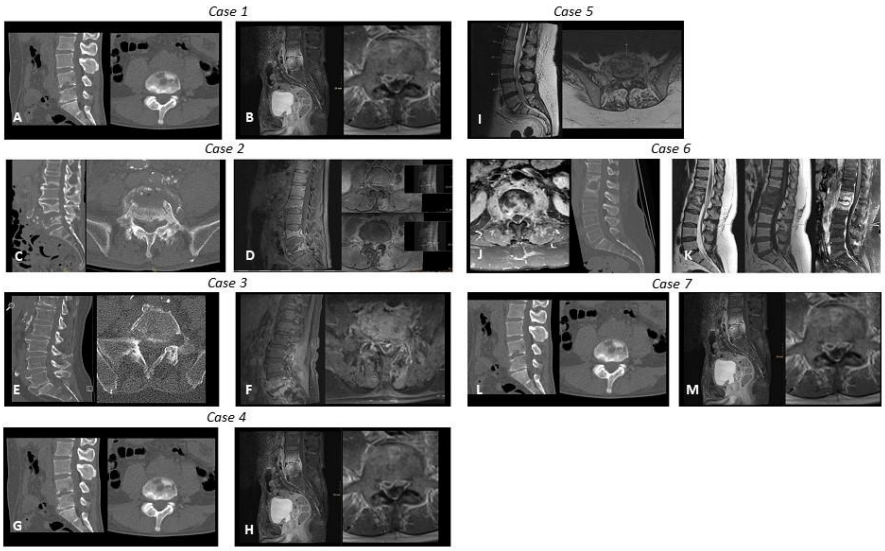

Case 1
Case 5
Case 2
Case 6
Case 3
Case 7
Case 4
A
B
I
C
D
J
K
E
F
L
M
G
H

Abb. 2


How long would you treat with antibiotics, presuming a good response in case 1?
How would you monitor treatment response of case 1? (more than one option possible)
How long would you treat with antibiotics, presuming a good response in case 2?
How would you monitor treatment response of case 1? (more than one option possible)
How long would you treat with antibiotics, presuming a good response in case 5?
How long would you treat with antibiotics, presuming a good response in case 6?
How would you monitor treatment response in case 2? (more than one option possible)
How long would you treat with antibiotics, presuming a good response in case 5?

# P125

## Biomechanische Stabilität nach vorderer zervikaler Korpektomie und Fusion – Risikofaktoren für Senkung.
## *Biomechanical stability after anterior cervical corpectomy and fusion – Risk factors for case subsidence*

A. Togyzbayeva[1], S. B. Bingöl[1], O. Gembruch[1], M. Darkwah Oppong[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

### Objective

Anterior cervical corpectomy and fusion (ACCF) using cage placement and anterior plating is a surgical technique aiming for long-term biomechanical stability of the cervical spine in various clinical situations. In this retrospective study, we analyzed rate and risk factors for cage subsidence after ACCF.

### Methods

Patients who underwent ACCF at our institution from August 2008 to April 2023 were enrolled in the study. The researchers analyzed the baseline demographic, clinical, and radiographic characteristics of these individuals, as well as the follow-up imaging data, in order to identify cases of cage subsidence during the postoperative period. Statistical analyses were conducted to further analyze the collected data.

### Results

Cage subsidence was observed in 5 out of 99 individuals (5.1%) included in the final cohort. These individuals had different diagnoses, including degenerative processes (n=48), trauma (n=21), infections (n=18), and tumors (n=12). The risk of cage subsidence increased as the number of removed vertebral bodies increased (1.5%, 11.1%, and 20% for 1, 2, and 3 levels respectively, p=0.031). The level of the lower index vertebra was significantly associated with cage subsidence (C3-C5: 0%, C6: 8.6%, C7: 9.1%, Th1: 50%, p=0.01). Interestingly, there were no cases of cage subsidence among individuals with bicortically positioned plating screws (0% vs 5.8%). The patients' baseline characteristics, as well as the material, size, and position of the cage used, did not have any impact on the occurrence of cage subsidence in the postoperative course.

### Conclusion

ACCF ensures biomechanical stability in the majority of patients who require this surgery. Specifically, patients who undergo multi-level corpectomy and those with lower cervical spine involvement are more susceptible to cage subsidence. Therefore, it is necessary to conduct long-term radiographic surveillance for these patients. In certain cases, early posterior stabilization may be warranted.

# P126

## Spontane spinale Blutungen: Eine Fallserie
*Spontaneous spinal hematoma: A case series*

C. Albrecht[1], T. Boekh-Behrens[2], M. Wostrack[1], B. Meyer[1], A. K. Jörger[1]

[1]Klinikum rechts der Isar, Technische Universität München, Neurochirurgie, München, Deutschland
[2]Klinikum rechts der Isar, Technische Universität München, Neuroradiologie, München, Deutschland

### Objective

Spontaneous spinal hematoma is a rare yet severe neurological disorder requiring immediate diagnostic evaluation and intervention to prevent enduring neurological deficits. This case series analyzes cases of spontaneous spinal hematoma, especially focusing on cases where vascular causes were identified despite initial inconclusive imaging.

### Methods

We conducted a retrospective study of 20 consecutive patients treated for spontaneous spinal hematoma at a Level I spine center between 01/01/2017 and 11/15/2023. Data included demographics, clinical presentation, imaging, and treatment details. Traumatic spinal hematomas were excluded. Additionally, we present three cases of spontaneous spinal hematoma attributed to diverse vascular pathologies.

### Results

Median age of all patients was 66 (range 39 - 85) years. 9 (45%) were male, 11 (55%) were female. Of 20 cases, 14 were epidural hematomas, 4 subdural, 1 combined epidural and subdural and 1 subarachnoid hemorrhage. 17 patients (85%) presented with a neurological deficit, while 3 patients experienced symptoms solely related to pain. Of the total cohort, 11 (55%) patients were under anticoagulant medication. Vascular anomalies were identified in 5 (25%) cases. In 4 (20%) cases the cause of the spinal hemorrhage remained unclear. MRI was performed for all patients, while DSA was conducted in 5 (25%) cases. 18 patients were treated surgically, while 2 patients were treated conservatively, due to the absence of neurological deficits and spontaneous regression of the epidural hematoma. Postoperatively, 13 (65%) patients showed improvement in their neurological function, 4 (20%) maintained their level, and only 3 (15%) experienced deterioration. The three cases outlined involve individuals with distinct vascular malformations, including two arteriovenous fistulas and one spinal hemangioblastoma, all managed through surgical intervention. Each patient underwent at least one DSA to identify the pathological anomaly.

### Conclusion

Spontaneous spinal hematomas demand urgent attention due to their potential for lasting neurological consequences. The study underscores the significance of thorough diagnostics and surgical exploration, especially in cases with unclear etiology, to identify and address vascular causes, preventing hematoma progression or recurrence. Special attention is dedicated to vascular malformations as contributors to spinal hematomas. Although these causes are exceptionally rare, they should consistently be taken into consideration.

# P127

## Auswirkungen des Sklerostin-Antikörpers Romosozumab auf das Gehirn in einem Osteoporosemodell in Ratten
*Effects of the sclerostin antibody romosozumab on the brain in the osteoporotic rat model*

S. Sperling[1], M. Komrakova[1], K. O. Böker[1], D. Hoffmann[1], M. Ninkovic[1], V. Rohde[1]

[1]Universitätsmedizin Göttingen, Göttingen, Göttingen, Deutschland

### Objective

Sclerostin is a secreted glycoprotein predominantly expressed by mature osteocytes. It acts as a negative regulator of Wnt signalling and bone formation in the human body. Although the primary role of sclerostin is to regulate bone mass through paracrine action, recent studies have suggested that sclerostin has effects on non-skeletal tissues. Sclerostin has been implicated in the pathogenesis of several neurodegenerative diseases. Romosozumab (ROMO) is a humanised monoclonal antibody that inhibits sclerostin, resulting in increased bone formation. Here we investigate the effect of ROMO on the expression of Wnt-related genes in the brain.

### Methods

At the age of 6 months, female Sprague Dawley rats were bilaterally ovariectomised (OVX) or SHAM ovariectomised (SHAM). 8 weeks after the operations, the OVX animals were treated with either ROMO (Evenity®, s.c, 25 mg/kg, 1x pro week), whole body vibration (VIB; 35 Hz, 2x/day, for 15 min) or a combination therapy ROMO+VIB. Control groups received as vehicle water for injections. The expression of the following genes in the brain, in relation to the housekeeper GAPDH, was examined by quantitative PCR: Wnt1, Wnt2, LRP5 and Cnntb1. Western blot of analysis for total ß-catenin was performed.

### Results

The upregulation of LRP5 ($p<0.0001$) and Wnt1 ($p<0.05$) was detected in OVX+ROMO+VIB treatment group when compared with OVX. The downregulation of Wnt2 ($p<0.0001$) and upregulation of Cnntb1 ($p<0.001$) was detected in OVX+ROMO comparing to OVX. The significant differences were detected in gene expression for all analysed genes between different treatment groups. Western blot analysis of ß-catenin protein in the brain showed significant difference between control group compared to all treatment groups, as well as between some treatment groups.

### Conclusion

Romosozumab, used to increase bone formation in postmenopausal women, affected the expression of genes/proteins related to Wnt signalling in the rat brain. If these changes are of functional relevance, either positive or negative (e.g. neurodegeneration), the effect of this antibody should be investigated using behavioural tests.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P128

### Eine Evidenzbewertung der Überwachung motorisch evozierter Potenziale zur Vermeidung mechanischer und vaskulärer Verletzungen während der Resektion von Hirntumoren

***An evidence assessment of motor evoked potential monitoring to prevent mechanical and vascular injuries during brain tumor resection***

P. Alvarez-Abut[1], E. Asimakidou[1], A. Raabe[1], K. Seidel[1]

[1]Inselspital – Universitätsspital Bern, Neurosurgery, Bern, Schweiz

#### Objective

During brain tumor surgeries, postoperative motor deficits can be caused by different mechanisms of injury, such as direct resection into motor eloquent structures (mechanical injury, M), vascular injury (V), or supplementary motor area syndrome (SMA). Motor evoked potentials (MEP) serve as a guide for the surgeon to monitor the integrity of motor eloquent tissue during the resection. Reversing MEP changes may avoid permanent motor deficits. We aim to evaluate the prognostic and preventive value of MEP to avoid postoperative permanent motor deficits (PMD), in regards to the mechanism of injury.

#### Methods

In our previous scoping review of MEP warning criteria in supratentorial surgeries (Asimakidou, 2021), we included all studies with pre-defined MEP alarm criteria and report of motor outcome. For the present subgroup analysis, we extracted all studies of supratentorial mass lesions with defined etiological pattern of MEP alteration or new postoperative motor deficits.

We compared the relative amount of reversible and irreversible MEP alterations in patients with and without postoperative permanent motor deficits. To understand which patients might have been saved by an MEP alarm given to the surgeon, we also compared the relative amount of reversible MEP alterations between the different patterns of injury in the no-PMD group (no or transient deficits).

#### Results

Of 68 papers, 21 were eligible describing 2078 surgeries with monitorable MEP. There were 391 motor deficits, 190 of which had description of the injury pattern. Of the injuries with known etiology, 47% were M, 39% were V and 14% due to SMA.

**Irreversible MEP alterations** were reported in 15% of the cases in the no-PMD group versus **77% in the PMD group** (P<0.001; OR 0.05, CI 95% 0.03-0.1, Fig 1). **Reversible MEP alterations** were described in **34% of the cases in the no-PMD group** versus 14% for the PMD group (P<0.001; OR 3.16, CI 95% 1.57-6.36, Fig 1). Among the potentially saved cases with no-PMD, 25% of the M injuries and **73 % of the V injuries presented reversible MEP alterations** (P<0.001; OR 8.1, CI 95% 3.10-21.14, Fig 2).

#### Conclusion

The significantly higher amount of reversible MEP alterations during vascular events in tumor surgeries in the no-PMD group demonstrates that by reversing MEP alterations permanent motor deficits cannot only be predicted but also prevented.

For mechanical injuries, MEP monitoring can mostly only predict permanent deficits and thus continuous dynamic mapping might be a valuable adjunct.

Abb. 1

| | No permanent motor deficit | Permanent motor deficit |
|---|---|---|
| **Stable MEP** | 59 (50.4%) | 8 (8.7%) |
| **Reversible MEP alteration** | **40 (34.2%)** | 13 (14.1%) |
| **Irreversible MEP alteration** | 18 (15.4%) | 71 (77.2%) |

**Figure 1. Motor evoked potential behaviour in cases without permanent motor deficit versus permanent motor deficit.** ***MEP:*** motor evoked potential.

Abb. 2

| | No permanent motor deficit | |
|---|---|---|
| | **Mechanical injury** | **Vascular injury** |
| **Stable MEP** | 28 (53.8%) | 3 (8.1%) |
| **Reversible MEP alteration** | 13 (25.0%) | **27 (73.0%)** |
| **Irreversible MEP alteration** | 11 (21.2%) | 7 (18.9%) |

**Figure 2. Motor evoked potential behaviour in cases without permanent motor deficit in regard to vascular or mechanical mechanism of motor injury.** ***MEP:*** motor evoked potential.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P129

### MRT-basiertes Risiko Assessment für das Schlaganfallrisiko bei Moyamoya Patienten (MARS-MA): Ein MRt-basiertes Scoring System für die Schwere der Moyamoya Krankheit

***MRI based Assessment of Risk for Stroke in Moyamoya Angiopathy (MARS-MA): An MRI-based scoring system for the severity of Moyamoya Angiopathy***

C. Roder[1,2], P. Haas[1,2], T. K. Hauser[3], M. Philipp Tobias[4], B. Ganna[4], M. Tatagiba[1,2], N. Khan[1,2,5], L. Zerweck[3]

[1]Universitätsklinikum Tübingen, Neurochirurgie, Tübingen, Deutschland
[2]Universitätsklinikum Tübingen, Zentrum für Moyamoya und Bypasschirurgie, Tübingen, Deutschland
[3]Universitätsklinikum Tübingen, Neuoradiologie, Tübingen, Deutschland
[4]Universitätsklinikum Freiburg, Nuklearmedizin, Freiburg i. Br., Deutschland
[5]Universitätskinderspital Zürich, Moyamoya Zentrum, Zürich, Schweiz

#### Objective

Before potential revascularization, Moyamoya patients require hemodynamic evaluation. In this study we validated the scoring system *Prior Infarcts, Reactivity and Angiography in Moyamoya Disease* (PRIAMID), respective the capability to predict neurological symptomatology. We further outlined a new scoring system *MRI based Assessment of Risk for Stroke in Moyamoya Angiopathy* (MARS-MA) and compared the scoring systems with respect to the capability to predict impaired [15O]water PET cerebral perfusion reserve capacity (CPR).

#### Methods

We evaluated 69 structural and 69 breath-hold functional MRI (bh-fMRI) data sets, 69 DSA data sets and 38 [15O]water PET data sets of Moyamoya patients. The PIRAMID system was validated in the territories of the internal carotid arteries and the anterior and middle cerebral arteries by receiver operating characteristic (ROC) curve analysis with neurological symptomatology as dependent variable. The components of the MARS-MA system and their weightings were determined by binary logistic regression analysis. Comparison of PIRAMID and MARS-MA and MARS-MA grade stratification were performed by ROC curve analysis with CPR as dependent variable.

#### Results

The PIRAMID score correlated well with symptomatology (area under the curve (AUC) = 0.749/0.784). The MARS-MA system consisting of impaired bh-fMRI, the presence of an Ivy sign and of arterial wall contrast enhancement correlated slightly better with CPR impairment than the PIRAMID system (AUC = 0.861 vs. 0.826, Akaike information criterion 140 vs. 146). We determined three grades with low, intermediate and high risk of impaired hemodynamics and therefore possible stroke (AUC = 0.860).

#### Conclusion

The entirely MRI-based MARS-MA scoring system might be a promising tool to predict impaired hemodynamics and therefore possible stroke.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P130

### Verbesserte Prädiktion der intrahospitalen Mortalität durch eine Kombination des ICH-Scores mit der CRP-/Albumin-Ratio bei Patienten mit spontaner intrazerebraler Blutung

***Improved prediction of intrahospital mortality by combining the ICH score with the CRP/albumin ratio in patients with spontaneous intracerebral haemorrhage***

K. Haferkorn[1], M. Bender[1], E. Uhl[1], M. Stein[1]

[1]Universitätskliniken Gießen und Marburg, Klinik für Neurochirurgie, Gießen, Deutschland

#### Objective

There is growing evidence that an increased C-reactive protein (CRP)/albumin ratio is associated with a higher risk of intrahospital mortality in patients with spontaneous intracerebral hemorrhage (sICH). The purpose of this study was to test whether the combination of the CRP/albumin-ratio and the ICH score (ICH-CRP/Alb score) could improve the prediction of compared to the established ICH score alone.

#### Methods

In this retrospective study, 379 patients with sICH between 02/2008 and 12/2017 were included. Blood samples were collected on admission and patients' demographic, medical and radiologic data were collected. The ICH score on admission was then assessed with an additional point if the CRP/albumin ratio was > 1.22. For a detailed evaluation, subgroups of patients with GCS ≤ 8 and for patients with intraventricular hemorrhage (IVH) were analyzed.

#### Results

The ROC analysis of the ICH score combined with a CRP/albumin ratio showed a higher AUC (AUC: 0.776, cut-off: ≥ 3, sensitivity: 0.907, specificity: 0.498, Youden index: 0.409) than the ICH score alone (AUC: 0.761, cut-off: ≥ 3, sensitivity: 0.881, specificity: 0.479, Youden index: 0.402). For patients with an initial GCS ≤8 (n=169) an improved prediction of intrahospital mortality for the ICH-CRP/Alb score (AUC: 0.719, cut-off ICH score ≥3, sensitivity 0.706, specificity 0.322, Youden index: 0.384) compared to the ICH score (AUC: 0. 672; cut-off ICH score ≥ 3, sensitivity: 0.588, specificity: 0.309, Youden index 0.279) was observed. For patients with IVH (n=269) the ICH-CRP/Alb score (AUC: 0.774, cut-off ICH score ≥ 4, sensitivity 0.687, specificity 0.271, Youden index 0.416) was also superior to the ICH score (AUC: 0.747, cut-off ICH score ≥ 4, sensitivity 0.596, specificity 0.235, Youden index 0.361).

#### Conclusion

The ICH score in combination with the CRP/albumin ratio showed an improvement in the prediction in the of intrahospital mortality compared to the original ICH score. The highest benefit in the prediction of intrahospital mortality was found in critically ill patients with IVH or low GCS.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P131

### Integration der dekompressiven Kraniotomie in die Standardbehandlung bei spontaner supratentorieller intrazerebraler Blutung: Eine systematische Übersichtsarbeit und Meta-Analyse

***Integrating decompressive craniectomy into standard treatment for spontaneous supratentorial intracerebral hemorrhage: A systematic review and meta-analysis***

A. Mulhem[1,2], A. Jaiswal[2], A. A. Alsuliman[1], K. L. Yaxley[2], S. Hammersen[1], S. R. Kantelhardt[1]

[1]Vivantes Klinikum im Friedrichshain, Neurochirurgie, Berlin, Deutschland
[2]University of Oxford, Department for Continuing Education, Oxford, Vereinigtes Königreich

#### Objective

The termination of the SWITCH trial investigating decompressive craniectomy's (DC) role in spontaneous supratentorial intracerebral hemorrhage (sICH) without published results has left the question of whether augmenting standard treatment (inclusive of medical interventions or non-DC surgical evacuation) can enhance morbidity or reduce mortality still open to debate.

#### Methods

A systematic literature review was conducted from inception to October 31, 2023. Both randomized controlled studies (RCTs) and non-randomized studies of intervention (NRSIs) were included if they compared neurological outcomes between sICH patients undergoing DC in addition to standard treatment, including medical treatment or surgical evacuation, and those undergoing standard care alone. Two independent reviewers screened full-text publications for eligibility. Primary outcomes included ratings of patients' neurological states using validated assessment tools (modified Rankin Scale (mRS), the Glasgow Outcome Score (GOS), or its extended version (GOS-E)) at short-term (1-6 months) and long-term (>6 months) with standardized mean differences (SMD). Secondary outcomes comprised short- and long-term mortality rates assessed through relative risk (RR). Pooled effects were calculated using random-effects models, the heterogeneity was presented as I2-statistics, and the quality of evidence was assessed using GRADEpro software.

#### Results

Twelve studies (encompassing 1222 patients) met the eligibility criteria, comprising 1 RCT and 11 NRSIs (1 prospective and 9 retrospective). In the short term, pooled effects favoured DC for neurological state and mortality; however, statistical significance was not achieved (SMD= 0.23, 95% CI -0.05 to 0.51, I2= 38.7%; RR= 0.79, 95% CI 0.58 to 1.08, I2= 30.1%). In the long term, only three studies provided outcome data, with pooled effects for neurological state and mortality being non-significant, trending in favour of standard care alone (SMD= -0.24, 95% CI -1.46 to 0.97, I2= 72.7%; RR= 1.15, 95% CI 0.65 to 2.03, I2= 0.0%). The quality of evidence in the short term was low; in the long term, it was assessed as very low.

#### Conclusion

While adding DC to standard treatment, encompassing medical and/or surgical evacuation may show potential improvement in short-term outcomes for sICH patients, there is currently insufficient evidence to support this treatment in the long term.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P132

### Digitale Subtraktionsangiografie in primär nicht aneurysmatischer Subarachnoidalblutung: Überdiagnose oder sinnvolle Ursachenforschung?

***Digital subtraction angiography in primary non-aneurysmal subarachnoid hemorrhage: Overdiagnosis or useful clarification of causes?***

C. Wolfert[1], B. Sommer[1], P. Krauss[1], C. Maurer[2], A. Berlis[2], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Klinik für Neurochirurgie, Augsburg, Deutschland
[2]Universitätsklinikum Augsburg, Klinik für Diagnostische und Interventionelle Neuroradiologie, Augsburg, Deutschland

#### Objective

Subarachnoid hemorrhage (SAH) being caused of intracranial aneurysms harbor a high risk of rebleeding if the aneurysm is not secured, possibly leading to severe disability or even death. The gold standard to exclude intracranial bleeding sources is the digital subtraction angiography (DSA). However, the benefit of DSA in perimesencephaluc bleeding (PM SAH) pattern is unclear and therefore it is not recommended in the current guideline. This can lead to false negative diagnosis, therefore our study aims to clarify the role of DSA in primary non aneurysmal SAH.

#### Methods

Our observational study compares the imaging results of 100 SAH patients with non-perimesencephalic (NPM) SAH (n=29) and PM SAH (n=71) from January 2010 to January 2021. All patients included underwent at least one CT or MR angiogram and one DSA.

#### Results

In total, 638 DSA were performed in these patients. Assessment for neurovascular pathologies was performed by the senior neuroradiologist. 25% of the patients included underwent repetitive DSA. Revealing an aneurysm in three patients (NPM SAH n=1; 3.4%, PM SAH n=2; 2.8%). Two of these aneurysms were accused for the initial SAH. These were one in the NPM SAH (1/29) and one in the PM SAH (1/71) group, both originating from the basilar artery.

#### Conclusion

To conclude, the percentage of secondary aneurysm finding causative for bleeding in NPM SAH is 3.4% and 1.4% in PM SAH.

However, rebleeding can lead to permanent neurological deficits and often goes along with a high rate of morbidity and mortality.

Therefore, even with regard to these small numbers we suggest repetitive DSA in every non traumatic SAH patient with special attention to the basilar artery.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P133

### Vergleichende Risikoprofilanalyse zwischen perimesenzephaler und aneurysmatischer Subarachnoidalblutung: Auswirkungen von Komorbiditäten auf das Patientenoutcome

***Comparative risk profile analysis between perimesencephalic and aneurysmal subarachnoid hemorrhage: Impact of comorbidities on patient outcomes***

W. H. Polanski[1], S. Arinrad[1], M. Lehmann[1], T. Juratli[1], D. Podlesek[1], P. Krukowski[2], K. Barlinn[3], I. Y. Eyüpoglu[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Institut und Poliklinik für diagnostische und interventionelle Neuroradiologie, Dresden, Deutschland
[3]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Neurologie, Dresden, Deutschland

#### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) and non-traumatic non-aneurysmal SAH (pSAH) represent two distinct and complex forms of cerebral bleeding. This study provides a comprehensive comparison between aSAH and pSAH, focusing on patient outcomes, complication rates, and the impact of comorbidities on these parameters.

#### Methods

We retrospectively analyzed clinical data from a large cohort of pSAH (n=188) and aSAH patients (n=458), emphasizing complication rates (hydrocephalus and vasospasms) and their pre-existing health conditions such as cardiovascular diseases, hypertension and diabetes with their impact on patients outcome.

#### Results

The median age of aSAH patients was 54.9 years, significantly younger than pSAH patients, who had a median age of 57.2 years (p=.026). In the aSAH patient group, men constituted 35.6%, whereas in the pSAH group, a higher proportion of 57.4% were male (p<.001). In pSAH patients it was found that 40.8% had hypertension, compared to 48.4% in aSAH patients (p=.047). Diabetes was present in 17% of pSAH patients, but only 7% in aSAH patients (p<.001). Coronary heart disease (CHD) was observed in 1.1% of aSAH patients and 3.7% of pSAH patients (p=.047). Lower Glasgow Outcome Scale (GOSE) values of 1-4 indicated a significantly worse outcome in 56% of aSAH patients, with only 22.9% of pSAH patients (p<0.001). Nicotine abuse and hypertension had a positive effect on improved outcomes in aSAH patients, but this effect was not observed in pSAH patients (p=.048 and p=.002). The occurrence of hydrocephalus was associated with poor outcomes in both groups (p<0.001), but was significantly more common in aSAH patients (73.6%) compared to pSAH patients (16.5%) (p<0.001). A similar pattern was seen for the occurrence of vasospasms with an incidence of 32.8% in aSAH patients and 19.7% in pSAH patients (p<0.042). These results were also significantly reflected in the modified Rankin Scale and the World Federation of Neurosurgical Societies grading system.

#### Conclusion

The pSAH and aSAH patient populations differ significantly in gender and age. The older pSAH patients have more comorbidities, but generally better outcomes and lower rates of hydrocephalus and vasospasm. In contrast, positive effects of hypertension and nicotine abuse on outcomes were observed in aSAH patients but not in pSAH patients.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P134

### Lebenserwartung bei Patienten mit unrupturierten intrakraniellen Aneurysmen - Systematischer Review und Meta-Analyse

***Life expectancy in patients with unruptured intracranial aneurysms – A systematic review and meta-analysis***

M. Heilig[1], L. T. van der Kamp[2], M. van Genderen[2], S. Hetjens[3], M. Vergouwen[2], N. Etminan[1], G. Rinkel[1,2]

[1]University Hospital Mannheim, Department of Neurosurgery, Mannheim, Deutschland
[2]University Medical Center Utrecht, Department of Neurology and Neurosurgery, Utrecht, Niederlande
[3]University Hospital Mannheim, Department of Medical Statistics and Biomathematics, Mannheim, Deutschland

#### Objective

Long-term subarachnoid haemorrhage (SAH) survivors have a higher mortality than the general population, possibly due to the influence of disease-associated risk factors such as smoking and hypertension. Since life expectancy is a pivotal factor in deciding on preventive aneurysm treatment, we assessed mortality and risk of vascular diseases and cancer in patients with unruptured intracranial aneurysms.

#### Methods

After a systematic search of the literature on PubMed and EMBASE, we screened 3791 articles by title/abstract and 215 articles by full text. We included studies with a longitudinal study design and at least three months of follow-up, reporting on the occurrence of death (overall cause or non-aneurysm-related), cancer, or cardiovascular and cerebrovascular disease (not treatment- or aneurysm-related). Two authors extracted all data independently from each other. We used linear regression models for data analysis and the Observational Study Quality Evaluation (OSQE) score to select studies for sensitivity analysis for high-quality studies.

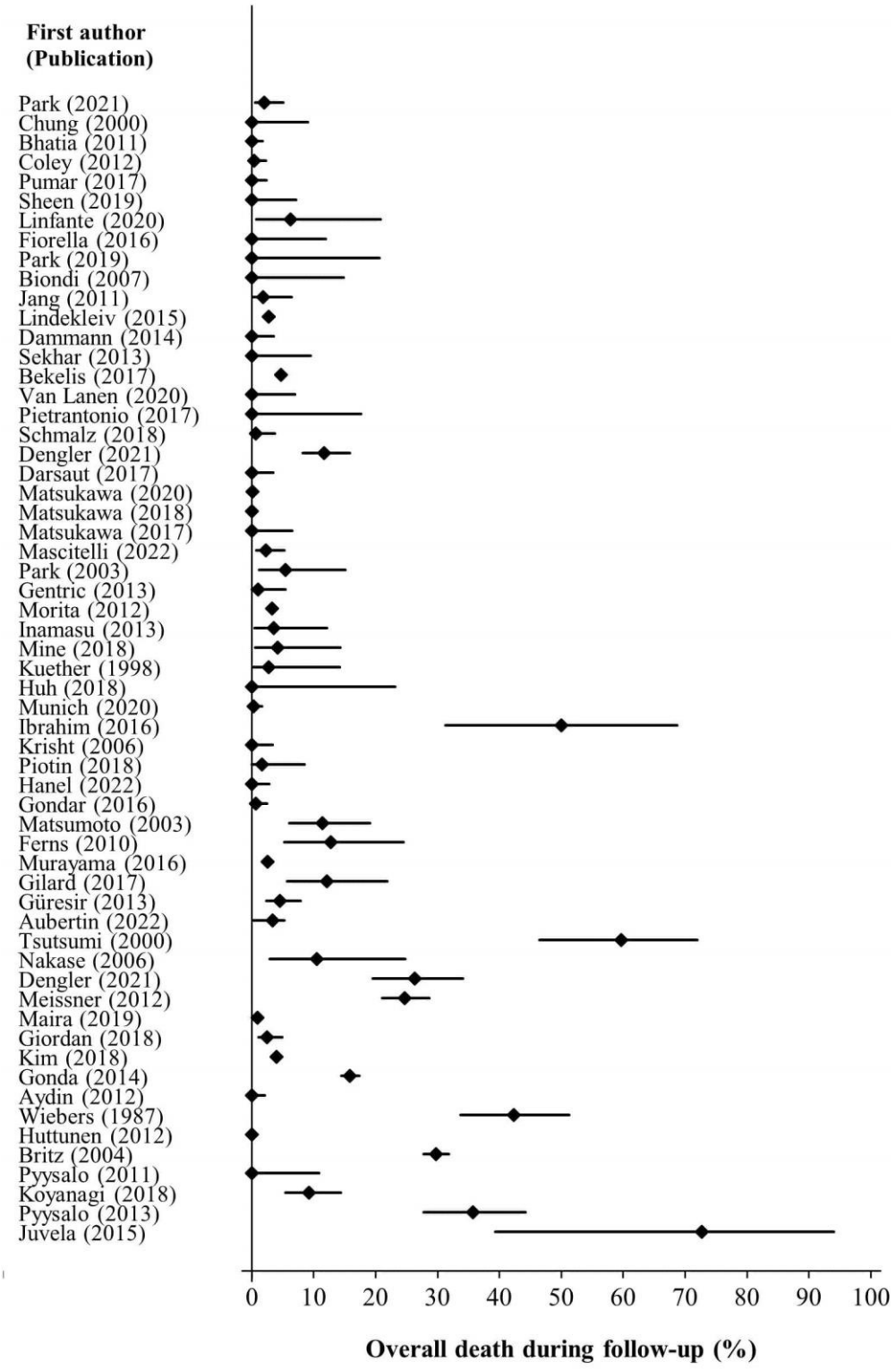
#### Results

We included 58 studies with data on 61,949 patients and 64,535 unruptured intracranial aneurysms. Patients had a mean age at baseline of 60.4 ± 5.6 years. The mean aneurysm size was 6.8 ± 2.9 mm, and 41,322 (92 %) aneurysms were located in the anterior circulation. Most patients underwent preventive aneurysm treatment (37 % neurosurgical, 43 % endovascular, 20 % no preventive treatment). Follow-up data were available for 57,423 patients who underwent a mean follow-up period of 4.9 ± 3 years. In total, 5.6 % (95 % CI, 5.4 – 5.8) of patients died during follow-up. In those studies differentiating aneurysm- and non-aneurysm related causes of death (n = 48), 852/1035 deaths (82.3 %) were non-aneurysm related. In high-quality long-term studies (OSQE ≥ 10, follow-up ≥ 5 years), 12.9 % (95 % CI, 10.3 – 15.8) of patients died from non-aneurysm related causes, 4.5 % (95 % CI, 2.5 – 5.2) were diagnosed with vascular disease, and 7.3 % (95 % CI, 5.4 – 9.6) were diagnosed with cancer.

#### Conclusion

Five years after diagnosis, more than 20 % of patients with an unruptured intracranial aneurysm will have died or been diagnosed with cancer or vascular disease. This proportion should be considered when balancing pros and cons of preventive treatment.

Abb. 1


First author
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Bhatia (2011)
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Tsutsumi (2000)
Nakase (2006)
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Meissner (2012)
Maira (2019)
Giordan (2018)
Kim (2018)
Gonda (2014)
Aydin (2012)
Wiebers (1987)
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Britz (2004)
Pyysalo (2011)
Koyanagi (2018)
Pyysalo (2013)
Juvela (2015)
0
10
20
30
40
50
60
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100
Overall death during follow-up (%)

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P135

### 3- jährige monozentrische Erfahrung in der interventionellen Behandlung des chronischen Subduralhämatoms.
### *3-year single-center experience in the interventional treatment of chronic subdural hematoma*

F. L. Casnati[1], D. Sila[1], S. Rath[1]

[1]Donau Isar Kliniken Deggendorf, Neurochirurgie und interventionelle Radiologie, Deggendorf, Deutschland

#### Objective

The chronic subdural hematoma is a common entity in the daily neurosurgical practice with increasing prevalence due to the aging population and antithrombotic therapy. It appears after bleeding in the so-called subdural space. Surgical evacuation of big/symptomatic hematomas is the treatment of choice. The embolization of the Art. meningea media has become an interesting target as an alternative option to conventional surgery. Mandai (2000) reported a case of a patient with coagulopathy with recurrent chronic subdural hematoma after many prior surgeries that remitted after embolization of the AMM. Since then, many people have seen this new modality as an alternative or a complementary method to conventional surgical treatment. Opposed to the conventional surgical treatment this method is less invasive and addresses the pathophysiology of this disease. Our research aimed to primarily identify the failure rate as well as to contribute to clarifying the indication of this novel method. We analyzed retrospectively our results and then compared them with our surgically treated patients, as well as with the literature.

#### Methods

We retrospectively reviewed 130 embolization procedures without preceding surgery conducted internally (2020-2023). Embolization of the AMM was performed on a bi-plane angiography suite Siemens artis zee under general anesthesia by experienced neurosurgeons using Contour TM 150-250 µm polyvinyl alcohol (PVA) particles delivered via 4F guiding catheter and Progreat TM microcatheter. We analyzed the treatment failure rate (as a need for secondary treatment of the hematoma) and complications.

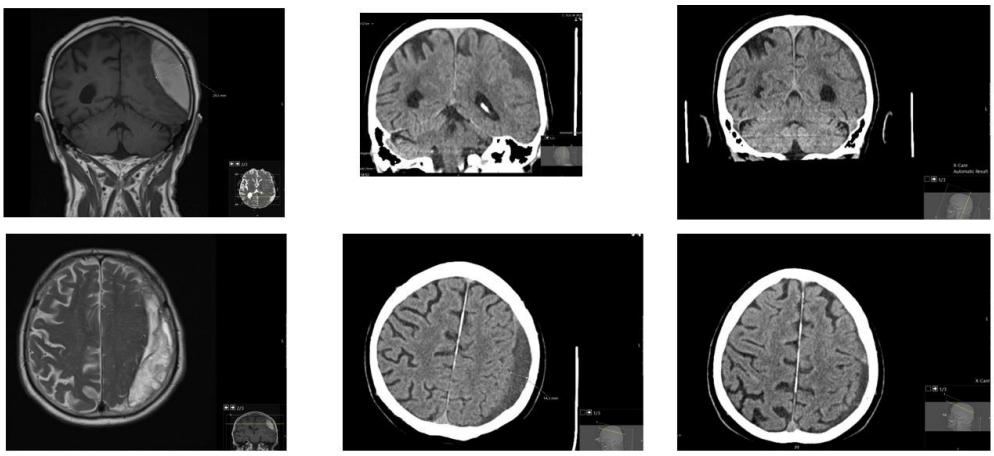
#### Results

101 pat., 29 bilateral (=130 procedures) (follow-up 89 pat.), 13 surgeries due to neurological deterioration (<1week), 6 surgeries due to recurrence or persistent hematoma, 5 complications: 1 unilat. amaurosis (partially transient), 2 facial paresis (transient), 1 stroke, 2 deaths (unrelated to the procedure); 23.1% recurrence after primary surgery without prior embolization (2020/21 = 2 years).

#### Conclusion

We found a failure rate of AMM embolization of 14.6% (lit. 1.4%-8.9%). 13 hematomas with mass signs showed treatment failure due to early neurological worsening. As our previous study showed, hematomas with a maximal width < 18 mm and midline shift < 5 mm measured on admission CT scan in the frontal plane without hyperdense hematoma could be candidates for endovascular treatment with MMA embolization. The complication rate is low ~5%.

Abb. 1



before embo 6 weeks 6 months

Abb. 2

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P136

### Statine beim chronischen Subduralhämatom: wird die Wirkung durch blutverdünnende Medikamente reduziert?
### *Statins in chronic subdural hematoma: is the effect reduced by antithrombotic medication?*

J. Klein[1], B. Carl[1], I. Y. Eyüpoglu[2]

[1]Helios Dr. Horst Schmidt Kliniken, Klinik für Neurochirurgie, Wiesbaden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

#### Objective

Statins have been reported to improve the outcome in patients treated conservatively for chronic subdural hematoma (cSDH). However, studies in surgical cSDH populations failed to demonstrate a favorable effect consistently. We hypothesized that the impact of statin medication upon the need for reoperation may be reduced by antithrombotic medication. Therefore, we investigated a subgroup of patients who took statins but no antithrombotic medication.

#### Methods

We conducted a retrospective chart review in all patients who received first-time surgery for cSDH via burr hole trepanation at two centers from 2012 through 2018. Patients were excluded if they had previously had cranial surgery, if the cSDH was drained via craniotomy, if no follow-up of at least one month was available, or if any missing information precluded the analysis. A subgroup of patients was defined who did not take antithrombotic medication during the formation of the cSDH. We performed logistic regression analysis including age, sex, statin use, Charlson comorbidity index, and Markwalder grading score; the primary outcome factor was repeat surgery due to residual or recurrent hematoma.

#### Results

After applying the exclusion criteria, we identified 561 patients. Of these 269 did not take antithrombotic medication and were included in the regression analysis (mean age 71.38 ± 13.45 years, 177 male, 92 female). 38 of these patients took statins. Reoperation rate in the statin vs. non-statin group was 7.89% vs 13.85%. In the regression analysis, none of the covariates yielded statistical significance.

#### Conclusion

This study did not confirm the hypothesis that the statin effect in cSDH depends on the use of antithrombotic medication. However, as the numerical difference in the reoperation rate between the statin vs. non-statin group is striking, an analysis of a larger cohort is warranted.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P137

### Einfluss der postoperativen Luft und des chronischen subduralen Hämatomvolumens auf die Rezidivrate. Eine vergleichende Messungsanalyse

***Influence of postoperative air and the extent of chronic subdural hematoma volume on recurrence rates. A comparative measurement analysis***

T. Araceli[1], K. M. Schebesch[2], F. Zeman[3], N. O. Schmidt[1], A. Haj[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland
[2]Paracelsus Medizinische Privatuniversität (PMU), Neurochirurgie, Nürnberg, Deutschland
[3]Universitätsklinikum Regensburg, Statistik, Regensburg, Deutschland

#### Objective

Despite the effectiveness of the surgical interventions, chronic subdural hematoma (cSDH) distinctively bear high recurrence rates, and pneumocephalus is one of the most common postoperative complications. There is lack of data regarding the cause of pneumocephalus and cSDH recurrence. The aim of this study was to fill this gap and present helpful assumptions for the acute or long-term management of this increasingly relevant condition.

#### Methods

129 patients were included in this retrospective study (91 males, mean age 74 years, range from 23 to 92 years). Pre-, postoperative and recurrence volumes were obtained from both CT-guided volumetric and empirical methods using the ABC/2 formula and compared using a Bland-Altman plot analysis. Univariate and multivariate analyses were performed balancing demographic, radiographic and clinical data with the occurrence of recurrence and of postoperative air and their volumes. Recurrence was defined as symptomatic enlargement of the cSDH on follow-up CT, indicating requirement to repeat surgery.

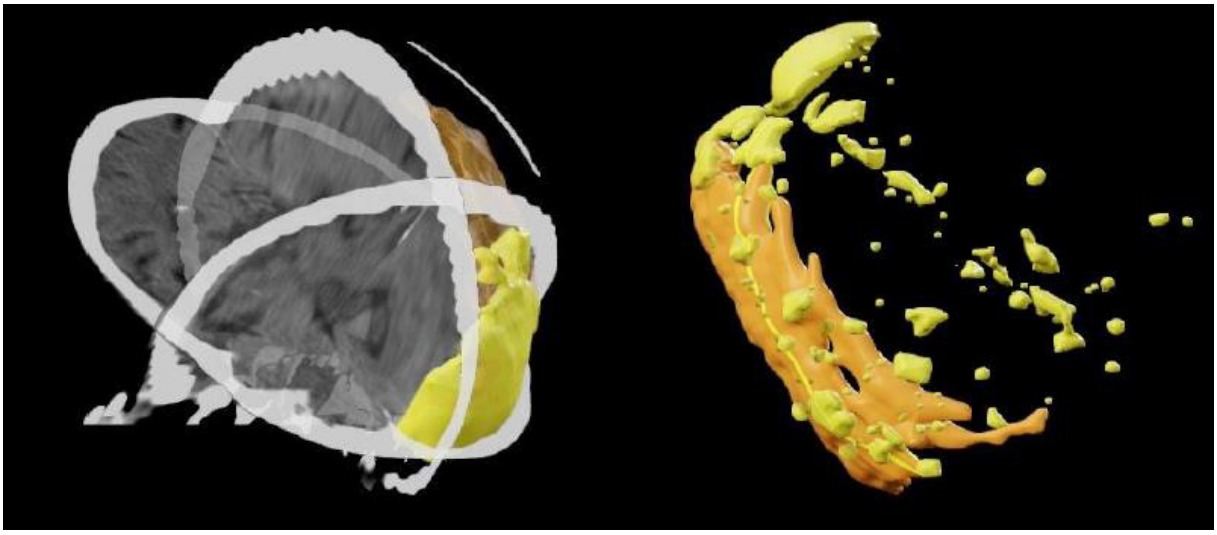
#### Results

Postoperative air volume increases relevantly with increasing preoperative volume (p=0.037). However, no relevant correlation was observed with all other parameters including age and duration of surgery. 24.03% of patients experienced recurrence. The mean recurrence volume was 105.7 ml (range from 29.2 ml to 188.6 ml). Logistic regressions revealed preoperative haematoma volume (p=0.001), presence of membranes (p=0.039), relative volume reduction (p=0.00), reduction <43% of the initial cSDH-volume (p<0.001), relative decrease in MLS (p=0.00) and presence of fresh blood components (p=0.039) to be significantly correlated with cSDH-recurrence. Multivariate analysis obtained preoperative volume (p<0.001) and relative decrease in MLS (p=0.002) as significant predictors of recurrence. Postoperative air volume shows no significant influence on hematoma recurrence and its volume. The deviation between the CT-guided volumetric and ABC/2 measurements was about 8.04 points in excess appearing within a statistically defined range of acceptability.

#### Conclusion

Our study identifies preoperative volume as a statistically significant factor related with the occurrence of pneumocephalus and recurrence. The accurate identification of this parameter, even using a quick and reliable empirical formula, can be helpful in advising and managing patients, since individuals with large initial hematoma volumes are more prone to develop complications and recurrences.

Abb. 1



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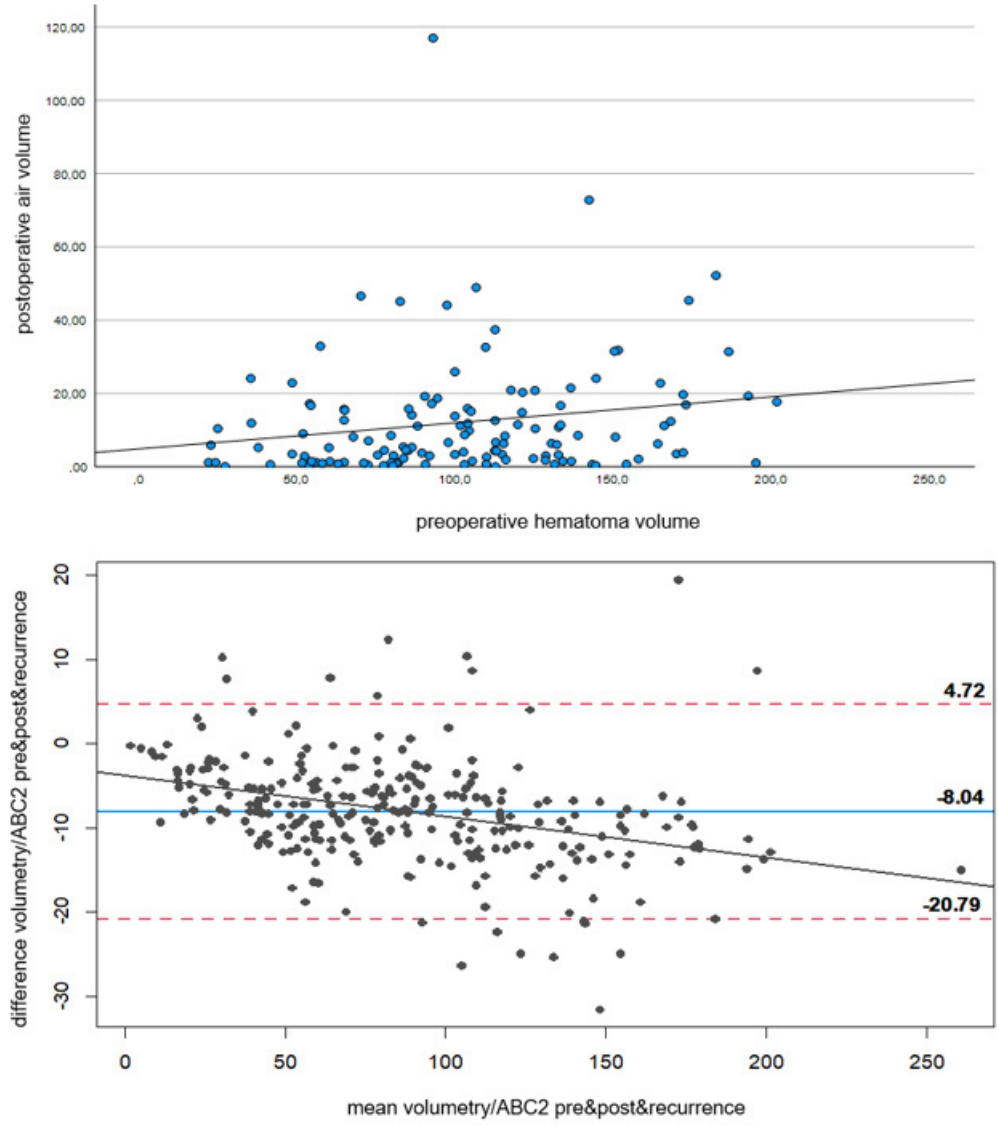
postoperative air volume
120,00
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60,00
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50,0
100,0
150,0
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preoperative hematoma volume
difference volumetry/ABC2 pre&post&recurrence
20
10
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-10
-20
-30
4.72
-8.04
-20.79
0
50
100
150
200
250
mean volumetry/ABC2 pre&post&recurrence

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P138

### Veränderungen der S100-β-Konzentrationen im Serum nach Behandlung von intrakraniellen Aneurysmen: Eine umfassende Studie

***Longitudinal changes of S100-β concentrations in serum after intracranial aneurysm treatment: A comprehensive study***

P. Geiger[1], W. M. Ho[1], S. A. Treichl[1], C. Preuss-Hernandez[1], C. Thomé[1], O. Petr[1]

[1]Medizinische Universität Innsbruck, Universitätsklinik für Neurochirurgie, Innsbruck, Österreich

#### Objective

An aneurysmal subarachnoid hemorrhage (SAH) is a life-threatening cerebrovascular event. Prediction of clinical outcomes remains lacking. Specific biomarkers associated with brain injury, such as S100-β, have emerged as potential candidates for improved prognostic markers.

#### Methods

The study cohort consisted of 100 patients, evenly divided into two groups: one with ruptured intracranial aneurysms and SAH, and the second with unruptured intracranial aneurysms (UIAs) requiring treatment. S100-β concentrations were measured using the Elecsys® S100 assay. Neurological status and all related parameters were prospectively recorded, and patients were followed up for six months using the modified Rankin Scale (mRS).

#### Results

Significant differences in S100-β concentrations were observed at several time points with higher values in SAH patients before and during treatment. Peak concentrations were reached 6 hours after treatment in SAH patients and day 1 after treatment in UIA-patients. S100-β levels declined more rapidly in UIA-patients, returning to normal range within one day after reaching the peak. Elevated S100-β values were significantly associated with an unfavorable neurological outcome at discharge (mRS 3-6) as well as with the occurrence of delayed cerebral ischemia (DCI) in SAH patients (P=0.017).

#### Conclusion

The dynamic changes in S100-β concentrations seem to reflect sundry pathophysiological processes in SAH patients and also in electively treated patients. S100-β levels were significantly associated with clinical outcomes and the development of delayed cerebral ischemia (DCI) in SAH patients. The potential of this prognostic biomarker may be beneficial in a daily clinical practice.

S100-β appears to have a potential as a prognostic biomarker in patients following aneurysmal subarachnoid hemorrhage. It could be supportive of predicting a neurological outcomes and monitoring disease progression in SAH patients, and thus enabling personalized treatment strategies and improved patient care.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P139

### Laser Speckle Bildgebung zur intraoperativen Untersuchung der zerebralen Autoregulation bei Patienten mit inzidentellen und rupturierten Aneurysmen

***Laser speckle imaging for intraoperative assessment of cerebral autoregulation in patients with incidental and ruptured aneurysms***

O. Bordizhenko[1,2], P. Dömer[1], S. Helgers[1], T. Otterburg[3], H. Dietzel[2], J. Woitzik[1]

[1]Carl-von-Ossietzky Universität Oldenburg, University Clinic for Neurosurgery, Oldenburg, Deutschland
[2]Krankenhaus Damme, Neurologie, Damme, Deutschland
[3]Evangelisches Krankenhaus Oldenburg, Klinik für Anästhesiologie, Intensivmedizin und Schmerztherapie, Oldenburg, Deutschland

#### Objective

Cerebral autoregulation ensures a constant brain perfusion regardless of changes in systemic blood pressure. Impairments in cerebral autoregulation have been documented in various pathologies such as malignant stroke or subarachnoid hemorrhage (SAH) and identified as a predictor of poor outcomes. Early recognition of this dysfunction allows for effective adjustment of perfusion pressure-based treatment strategies. Existing data primarily focus on the postoperative phase during intensive care management. The detection of autoregulation disturbances in the acute phase remains insufficiently investigated. This study aimed to intraoperatively measure cerebral autoregulation using non-invasive Laser Speckle Imaging (LSI) in patients with SAH and unruptured aneurysms.

#### Methods

Intraoperative LSI imaging was performed using a Moor FLPI2 device. Patients with SAH or an unruptured aneurysm requiring surgical intervention were included. During LASCA imaging, a blood pressure difference of 10 mmHg MAP was induced, and the cerebral blood flow response was recorded using LSI. Cerebral autoregulation was determined at various positions distributed over the exposed cortex in all included patients.

#### Results

In patients with SAH, there was an increase in cortical perfusion by 0.26% per mmHg MAP in response to an increase in MAP. In patients with unruptured aneurysms, this increase was only 0.12% per mmHg MAP. Analysis of different areas of the exposed cortex revealed stronger differences in autoregulation in SAH patients (IQR 0.61% per mmHg MAP) compared to patients with unruptured aneurysms (IQR 0.33% per mmHg MAP).

#### Conclusion

Cerebral autoregulation can be assessed and visualized in real-time using non-invasive LSI. In this pilot study, regional differences in autoregulation disturbances were identified between SAH patients and those with an unruptured aneurysm. Intraoperative LSI for determining cerebral autoregulation offers the opportunity to react to autoregulation disturbances in the early postoperative phase and adjust intensive care treatment strategies accordingly.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P140

### Mikrochirurgisches Clipping von PICA-Aneurysmen über einen medianen, subokzipitalen Zugang in einer Serie von 25 Patieneten

*Median suboccipital approach for microsurgical clipping of PICA aneurysms in a series of 25 patients*

J. M. Lang[1], F. Götz[2], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Medizinische Hochschule Hannover, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Hannover, Deutschland

#### Objective

Aneurysms of the posterior inferior cerebellar artery (PICA) are heterogenous in morphology and origin and therefore often difficult to treat due to the proximity to the brainstem and lower cranial nerves. The far lateral approach (FLA) is widely used for micosurgical treatment of PICA aneurysms. An alternative is the median suboccipital approach (MSA). Here, we present our experience with the MSA for microsurgical treatment of PICA aneurysms.

#### Methods

Evaluation of a consecutive series of 25 patients with PICA aneurysms treated microsurgically via MSA regarding demographic data, preoperative status, aneurysm location and shape, and outcome.

#### Results

Twenty-five patients (16 women, 9 men, mean age 53,8 years; range 1-83 years) with a total of 31 PICA aneurysms (mean size 5,2 mm; range 2-17 mm) were microsurgically treated via a MSA (18 patients in the semi-sitting position, 7 patients in prone position). 22 patients suffered a subarachnoid haemorrhage (HH grade 4 and 5 in 13 patients, HH grade 2 and 3 in 9 patients), additionally a space-occupying cerebellar hemorrhage was present in 7 patients. Aneurysms were located on the left in 13 patients, in 12 patients on the right. In the majority, aneurysm shape was saccular (23 aneurysms), and fusiform in the remaining (8 aneurysms). Most aneurysms originated from the anterior medullary segment (9 aneurysms) or tonsillo-medullary segment (9 aneurysms). All 31 aneurysms were completely occluded: 30 aneurysms with clip ligation, one aneurysm, totally thrombosed, was resected. The patency of PICA could not be preserved in 3 patients after clip ligation resulting in territorial infarction of PICA. Outcome was good in 11 patients (mRS 0-3) and poor in 8 patients (mRS 4 and 5). Six patients died. Neither postoperative hemorrhage nor cerebrospinal fluid leakage was observed needed revision.

#### Conclusion

MSA is a suitable and safe approach to treat microsurgically PICA aneurysms of heterogenous morphology and of all PICA segments.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## P141

### Decompressive Craniectomy bei Schlecht-gradiger Aneurysmatischer Subarachnoidalblutung: Eine systematische Übersichtsarbeit und Meta-Analyse

***Decompressive craniectomy for poor-grade aneurysmal subarachnoid hemorrhage: A systematic review and meta-analysis***

A. Mulhem[1,2], A. Jaiswal[2], A. A. Alsuliman[1], K. L. Yaxley[2], S. Hammersen[1], S. R. Kantelhardt[1]

[1]Vivantes Klinikum im Friedrichshain, Neurochirurgie, Berlin, Deutschland
[2]University of Oxford, Department for Continuing Education, Oxford, Vereinigtes Königreich

#### Objective

The efficacy of decompressive craniectomy (DC) as an adjunct to standard treatment for improving neurological outcomes and reducing mortality in patients with poor-grade aneurysmal subarachnoid haemorrhage (aSAH), specifically grades IV and V per World Federation of Neurosurgical Societies (WFNS) or Hunt and Hess (H&H), remains unclear. Given the delayed launch of the promised PICASSO trial, this study aims to explore the impact of DC in the absence of definitive evidence.

#### Methods

We conducted a systematic review comparing neurological outcomes between patients who underwent DC in addition to standard care and those receiving standard care alone (clipping or coiling without decompression) for managing poor-grade aSAH (grades IV or V). A comprehensive search of seven databases, including MEDLINE and EMBASE, was conducted from inception until October 31, 2023. Two independent reviewers assessed full-text publications for eligibility. Primary outcomes included short-term (1-6 months) and long-term (>6 months) neurological states measured using the modified Rankin Scale (mRS), the Glasgow Outcome Score (GOS), or its extended version (GOS-E), with standardized mean differences (SMD). Secondary outcomes comprised short- and long-term mortality rates assessed through relative risk (RR). Pooled effects were calculated using random-effects models, and the quality of evidence was evaluated using the GRADE approach.

#### Results

Five studies (304 patients) meeting inclusion criteria were identified, all being non-randomized intervention studies (1 prospective and 4 retrospectives). Baseline characteristics (age, initial Glasgow Coma Scale, and midline shift) did not significantly differ between DC and no-DC groups. Pooled effects for neurological outcomes in both short and long terms were not significant (SMD= -0.11, 95% CI -0.59 to 0.38 in the short term, and SMD= -0.49, 95% CI -1.88 to 0.90 in the long term). Short-term mortality was slightly in favour of DC, however, insignificant (RR= 0.63, 95% CI 0.28 to 1.41), and in the long-term, there was no difference between the two groups (RR= 1.03, 95% CI 0.70 to 1.52). The certainty of the evidence was deemed very low.

#### Conclusion

This meta-analysis highlights the current lack of evidence supporting the use of DC in addition to standard care for poor-grade aSAH, showing no improvement in neurological outcomes or reduction in mortality. The forthcoming results of the PICASSO trial will be instrumental in elucidating this issue.

# Vaskuläre Neurochirurgie – Verschiedenes 3 | Vascular Neurosurgery – Various 3

## J-Cr 001

### Strategien für den Umgang mit raketendurchschlagenden Hirnverletzungen in der modernen Kriegsführung: die Erfahrungen aus dem kroatischen Heimatkrieg

***Strategies for managing missile penetrating brain injury in modern warfare: The experience from croatian homeland war***

B. Splavski[1,2]

[1]University of Applied Health Sciences Zagreb, Zagreb, Kroatien
[2]Dubrovnik General Hospital, Surgery, Dubrovnik, Kroatien

#### Objective

War missile penetrating brain injury refers to traumatic damage caused by projectiles of different masses and velocities to the scalp, cranial vault/base, brain coverings, brain tissue/parenchyma, and cerebral ventricles. This injury is highly contaminated and can penetrate the dura, posing a life-threatening risk to the patient. It can also predispose the wounded to cerebrospinal fluid leaks and infective/seizure complications.

#### Methods

This review explores management strategies for missile penetrating brain injury in modern warfare by analyzing the most important factors that influence the outcome. It is based on the single-institution experience of regular neurosurgical practice during the 1991 – 1995 homeland war in Croatia.

#### Results

Admission state of consciousness and pupil reactivity were the most sensitive outcome predictors. The time interval between injury and hospital admission was also an important factor influencing the outcome and offering a better prognosis if it was short, but it could also uncover moribund patients with no chance of survival. Factors such as age, gender, and missile type did not have a significant effect on survival. The correlation between intracranially retained bone/metal foreign bodies and infections or seizures was not found.

#### Conclusion

In cases of serious war brain injury, it is important to act quickly and efficiently. Administering wide-range antibiotics, performing urgent CT scans, and promptly transporting the patient to the nearest neurosurgical facility is critical in ensuring the best possible outcome. Two surgical management approaches are commonly used – a craniotomy with removal of debris and waterproof sealing of the dura, or a decompressive craniectomy with leaving the dura wide-open. Removing any retained fragments is not necessary since there was no proven link between their presence and the development of infections or seizure disorders.

# Tumor – Verschiedenes 2 | Tumour – Various 2

## P143

### *Ein fMRT-Task für Sprachverständnis und semantische Entscheidungsfindung identifiziert kortikale Bereiche von Aufmerksamkeits- und Exekutivfunktionen*
### *A language comprehension and semantic decision fMRI task identifies cortical areas critical to attention and executive functions*

P. Keil[1], C. Nettekoven[1], K. Jonas[2], R. Loução[1], C. Kabbasch[3], R. Goldbrunner[4], C. Weiß Lucas[1]

[1]Universitätsklinikum Köln, Zentrum für Neurochirurgie, Köln, Deutschland
[2]Universität zu Köln, Department für Heilpädagogik und Rehabilitation, Köln, Deutschland
[3]Universitätsklinikum Köln, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Köln, Deutschland
[4]Charité – Universitätsmedizin Berlin, Neurochirurgische Klinik, Berlin, Deutschland

#### Objective

Preservation of the attention network during resection surgery is of high importance for the patients" quality of life, but tracking the network and monitoring its function is challenging. Common tasks like picture naming (PN) might not be sufficiently well-suited to capture attention network correlates due to their simplicity and strong learning effects. We here present an approach to visualize auditory attention network components using a novel functional MRI (fMRI) task, compared to PN.

#### Methods

15 healthy participants (7 males; mean age: 28 yrs) performed a semantic decision (SD) task during clustered fMRI acquisition (TR=12 s, total scan duration 7:30 min) in a 3 Tesla scanner. The SD task comprised (1) listening to a sentence, and (2) decision for one semantically related object drawing out of three options via button press. The sentences were either meaningful (and semantically related to one of the presented objects), nonsense, or reversed (i.e., not understandable). We compared performance of the SD task to a PN task, where the same images used in SD were presented without additional audio and participants reported the depicted object in a short sentence in German. BOLD data were analysed using the Matlab toolbox SPM 12.

#### Results

Group analysis of SD task-fMRI allowed for highly reliable identification of the left intraparietal sulcus (IPS, local maximum at MNI-coordinates -27, -61, 56), the right frontal eye field (FEF, [MNI]: 33, -13, 65) and the pre-supplementary motor area (pre-SMA), expanding into both hemispheres ([MNI]: 3, 5, 50)($p<0.001$, FWE-corr.). Significant activations of the contrahemispheric counterparts of both areas ($p<0.001$ unc.) did not survive FWE correction. All of these areas were significantly more active during SD when compared to picture naming ($p<0.05$, FWE-corr.). PN was suitable for mappings of the primary facial/vocal motor and visual areas, but less for group level mappings of higher cognitive functions.

#### Conclusion

Compared to PN, SD provides more robust task-fMRI mapping results regarding important hubs of the attentional network, such as the IPS. Including the respective individual results into the planning of brain tumour surgeries couldhelppreserve important daily-living activities and quality of life.The intraoperative and clinical value, however, remain to be confirmed in a clinical study.

# Tumor – Verschiedenes 2 | Tumour – Various 2

## P144

### Komplikationen der Gliomchirurgie: Ergebnisse einer monozentrischen, prospektiv geführten Datenbank zur Komplikationserfassung in einem Krankenhaus der Maximalversorgung

***Adverse events in glioma surgery: Results of a prospectively compiled database at a single-center tertiary care hospital***

M. Kaes[1], C. Jungk[1], A. Unterberg[1], M. Jakobs[1], C. Beynon[1], S. Krieg[1], M. Scherer[1], D. Haux[1], P. Dao Trong[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

#### Objective

Adverse events in glioma surgery can cause severe problems for patients affected and to healthcare systems. Therefore, understanding and avoiding adverse events should be essential in centers performing glioma surgery. Nevertheless, it is still uncommon to assess adverse event data in a prospective, standardized manner. In this study we want to share the findings of our prospectively compiled database for adverse events in glioma surgery.

#### Methods

Every patient treated at our institution received a peer-reviewed, standardized discharge paper with focus on adverse events. Any event, that led to readmission, worsening of clinical outcome, new neurological deficits, revision surgery, contributed to death or prolonged hospital stay was recorded and classified according to the Clavien-Dindo classification (CDC). Further, we compared our complication data with the database of the institute for reimbursement in hospitals (InEK).

#### Results

From January 2022 to May 2023 a total of n=282 cranial glioma surgeries were performed at our institution. Surgery was performed using a common craniotomy in 203 cases (72%), an awake craniotomy in 23 cases (8.2%) and in 56 cases (19.8 %) a stereotactic approach for biopsy was used. A total of n=63 (22%) cases showed adverse events. The most common adverse event was a new neurological deficit in 35 cases (12.4%), of which 28.6% completely resolved prior to discharge, followed by non-surgery related adverse events in 17 cases (6%). Wound healing disorders and CSF-leaks were recorded in 5 cases (1.8%) and in 4 cases (1.4%), respectively. The complication grading according to the CDC showed the following complication grades: grade 1 n=27 (9.6%), grade 2 n=19 (6.7%), grade 3 n=13 (4.6%), grade 4 n=4 (1.4%), grade 5 n=5 (1.8%). Revision surgery was necessary in 15 cases (5.3%). Comparison with over 7600 cases of the InEK database showed a higher frequency for detection of adverse events and further a better distinction between the types of complications in our prospective database.

#### Conclusion

Adverse events in glioma surgery are a common problem, mostly consisting of new neurological deficits. Understanding and classifying these events in a prospective, standardized manner will help to reduce the risk of adverse events in glioma surgery in the future.

# P145

## Weiterentwicklung der chimären Antigenrezeptor-Technologie (CAR) zur Behandlung von Glioblastomen: Präklinische Erkenntnisse und therapeutisches Potenzial

***Advancing Chimeric Antigen Receptor (CAR) technology for Glioblastoma treatment: Preclinical insights and therapeutic potential***

A. O. Mohammed[1], M. Sun[2], K. Joseph[1], J. Beck[1], M. Weller[2], T. Weiss[2], V. Ravi[1]

[1]Department of Neurosurgery, University of Freiburg, Freiburg i. Br., Deutschland
[2]University Hospital Zurich, Department of Neurology, Zürich, Schweiz

### Objective

Glioblastoma (GBM) represents a formidable challenge owing to its aggressive nature and limited treatment options. Despite intensive research efforts, current therapeutic strategies for GBM have exhibited suboptimal success rates and minimal improvement in overall survival. However, chimeric antigen receptor (CAR) technology has revolutionized solid cancer immunotherapy, offering a promising avenue for other cancers. This study underscores the importance of continued research to overcome existing hurdles and further advance CAR based technologies for GBM.

### Methods

This study investigated the feasibility of employing CAR technology to selectively identify and target GBM cells in a human cortical GBM model. The methodology involves genetically engineering patients' peripheral blood mononuclear cells (PBMCs) to express a unique CAR designed to target GBM-associated antigens. In a preclinical model incorporating human brain tissue and patient-derived cell lines, tumor growth and GBM invasiveness was studied, along with cellular exhaustion. Additionally, the behavior of CAR expressing immune cells within the tumor microenvironment was studied by cellular tracking as well as expression of exhaustion markers.

### Results

CAR-modified PBMC"s exhibited prolonged activation compared to controls ($p>0.005$). Furthermore, when synergistically combined with chemotherapy, a potentiated therapeutic effect was observed, with 50% reduction of tumor. Similar significant reduction in tumor growth and invasion was observed in ex-vivo human neocortical GBM model. Additionally, cytoxic effects of PBMC therapy was also determined, with no significant loss of cells in the neural microenvironment.

### Conclusion

In summary, the use of chimeric antigen receptor (CAR) technology to prime immune cells represents a promising strategy for circumventing the immunosuppressive properties of glioblastoma multiforme (GBM). Positive outcomes from preclinical investigations have demonstrated the viability and safety of CAR T-cell therapy for potential clinical applications.

# P146

## Auf künstlicher Intelligenz basierende Differenzierung von niedrig- und hochgradigen ZNS-Gliomen
*Artificial intelligence-based differentiation of low-grade and high-grade CNS gliomas*

M. Musigmann[1], M. Bilgin[1], S. Bilgin[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

### Objective

The prognosis and further treatment planning differ considerably between low-grade and high-grade gliomas. Low-grade gliomas progress over time and can transform into malignant variants of WHO grade 3 and 4. It is very important to differentiate reliably between low-grade and high-grade gliomas to ensure the best possible treatment. Neuroimaging techniques such as CT and MRI are of central importance for the diagnosis of brain tumors. The aim of our study is to differentiate low-grade and high-grade gliomas using contrast-enhanced CT images and radiomics-based machine learning.

### Methods

Our retrospective, IRB-approved study is based on contrast-enhanced CT images of 126 patients with histologically confirmed low-grade and high-grade gliomas. The segmentation of the contrast-enhanced parts of the tumor on the CT images was performed semi-automatically using the open-source software platform 3D Slicer. The radiomic features required for our analyses were calculated using the PyRadiomics software. Three different methods were tested for feature preselection. Subsequent model developments were carried out using three conventional machine learning algorithms and a neural network. All performance values were determined based on independent test data. In addition, the classification error of the final model was analyzed as a function of the tumor subtype.

### Results

We obtained our best model based on a Naïve Bayesian approach. Very good results were also achieved with the neural network. Using independent test data, our final six-feature model yields a mean AUC of 90.3 %, a mean accuracy of 83.9 %, a mean sensitivity of 80.7 %, and a mean specificity of 86.4 %. The classification error for many tumor subtypes proved to be less than 10 %. The model was developed a total of 100 times, each time with new training data. Subsequently, the performance was determined each time with new independent test data. The performance of the model proved to be very stable during these 100 runs. In addition, we were able to identify which radiomic features are of particular importance for the differentiation between low-grade and high-grade gliomas.

### Conclusion

Our study shows that low-grade and high-grade gliomas can be differentiated with high performance based on contrast-enhanced CT images using radiomics-based machine learning. In the future, such methods based on artificial intelligence could potentially enable physicians to perform fewer biopsies and speed up further treatment planning.

# P147

## Vergleich von klinischem Verlauf und Gesamtüberleben bei Patienten mit IDH-Wildtyp-Glioblastom, diagnostiziert anhand histologischer Merkmale versus molekularer Veränderungen

***Comparison of clinical progression and overall survival in patients with IDH-Wildtype glioblastoma diagnosed by histological features versus molecular alterations***

F. Bytygi[1], A. Csokonay[2], M. Lotfinia[2], A. Koch[3], F. Sergejew[4], E. Spüntrup[5], J. Walter[6], M. Walter-Diessars[7]

[1]Klinikum Saarbrücken, Neurochirurgie, Saarbrücken, Deutschland
[2]Klinikum Saarbrücken, Klinik für Neurochirurgie, Saarbrücken, Deutschland
[3]Charité – Universitätsmedizin Berlin, Neuropathologie, Berlin, Deutschland
[4]Klinikum Saarbrücken, Department of Neuroradiology, Saarbrücken, Deutschland
[5]Medical Center Saarbruecken, Radiology, Saarbrücken, Deutschland
[6]Klinikum Saarbrücken, Neurosurgery, Saarbrücken, Deutschland
[7]Medical Center Saarbruecken, Neurosurgery, Saarbrücken, Deutschland

### Objective

The 2021-WHO classification of tumors of the CNS is done according to molecular features in addition to histological
characteristics. The presence of either TERT promoter mutations, chromosome 7 gain/10loss, and /or EGFR amplification in IDH-wildtype Gliomas, lacking the histological characteristics, show aggressive clinical behavior and should be treated as Glioblastoma WHO 4, based on cIMPACT-NOW criteria. The aim of this study is to present a series of patients presenting with radiographic characteristics of diffuse growing astrocytic glioma and compare the clinical course and overall survival rate between those diagnosed as glioblastoma based on histological features versus those based on molecular alterations.

### Methods

Patient data was analyzed retrospectively forpatients presenting with diffuse astrocytoma, lacking the radiographic appearance of high-grade glioma, and undergoing surgical biopsy/resection at our hospital from January 2020 to December 2021. We reviewed and compared for each patient the clinical presentation, histological findings, molecular alterations, and overall survival rate.

### Results

This cohort included 13 patients based on the first radiological presentation showing T2 hyperintense lesions without enhancement in MRI. 6 specimen gliomas were diagnosed as Glioblastoma WHO 4 based on the presence of histological features (Groupe 1). 7 specimen gliomas were diagnosed as Glioblastoma WHO 4 based on harboring one of the molecular alterations (Groupe 2). Progressive Disease was diagnosed earlier after biopsy or resection on Groupe 1. Overall survival didn"t show a significant difference on both groups (Groupe 1: 11 months and Groupe 2: 12 months). IDH-mutant gliomas – Astrocytoma WHO 4, with the presence of traditional histological findings, have also shown in our cohort a longer stable disease and overall survivor. Comparing patients with the presence of only one molecular alteration with those with the presence of more molecular alterations didn"t show a significant longer overall survival or a longer stable disease.

### Conclusion

Patients with IDH-wildtype gliomas, independently from diffuse radiographic appearance or lacking the presence of higher-grade traditional histology show an aggressive clinical behavior. A prompt biopsy and/or resection to confirm the diagnosis is of a significant clinical importance to be able to begin the adjuvant therapy. In our cohort is once again shown that the progression and overall prognosis is similar to glioblastoma.

# Tumor – Verschiedenes 2 | Tumour – Various 2

## P148

### Korrelation von präoperativen nTMS Daten mit intraoperativen Mapping Daten bei Patienten mit präzentralen Tumoren

***Correlation of preoperative nTMS data with intraoperative mapping findings in patients with precentral gyrus lesions***

A. Jung[1], D. Löschner[1], J. Rathert[1], R. Gerlach[1]

[1]Helios Klinikum Erfurt, Neurochirurgie, Erfurt, Deutschland

#### Objective

Microsurgical resection of eloquent intra-axial brain tumors is associated with an improved oncological outcome compared to biopsy alone. Navigated transcranial magnet stimulation (nTMS) is a non-invasive pre-surgical tool to identify motor and language function in patients with intra-axial lesions in eloquent brain areas. We hereby present our results of nTMS implementation in the preoperative workup and decision-making process in a series of patients with lesions in the precentral gyrus and correlate data to their clinical course and surgical outcome.

#### Methods

From November 2022 to October 2023 all patients presenting with pathologies in the precentral gyrus were analyzed, performing preoperative nTMS in a standardized workup. Results of nTMS were implemented in the decision process if microsurgical resection is feasible or a biopsy should be performed. Surgery was performed using IONM with scalp electrodes, a grid electrode in unchanging position and direct cortical and subcortical stimulation. nTMS Data was correlated to intraoperative stimulation results. Outcome and clinical course was assessed up to discharge from the hospital.

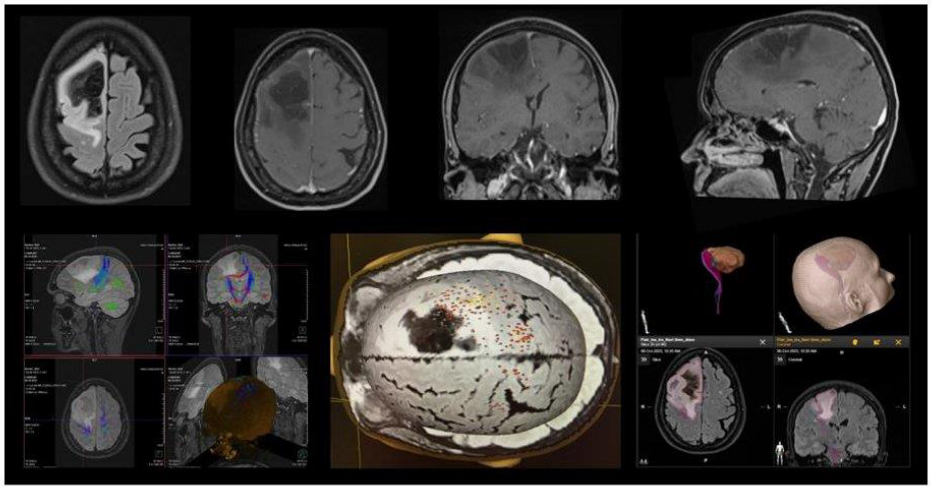
#### Results

nTMS was performed in 8 cases (2 left and 6 right hemispheric) of patients with precentral gyrus tumours. Mean patient age was 47,71 ± 22,71 years. 4 tumours were histological confirmed as WHO grade 2 and 3, 2 as glioblastoma (WHO grade 4), 1 was validated as non-specific gliosis. For 7 patients nTMS was generating reliable MEP. Best MEP was generated with M. abductor pollicis brevis (APB) in 5 cases, with M. abductor digiti minimi (ADM) in 2 cases. Mean motor treshold was 47,5 V/m. In 4 cases in the dorsolateral tumour circumference positive MEP for upper extremity (UE) were detected. With 2 patients no MEP in tumour expansion was seen.Primary motor cortex function was lateralized in 4 cases and in anatomical place in 3 cases. Intraoperative neuromonitoring (transcranial SSEP/ MEP, MEP Grid electrode) was stable during all surgeries. Slightly SEP reduction in 1 case kept clinically inapparent. In 6 cases (75%) gross total tumour resection was achieved.Clinical examination of lower extremities showed no worsening in postoperative hospitalization. For UE we saw temporary muscle paresis in 4 cases (50%). All patients were timely able to receive further neurooncological treatment.

#### Conclusion

nTMS is a very effective, non-invasive presurgical tool deciding between microsurgical resection or biopsy with high predictice value for clinical outcome.

Abb. 1



preoperative workup: right sided tumour in precentral gyrus

# Tumor – Verschiedenes 2 | Tumour – Various 2

## P149

### Normalisierung und Unmixing von hyperspektralen Aufnahmen für Hirntumorresektion unter Verwendung von Deep Learning

***Deep learning-based normalization and unmixing of hyperspectral images for brain tumor surgery***

E. Suero Molina[1,2], D. Black[3], J. Gill[3], A. Xie[3], S. Kaneko[1,4], A. Di Ieva[2], W. Stummer[1]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[3]University of British Columbia, Vancouver, Kanada
[4]Hokkaido University Graduate School of Medicine, Department of Neurosurgery, Sapporo, Japan

#### Objective

Identifying glioma margins is difficult. Advances in hyperspectral imaging (HSI) for fluorescence-guided surgery (FGS) have enhanced tumor detection based on their light emission spectra. However, computations are very sensitive to autofluorescence from endogenous fluorophores, and artifacts from the optical and topographic properties of the tissue. To overcome these challenges, measured spectra are normalized to account for artifacts and spectrally unmixed to isolate the protoporphyrin IX (PpIX) signal, which indicates malignant tissue. Existing methods are simplistic and based on phantoms and are unable to account for nonlinear effects such as multiple scattering, the dual photostates of PpIX, or the inhomogeneous optical properties of the tissue. These may include wavelength-dependent variations in absorption and scattering, which are also unmodeled. We propose a deep learning (DL)-based pipeline encompassing normalization and unmixing, which can fully account for the nonlinear effects and produce more accurate distributions of fluorophore abundances.

#### Methods

The architecture consists of a fully connected multi-layer perceptron to perform the normalization, followed by an encoder network for unmixing. A decoder network or a linear combination of known fluorophore spectra, weighted by the encoder outputs, can be used to compute a reconstruction loss for unsupervised learning on human data with no ground-truth PpIX abundance. A second encoder network with shared weights into which the pure fluorophore spectra are input ensures statistical independence of the computed abundances. This unsupervised approach was compared to the standard classical method and a fully supervised 1D convolutional neural network with two residual blocks and three fully connected layers.

#### Results

On phantom and pig brain data with known PpIX concentration, the supervised model achieved coefficients of determination (R2) between the known and computed PpIX concentrations of 0.997 and 0.970, respectively. In contrast, the classical approach achieves only 0.93 and 0.82. The unsupervised approach's R2 values were 0.98 and 0.91, respectively. On human data, the unsupervised model gives qualitatively more realistic results, better removing bright spots of specular reflectance and greatly reducing the variance of the computed PpIX abundance over biopsies that should be relatively homogeneous.

#### Conclusion

These results show promise for using deep learning to improve the precision and accuracy of HSI FGS.

# P150

## Wirksamkeit der BRAF/MEK-Inhibitor Therapie für Epitheloides Glioblastom mit neuartiger BRAFV6000 Mutation - ein Fallbericht

***Efficacy of BRAF/MEK-Inhibitor therapy for epithelioid glioblastoma with a novel BRAFV600 mutation – A case report***

C. Buszello[1], J. Steininger[2], R. Oertel[3], M. Meinhardt[4], K. Engellandt[5], S. Herold[6], S. Stasik[7,8], B. Renner[3], C. Thiede[7], I. Y. Eyüpoglu[1], G. Schackert[1], S. Beissert[2], F. Meier[2,8,9], J. Radke[10], D. Westphal[2,8], T. Juratli[1,8]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Dermatologie, Dresden, Deutschland
[3]Technische Universität Dresden, Institut für Klinische Pharmakologie, Dresden, Deutschland
[4]Universitätsklinikum Carl Gustav Carus Dresden, Institut für Pathologie – Bereich Neuropathologie, Dresden, Deutschland
[5]Universitätsklinikum Carl Gustav Carus Dresden, Institut und Poliklinik für diagnostische und interventionelle Neuroradiologie, Dresden, Deutschland
[6]Institut für Pathologie, Dresden, Deutschland
[7]Universitätsklinikum Carl Gustav Carus Dresden, Medizinische Klinik, Dresden, Deutschland
[8]Nationales Centrum für Tumorerkrankungen Dresden (NCT/UCC), Dresden, Deutschland
[9]Hauttumorzentrum am Nationalen Centrum für Tumorerkrankungen Dresden (NCT/UCC), Dresden, Deutschland
[10]Universität Greifswald, Institut für Pathologie, Greifswald, Deutschland

### Objective

Epithelioid glioblastoma (eGB), a very aggressive and rare brain tumour, is associated with a dismal median overall survival. Effective therapies for patients with eGB, particularly with leptomeningeal dissemination, are still lacking.

### Methods

Here, we describe a case of a 25-year-old male diagnosed with an intramedullary cervical tumour with subsequent leptomeningeal disease. In order to identify the tumour entity and propose an effective treatment strategy, extensive molecular, proteomics and immunohistochemistry analyses were conducted.

### Results

Histopathology identified a highly necrotizing, epithelioid-type tumour with high cell density, corresponding to an eGB. DNA analysis revealed an unprecedented B-Raf protooncogene, serine/threonine kinase (BRAF) gene variant in exon 15 (c.1799-1810delinsATG, p.V600_W604delinsDG), triggering activation of the mitogen-activated protein kinase (MAPK) pathway.

We initiated MAPKi therapy, utilising a combination of BRAF and mitogen-activated protein kinase kinase (MEK) inhibitors. Liquid chromatography–tandem mass spectrometry analysis confirmed the drugs" presence in the patient"s cerebrospinal fluid, indicating their capacity to cross the blood-brain barrier. Remarkably, the patient responded very well to therapy and transitioned from a near-comatose state to significantly improved health, sustained for over three months.

### Conclusion

This study highlights that MAPKi, particularly targeted towards novel BRAFV600 mutations, might offer promising advancements in eGB treatment strategies.

# P151

## Untersuchung postoperativer motorischer Funktion mittels navigierter transkranieller Magnetstimulation
*Evaluating postoperative motor function using postoperative navigated transcranial magnetic stimulation motor mapping*

T. Eibl[1], M. Schrey[1], J. Rossmann[1], A. Liebert[1], L. Ritter[1], R. Lange[2], H. H. Steiner[1], K. M. Schebesch[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Neurochirurgie, Nürnberg, Deutschland
[2]Klinikum Nürnberg, Paracelsus Medizinische Universität, Neurologie, Nürnberg, Deutschland

### Objective

Navigated transcranial magnetic stimulation (nTMS) motor mapping has emerged to a valuable diagnostic tool in the preoperative workflow of brain tumor patients. Using nTMS data, functional outcome of brain tumor patients is significantly improved. Postoperative nTMS motor mapping is rarely performed in order to evaluate surgery-associated corticospinal tract injury and functional outcome.

### Methods

Patients who received pre- and postoperative nTMS motor mapping were analyzed in a retrospective study. All patients received microsurgical tumor resection aiming at gross total resection. Postoperative nTMS was conducted within 14 days after tumor surgery. Aside from clinical data, nTMS and DTI examinations were statistically analyzed. Corticospinal tracts (CST) were visualized at 75% of the patient"s fractional anisotropy threshold using pre- and postoperative DTI. Distances between the tumor and the CST (LTD) as well as the resection cavity and the CST (CTD) were measured and correlated. Primary outcome was the surgery-related motoric deficit after 4 weeks.

### Results

21 patients (52.4% female) aged 62.4 ± 15.8 years were included into the study. N=7 (33.3%) patients had high grade gliomas, n=8 (38.1%) cerebral metastases, n=4 (19%) meningiomas, n=1 cerebral abscess and n=1 radiation necrosis. 11 (52.4%) had postoperative worsening in motor function. Motor evoked potentials could be registered in 17 cases (81%). Mean LTD was 8.4 ± 6.7 mm and mean CTD was 9.0 ± 6.6mm ($rs$=0.65, p=0.017). Resting motor thresholds of the tumor hemisphere increased from 37.6 ± 9.9% to 47.9 ± 13.3% stimulator output (p=0.005), whereas motor thresholds of the contralateral hemisphere did not change postoperatively. Motor thresholds further increased significantly, if patients had a stable motor function (p=0.02), but remained unchanged in patients with persistent postoperative worsening in motor status. Additionally, if motor evoked potentials of the paretic limb could be registered, the deficit improved to at least MRC grade 4/5 in 7 out of 9 cases.

### Conclusion

Preoperative planning correlated well with postoperative tractography. Motor thresholds of the tumor side increased postoperatively. Motoric deficits significantly improved if postoperative nTMS mapping was possible. The results of the present study underline the predictive value of nTMS motor mapping even in patients with disrupted motor function.

# P152

## Die Herstellung einer Einzelzellsuspension aus frischem humanen peritumoralen Glioblastomgewebe: Vergleich verschiedener Gewebelyse-Protokolle mittels FACS

***Generating a single-cell suspension from fresh human peritumoral glioblastoma tissue: Comparison of different dissociation protocols with FACS analysis***

J. Falter[1], M. Xydia[2], P. Beckhove[2], N. O. Schmidt[1], M. Proescholdt[1]

[1]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland
[2]Leibniz-Institut für Immuntherapie, Regensburg, Deutschland

### Objective

The generation of a single-cell suspension from glioblastoma for further downstream single-cell analyses is an ongoing issue trading sufficient dissociation off against detrimental alterations or loss of single cell populations. Effects of pre-analytical dissociation protocols on potentially biasing loss of certain cell populations and the quality of dissociation remain elusive.

### Methods

Fresh human tissue samples from the peritumoral brain zone were processed according to different dissociation protocols and were analyzed with an 8-color FACS-analysis targeting immune cells. We separated the samples to compare manual dissociation vs. dissociation with gentleMACS™ Octo Dissociator (Miltenyi Biotec) and non-enzymatical vs. enzymatical (Collagenase IV / Collagenase I) and w/wo red blood cell (RBC) lysis. FACS analysis was performed with FACSLyric™ and the FACS-panel consisted of CD45-BV605, CD3-APC, CD20-PE, TMEM119-AF700, CD11b-BV421, CD16-PerCPCy5.5, CD4-PE-Cy7, CD8-APC-Cy7 and Zombie Aqua. Thorough compensation had to be performed for the intraoperatively used sodium fluorescein.

### Results

The proportion of CD45+ cells from the live cell population was 50% less with the non-enzymatic and manual dissociation protocol. From CD45+ cells, the proportion of CD3+ cells was only 10.6% with enzymatical (collagenase IV/DNase) dissociation and dissociation with gentleMACS™ Octo Dissociator, compared to 4.81% with the manual and non-enzmatic protocol. Within the D45+ population, the CD20+ cell proportion differed with 1.26% vs. 0.8%. The proportions within the CD45+CD3+ population of CD4+ (60%) and CD8+ (25%) did not differ, nor did cell numbers within the CD45+ cell population for CD11b+ (90%) and CD16+ (19%) show differences between groups. The novel TMEM119 (microglia-specific) marker showed good differentiation between CD11b+TMEM119+ and CD11b+TMEM119- cells with the enzymatic dissociation protocol. CD11b+ TMEM119- cells (i.e. macrophages) were lost with the non-enzymatic and manual protocol. Red blood cell (RBC) lysis showed detrimental effects on cell integrity with marked overall cell destruction.

### Conclusion

Gentle non-enzymatic and manual dissociation of tissue leads to a loss of T-cells, the very rare B-cells, and macrophages possibly via exclusion of doublets. Enzymatic dissociation is recommendable and RBC lysis should be avoided. Biases in downstream analyses can be introduced at the early stage of tissue dissociation; protocols have to be chosen and performed thoroughly.

# P260

## Untersuchung der Auswirkungen von EGFL7 auf Tumor-Mikroumgebung und Gesamtstoffwechsel des Körpers in einem experimentellen murinen GBM-Modell.

***Investigation of the effects of EGFL7 on tumor microenvironment and whole-body metabolism in an experimental murine GBM model***

P. Warnke[1], U. Schumann[1], A. Hagstotz[1], R. Stoll[2], M. H. Schmidt[1]

[1]Institute of Anatomy, Dresden, Deutschland
[2]Ruhr-Universität Bochum, Biomolecular NMR Spectroscopy, Bochum, Deutschland

### Objective

Glioblastoma multiforme (GBM) is the most common aggressive primary brain tumor, accounting for 80% of all primary CNS tumors in adults with a poor survival prognosis. It combines an extreme invasive growth, a highly immunosuppressive tumor microenvironment (TME) and lacks immunogenicity leading to a high recurrence rate. Continuous MRI monitoring is crucial. The aberrant metabolism in GBM has been identified as a potential therapeutic target and prognostic factor as shown for IDH-mutation. Metabolites such as lactate can lower intratumoral pH levels, impeding the activity of T-cells and other immune components. EGFL7, a potential prognostic marker, crucially modulates neoangiogenesis and blood brain barrier (BBB) integrity.

### Methods

Murine GBM cells (GL261) ectopically expressing EGFL7 were stereotactically implanted into the striatum of C57BL/6-mice. Pre- and post-tumor-implantation, intraperitoneal glucose tolerance test and body composition tests were performed to determine the effect of EGFL7 on GBM metabolomics. EGFL7-associated molecular patterns within the TME were assessed using bulkRNA sequencing of tumor tissue, NMR spectroscopy of serum and tumor tissue. In addition, NMR spectroscopy was used to compare intratumoral and blood stream levels of metabolites.

### Results

The implanted GBM influences body composition and glucose tolerance in mice leading to glucose resistance during tumor progression. Analysis of body composition reveals significant changes in fat, lean mass, and free fluid, especially in the final stage. Murine EGFL7 overexpression, examined through bulkRNA sequencing, induces notable shifts in metabolic pathways, with robust upregulation observed in lactate metabolism. Additionally, NMR-based metabolomics identified lactate as a discriminator in both tumor mass and peripheral blood of tumor-bearing mice. EGFL7 may indirectly support tumor growth by upregulation lactate metabolism. Furthermore, other aberrant pathways impacting the TME have been identified, suggesting additional functions of EGFL7.

### Conclusion

GBM metabolomics research is an auspicious option to improve GBM therapy and this study emphasizes that EGFL7 should be integrated. The combination of a disrupted BBB and an aberrant metabolism, potentially mediated by EGFL7, could lead to intratumoral metabolites entering the bloodstream. Our data indicate the need for further research on this topic to discover new anti-tumor agents and explore various potential observation parameters in a clinical setting.

# P154

## Zeit- und lokalisationsabhängige Genexpressionsänderungen und Ko-Färbemuster von Metabolismus- und Stammzellmarkern während der Progression des Glioblastoms

***Time and region dependent gene expression changes and co-staining patterns of metabolic and stemness markers during glioblastoma progression***

C. Kubelt[1], L. Gilles[1], D. Hellmold[1], T. Blumenbecker[1], E. Peschke[2], O. Will[2], H. Ahmeti[1], J. B. Hövener[2], O. Jansen[3], R. Lucius[4], M. Synowitz[1], J. Held-Feindt[1]

[1]University Medical Center Schleswig-Holstein, Campus Kiel, Department of Neurosurgery, Kiel, Deutschland
[2]University Medical Center Schleswig-Holstein, Campus Kiel, Section Biomedical Imaging, Molecular Imaging North Competence Center (MOIN CC), Department of Radiology and Neuroradiology, Kiel, Deutschland
[3]University Medical Center Schleswig-Holstein, Campus Kiel, Department of Radiology and Neuroradiology, Kiel, Deutschland
[4]Kiel University, Institute of Anatomy, Kiel, Deutschland

### Objective

Growth and therapeutic resistance of glioblastoma (GBM) are promoted by metabolic alterations. Also, glioma stem-like cells (GSCs), a subpopulation of GBM cells, contribute to these aggressive properties. Regarding metabolism, GSCs seem to be less glycolytic than the tumor bulk, however, they are able to switch between oxidative phosphorylation and aerobic glycolysis. Given that further knowledge of the metabolism of GSCs could be harnessed clinically, we focused on the connection between metabolic alterations and stemness.

### Methods

Time and region dependent gene expression changes and co-staining patterns of metabolic [pyruvate kinase muscle isozyme 1/2 (PKM1/2), glucose transporter 1 (GLUT1), monocarboxylate transporter 1/4 (MCT1/4)] and stemness markers [Nestin, Krüppel-like factor 4 (KLF4)] were analyzed using polymerase chain reaction and immunofluorescence double staining during GBM progression in a rodent model and patient-derived samples.

### Results

Rat tumor biopsies revealed a temporally increasing expression of GLUT1, higher expression of MCT1/4, Nestin, and KLF4, and lower expression of PKM1 compared to contralateral hemisphere. Patient-derived tumors showed a higher expression of PKM2 and Nestin in tumor center vs. edge. Whereas rare co-staining of GLUT1/Nestin was found in tumor biopsies, PKM1/2, and MCT1/4 revealed a more distinct co-staining with Nestin in rats and humans. In human and rat tumors KLF4 was mainly co-stained with GLUT1, MCT1, and PKM1/2. All of the metabolic markers yielded individual co-staining patterns among themselves. Co-staining mainly occurred later in tumor progression and more pronounced in tumor centers. Lastly, positive correlations were found amongst markers that showed co-staining.

### Conclusion

Our results highlight a link between metabolic alterations and stemness in GBM progression, with complex differences depending on the studied markers, time points, and respective regions.

# P155

## Resektion von motorisch eloquenten Tumoren - anhand nTMS Motor Mapping als hochriskant für postoperative Defizite klassifiziert

***Resection of brain tumors considered as high risk procedures for postoperative deficits according to nTMS motor mapping risk stratification***

T. Eibl[1], M. Schrey[1], A. Liebert[1], L. Ritter[1], R. Lange[2], H. H. Steiner[1], K. M. Schebesch[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Neurochirurgie, Nürnberg, Deutschland
[2]Klinikum Nürnberg, Paracelsus Medizinische Universität, Neurologie, Nürnberg, Deutschland

### Objective

Navigated transcranial magnetic stimulation (nTMS) motor mapping is an important tool for preoperative risk stratification of functional outcome prior to resection of brain tumors. Several models for nTMS-based risk assessment have been published. Main risk factors for permanent surgery-related motor deficits are distance to the corticospinal tract <8mm and infiltration of the motor cortex. An analysis of tumors which fulfill at least one risk factor has not been published yet.

### Methods

Patients with gliomas or cerebral metastases undergoing nTMS mapping for motor function (Nexstim NBS 5, Nexstim Oy, Helsinki, Finland) were retrospectively evaluated. Inclusion criteria were tumorous infiltration into the nTMS positive cortex and/or distance between the lesion and the tumor (LTD) <8mm.

Clinical examinations, imaging studies, nTMS examinations and tractography were analyzed. Primary endpoint was the occurrence of a new surgery-related motor deficit or worsening in motor status which persisted at least 4 weeks postoperatively.

### Results

74 patients (36.5% female) aged 56.8 ± 14.4 years were included. High grade gliomas n=42 (56.8%), low grade gliomas n=9 (12.2%) and cerebral metastases n=23 (31.1%). 38 (51.4%) presented preoperatively with motor deficits and hemiparesis was the most common preoperative deficit in 17 (23%) cases. nTMS positive cortex was infiltrated in 39 patients (52.7%), mean distance between the tumor and the corticospinal tract was 4.9 ± 4.8mm. A gross total resection (GTR) was achieved in 32 cases (43.2%). Postoperatively, 31 (41.9%) patients had new motor deficits or worsened motor function. Surgery-related deficits remained in 20 patients (27%). LTDs trended to be shorter if patients deteriorated postoperatively (p=0.099). In patients with preoperative intact motor status, lower resting motor threshold (p=0.003) and lower LTD (p=0.012) were risk factors for postoperative decline in motor function. Tumor histology, extent of resection and infiltration of the nTMS positive cortex were not associated with declining motor function.

### Conclusion

In high-risk situations, nTMS based presurgical planning potentially increases gross total resections. In patients with preoperative intact motor function, closer LTDs indicated an increased risk for postoperative motor deterioration and low motor thresholds were additionally associated with unfavorable functional outcome.

# P156

## Außergewöhnliche Malignität: Aggressive leptomeningeale Ausbreitung bei einem NF1-assoziierten Sehbahngliom

***Unprecedented malignancy: Aggressive leptomeningeal spreading in an NF1-Associated optic pathway glioma***

E. Rampeltshammer[1], S. Strobel[2], Y. Xiong[3], C. Monoranu[2], C. Matthies[1], A. F. Keßler[1]

[1]Universitätsklinikum Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Universitätsklinikum Würzburg, Institut für Pathologie, Abteilung Neuropathologie, Würzburg, Deutschland
[3]Universitätsklinikum Würzburg, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Würzburg, Deutschland

### Objective

Neurofibromatosis type 1 (NF1) is a genetic syndrome, affecting approximately 1 in 3,000 individuals globally, predisposing them to various tumors. NF1 patients often face risks such as low-grade gliomas (LGG) and neurofibromas of glial origin. Within the NF1 patient population, around 20% present with LGG, primarily pilocytic astrocytoma (PA), typically found in the optico-hypothalamic or cerebellar region. Malignant transformations in PAs, especially in NF1 patients, are rare, predominantly observed post-radiotherapy. Herein, we detail a case of a 30-year-old male NF1 patient experiencing aggressive meningeal spread of an initial optic pathway low-grade glioma (OPG).

### Methods

We analyzed the patient's clinical presentation, MRI findings, histopathological data, and conducted a comprehensive literature review.

### Results

The 30-year-old male with a longstanding NF1 diagnosis, including OPG since childhood was hospitalized for severe head and neck pain. Recent MRI scans, compared to prior assessments, showed a consistent OPG status. However, cerebrospinal fluid (CSF) anomalies initially pointed towards bacterial meningitis. Elevated intracranial pressure prompted the insertion of an external ventricular drainage (EVD). An increased cell count persisted despite antibacterial treatment, and CSF test were negative for bacteria. Subsequent cytological evaluations unveiled atypical cells with a Ki67 index > 50%, indicating hematologic neoplasia. The intense cellular dedifferentiation hindered definite histological classification. Despite emergency intrathecal chemotherapy, the patient's condition deteriorated rapidly, culminating in his demise three months post-admission. Histological analysis confirmed a fulminant malignant transformation of the OPG with widespread tumor dissemination across various neural regions.

### Conclusion

Despite an exhaustive literature review, no prior associations were found linking this specific presentation of OPG in an NF1 patient to such aggressive meningeal spread.

This case underlines the need for rigorous monitoring and genetic assessments in NF1 patients with PAs. Detailed investigations can yield crucial insights into disease trajectory, enabling prompt and individualized therapeutic interventions in such rare trajectories.

# P157

## Einfluss der unterschiedlichen second-line Therapien bei rezidivierten Glioblastom Patienten- eine retrospektive, monozentrische Studie

*Impact of different second-line therapies in recurrent glioblastoma patients – A retrospective, monocentric study*

H. Fischer[1], M. Sabel[1], M. Rapp[1]

[1]Universitätsklinikum Düsseldorf, Düsseldorf, Deutschland

### Objective

After the diagnosis of a glioblastoma (GBM) recurrence, there is no standard therapy defined. 2nd line therapy is discussed individually, depending on previous therapies, tumor localization and neurological patient condition in respect to balance increasing overall survival (OS) and maintaining quality of life (QoL). Here, we present a monocentric analysis of the impact of different therapy regimes after tumor recurrence at our neurooncological center.

### Methods

Patients with the diagnosis of the first recurrence of IDH wild-type GBM, who received initial therapy according to STUPP at our center, were divided into three groups according to the different treatment modalities. Group 1) received no further therapy, 2) adjuvant therapy only and 3) surgical re-resection, which was partially combined with further adjuvant therapy. Survival data and complications were correlated with sociodemographic data.

### Results

Between 2010 and 2022, 489 recurrent GBM patients were treated at our center. Finally, 343 patients could be included into further analysis (Group 1: 71 patients, group 2: 55 patients and group 3: 217 patients). In 71 patients a complete resection of recurrent GBM was performed. A residual tumor remained in 146 cases. Regarding OS a significant increase in the surgical patient group was observed (1: 2m, 2: 4m, 3: 8m; (p=<0.001)) but no significant difference in PFS (p=0.504). After three months a significant difference in KPS change within the groups (p=<0.001) became visible: Group 1) worsened by a median of 80, 2) by 10 points and 3) did not change in KPS after beginning of therapy. 123 patients in group 3) received intra-OP Gliadel wafer. There was no significant difference in median OS between patients with implantation and without implantation of Gliadel (with: 7m; without: 9m) (p=0.474). Nevertheless, no increased number of complications could be detected after implantation of Gliadel.

### Conclusion

Conclusion: Our data confirm the positive impact on OS of re-resection in recurrent GBM patients with stable KPS in the course of therapy. Additional intra-operative use of Gliadel Wafer is not correlated with increased post OP (>6months post OP) complication but interestingly in our patient cohort neither with impact on OS.

# P158

## Eine fragenbogenbasierte Studie zur Anwendbarkeit und Wirksamkeit wiederaufladbarer SCS-Neurostimulatoren mit ECAP-gesteuerter Closed-Loop-Technologie

***A questionnaire-based study of the usability and efficacy of rechargeable implantable pulse generators with ECAP-controlled closed-loop spinal cord stimulation***

M. M. Hajiabadi[1,2], C. Wieckhusen[1,2], P. Vicheva[1], M. Jakobs[1,2], S. Krieg[1,2], R. Ahmadi[1,2]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[2]Ruprecht-Karls-Universität Heidelberg, Neurochirurgie, Heidelberg, Deutschland

### Objective

Since 2004, rechargeable implantable generators (r-IPGs) for spinal cord stimulation (SCS) have promised extended lifetimes of up to 25 years. Novel closed-loop SCS (cl-SCS), based on evoked compound action potentials (ECAPs) as feedback, maintain consistent stimulation and mitigate potential over- or under-stimulation. However, long-term data on these devices, their recharging, interruption during recharging and effort are limited.

### Methods

A standardized 48-item questionnaire was sent to all chronic pain patients using a cl-SCS device. The primary endpoint was the overall convenience of the recharging process, rated on an ordinal scale from "very easy" (0 points) to "very difficult" (100 points). Secondary endpoints were charge burden (time spent recharging per week), user confidence and complication rates. Endpoints were analysed for multiplesubgroups.

### Results

Data sets of 8 SCS patients (62% return rate) were returned and eligible for data analysis. The mean age was 50.1 ± 7.8 (± SD) years. The duration of therapy with the IPG was 16.0± 8.3 months (mean ± SD). All patients checked and handled the IPG themselves. The overall handling of recharging was rated as "very easy" with 12.6 ± 12.7 points (mean ± SD). The mean charge burden was 202 ± 222 min/week (mean ± SD); 87.5% of the patients felt confident recharging the neurostimulator. Failed recharges and interruption of stimulation were reported in one patient.

### Conclusion

Chronic pain patients using cl-SCS are confident in using the IPG. It is more comfortable, but requires more effort than conventional devices, but has fewer problems with recharging and interruptions. These first data on the comfort and maintenance of cl-SCS call for a broader comparison with conventional SCS in future studies.

# P159

## Kombinierte epidurale Rückenmarkstimulation und sakrale Nervenstimulation zur Therapie des Schmerz-Inkontinenz-Syndromes mittels konkomitanter Stimulationsarten

***Combined spinal cord and sacral nerve stimulation for therapy of pain-incontinence syndrome with concomitant waveforms***

G. Bara[1], J. Maciaczyk[1]

[1]Universitätsklinikum Bonn, Stereotaxie und Funktionelle Neurochirurgie, Bonn, Deutschland

### Objective

Therapy resistant lower back and pelvic pain resulting from previous surgery, represents one of the most common indication for the chronic epidural spinal cord stimulation. Rarely, as a consequence of concomitant surgery-related injury, the patient may additionally suffer from voiding dysfunction also amenable to neurostimulation treatment. We present a combined spiinal cord stimulation (SCS) and sacral nerve stimulation (SNS) in small cohort of patients suffering from voiding dysfunction accompanied by neuropathic back/leg/pelvic pain.

### Methods

Patients failing the conservative treatment were referred through an interdisciplinary pelvic floor center. The implantation was performed in 4 patients suffering from low back/leg/ pelvic floor pain combined with void dysfunction. To target both of these symptoms, a SCS electrode and two S3 SNS electrodes were placed percutaneously for the trial period and connected to external stimulator in order to assess the efficacy of the stimulation. The trial lasted between 6 and 14 days, incorporated testing of various waveforms (tonic, microburst, FAST, Contour) and was followed by the implantation of a neurostimulator upon successful trial. Neurostimulator was able to deliver a distinct waveform to each electrode. Follow-up ranged from 1 to 3 months including pain intensity score and urodynamic examination.

### Results

All 4 patients had a successful trial and were subsequently implanted with a neurostimulator. Under tonic stimulation, all of them reported over 90% reduction neuropathic pain (median VAS 8/10 preoperatively and 1.5/10 postoperatively). Two of these patients suffered previously from bladder emptying problems with the necessity of self-catheterization. SNS restored normal bladder function with no need of further self-catheterization. 1 patient suffered from stress-incontinence which completely disappeared. The uro-dynamic exams showed no residual urine. To note, patients prefered paresthesia-free stimulation for lower back/leg pain and tonic stimulation for void dysfunction combined with tonic sacral stimulation.

### Conclusion

In this cohort of patients, we observed an significant response of pain-incontinence syndrome to the combined SCS/SNS therapy with pain reduction and restoration of bladder function. The application of concomitant waveforms broadens the therapeutic spectrum of complex pain-void dysfunction syndromes. The examination of lager cohort of patients is warranted.

# P160

## Computergestützte Fluiddynamik bei Patienten mit Trigeminusneuralgie – Vorstudie
*Computational fluid dynamics in patients with trigeminal neuralgia – Preliminary study*

D. Jankovic[1], K. Sasaki[2], F. Komatsu[2], K. Kralik[3], Y. Kato[2]

[1]University Medical Center, Department of Neurosurgery, Mainz, Deutschland
[2]Fujita Health University Bantane Hospital, Department of Neurosurgery, Nagoya, Japan
[3]Faculty of Medicine, J.J. Strossmayer University, Department of Medical Statistics and Informatics, Osijek, Kroatien

### Objective

In the last decade, computational fluid dynamics (CFD) has shown valuable application in the field of vascular neurosurgery. Although earlier studies showed higher values of wall shear stress in neurovascular conflict, hemodynamic patterns in the blood vessel after microvascular decompression are unknown. This study aimed to analyze the hemodynamic features of the offending artery preoperatively and postoperatively using computational fluid dynamics.

### Methods

We performed a retrospective study of 11 consecutive patients undergoing endoscopic decompression of trigeminal neuralgia at the Department of Neurosurgery, Fujita Health University Bantane Hospital. The patient data were de-identified before analysis. Basic demographic data and neurologic admission status were collected. Analyzed radiological findings including location and site of neurovascular conflict, and identification of offending vessel. Barrow Neurological Institute Pain Scale (BNI-PS) was used to analyze the pain intensity pre-operatively and postoperatively. Hemoscope software (Amin, Ziosoft Corporation, Minato ward, Tokyo, Japan) was used to process images from 11 patients who underwent microvascular decompression. Pressure (P), wall shear stress (WSS) gradient and vectors, normalized WSS, and streamlines (SL) direction and velocity were assessed.

### Results

This analysis included 11 patients with a median age of 71 years (54.5 % female). Superior Cerebellar Artery (SCA) was the most common offending vessel. Comparing the values of WSS on the three measured parts of the blood vessel using CFD, we noticed that the area of neurovascular contact had the highest WSS mean 2.8 Pa (IQR 2.4-4.43 Pa). In addition, we observed a decrease in WSS in the area of neurovascular contact postoperatively ($p=0.003$).

### Conclusion

Although there were high WSS preoperatively, we noticed that a lower WSS was observed postoperatively, in addition to a postoperatively better BNI pain score, especially in the area of neurovascular decompression. CFD could serve as an additional diagnostic tool in preoperative planning, as well as for evaluating the treatment outcome. The utility of CFD in the recurrence of TN cases should be investigated.

# P161

## Erfahrungen mit 40 intrathekalen Schmerzpumpen zur Behandlung des therapierefraktären Tumorschmerzes in terminal kranken Patienten

***Experience with 40 intrathecal programmable pain pumps for the treatment of refractory pain in terminalle ill patients***

M. Fritsch[1], A. Pabiniak[1], A. Kellner[1], M. Kunz[1]

[1]NCH DBKNB, Neubrandenburg, Deutschland

### Objective

Pain control presents a challenge in the management of terminally ill patients, with an expected survival time of less than one year. We implanted 40 lumbar intrathecal pain pumps in terminally ill patients with refractory cancer-related pain. All received a multidisciplinary evaluation and were treated between January 2017 and December 2022.

### Methods

The patient group consisted of 21 males and 19 females (age 35-83, mean age 65). The primary tumors were: 9 pancreas carcinoma, 6 mamma carcinoma, 6 prostata carcinoma, 5 colon/rectum carcinoma, 4 bronchial carcinoma, 3 plasmocytoma/lymphoma, 2 kidney carcinoma, 2 cervix uteri carcinoma, 1 bladder carcinoma, 1 stomach carcinoma. The patients stayed at the hospital 2-8 days after the surgery (mean 4,7 days). We observed one surgical wound break down requiring revision. No catheter dislocations were observed. All patients were followed regularly in 1-3 months intervall to refill and reprogram the pumps according to the actual pain status. The patients filled out questionnaires scoring their pain and its influence on their daily acitvities and quality of life. The follow up periods range from 2 months to 2 years (mean 8 months), depending on the individual cancer history.

### Results

We found a significant pain reduction and an increase in the quality of life in all patients.

### Conclusion

This is the largest reported series in Germany of terminally ill patients who received an intrathecal pain pump. We promote the concept of implantation even if patients are terminall ill and life expectency is limited to less than one year.

# P162

## Einfluss der COVID-19-Pandemie (C-19) auf Schmerzen, Lebensqualität und depressive Symptome bei Patienten mit Persistent Spinal Pain Syndrome Typ II nach Neuromodulation

***Influence of the COVID-19 pandemic on pain, quality of life, and depression in patients with Persistent Spinal Pain Syndrome Type II (PSPS Type II) provided with neuromodulation***

F. P. Schwarm[1], Y. El Barkani[1], J. Nagl[2], E. Uhl[2], M. A. Kolodziej[1]

[1]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland
[2]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland

### Objective

Coronavirus disease (C-19) has led to a global pandemic since its emergence in December 2019. The majority of research into C-19 has focused on transmission, and mortality and morbidity associated with the virus. However, less attention has been given to its impact on patients with persistent spinal pain syndrome type II (PSPS type II) supplied with spinal cord stimulation (SCS) or intrathecal morphine pump (ITMP).

### Methods

A single-center retrospective analysis of 86 patients with PSPS type II was performed. Medical records were analyzed from all patients treated with SCS and ITMP before C-19. Pain intensity (NRS), generic health status (EQ-5D-5L), Becks Depressions Inventory (BDI-V), and Pain Catastrophizing Scale (PCS) were assessed before as well as during the global pandemic. Further, the participants completed a self-designed C-19 questionnaire. Statistical analysis was performed using Mann-Whitney U and Wilcoxon rank-sum test.

### Results

In total, 43 patients with complete datasets were included in the final analysis. During C-19 there was a significant deterioration in the EQ5D5L (p=0.004) and BDI-V (p=0.001). There were no significant differences for NRS and PDI. Fear of C-19 infection could be seen as a significant predictor of NRS deterioration (p=0.032). 44% patients were affected by C-19 itself. No more subjective pain was reported during C-19 (88%), 84% saw no change in pain perception. Fear of a vaccination was denied by 88%. 40% of patients felt isolated. The majority of the patients did not state that doctors were less accessible (88%). Relationship status and media use had no influence on the outcome parameters.

### Conclusion

The results of this study showed a significant worsening of quality of life and depressive symptoms during the pandemic in patients with PSPS type II. Fear of C-19 could be seen as a negative predictive factor for pain perception. Neurosurgical pain patients were able to reach their therapists easily despite the pandemic.

# P163

## Trigeminusnervenlänge als prädisponierender Faktor für klinisch signifikante neurovaskuläre Konflikte bei Trigeminusneuralgie

***Trigeminal nerve length as a predisposing factor for clinically significant neurovascular conflict in trigeminal neuralgia***

F. Wolff Fernandes[1], S. Bergmann[1], K. Döring[2], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Medizinische Hochschule Hannover, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Hannover, Deutschland

### Objective

The etiology of trigeminal neuralgia (TN), particularly how neurovascular conflict or trigeminal nerve distortion induces pain, remains incompletely understood. This study aimed to investigate whether the anatomical configuration of the trigeminal nerve and its adjacent structures could serve as a predisposing factor for clinically significant neurovascular conflict in TN.

### Methods

We conducted a retrospective analysis involving 70 patients with idiopathic TN and 70 healthy participants, utilizing Constructive Interference in Steady State (CISS) magnetic resonance imaging. Measurements included the length of both trigeminal nerves from the nerve root entry zone to the entrance into Meckel"s cave, intertrigeminal distance, prepontine distance, and sagittal angle on each nerve at the level of the porus trigeminus. Correlations were made between the length and sagittal angle of the nerve on the painful and non-painful sides. Intraoperative findings, such as arterial compression, venous compression, and arachnoid membranes distorting the nerve, were recorded along with side and distribution of pain.

### Results

The mean age at surgery was 56 years (19 to 91 years). Arterial compression was the most common intraoperative finding (88.8%), followed by arachnoid adhesions distorting the nerve (73.8%), and venous compression (50%). A statistically significant difference was found in the mean length of the trigeminal nerve on the pain side compared to the non-pain side (10.6 vs. 10.3). Patients with TN had shorter trigeminal nerves compared to the control group on the left (11.3 vs. 11.9 mm) and right side (9.9 vs. 10.4 mm). However, no statistically significant difference was observed in the intertrigeminal distance, sagittal angle, and prepontine distance between the two groups. Additionally, a shorter trigeminal nerve correlated with a higher number of intraoperative findings, particularly venous compression and arachnoid adhesions.

### Conclusion

Our findings support the hypothesis that a shorter trigeminal nerve may render individuals more susceptible to clinically significant neurovascular conflict in trigeminal neuralgia.

Abb. 1

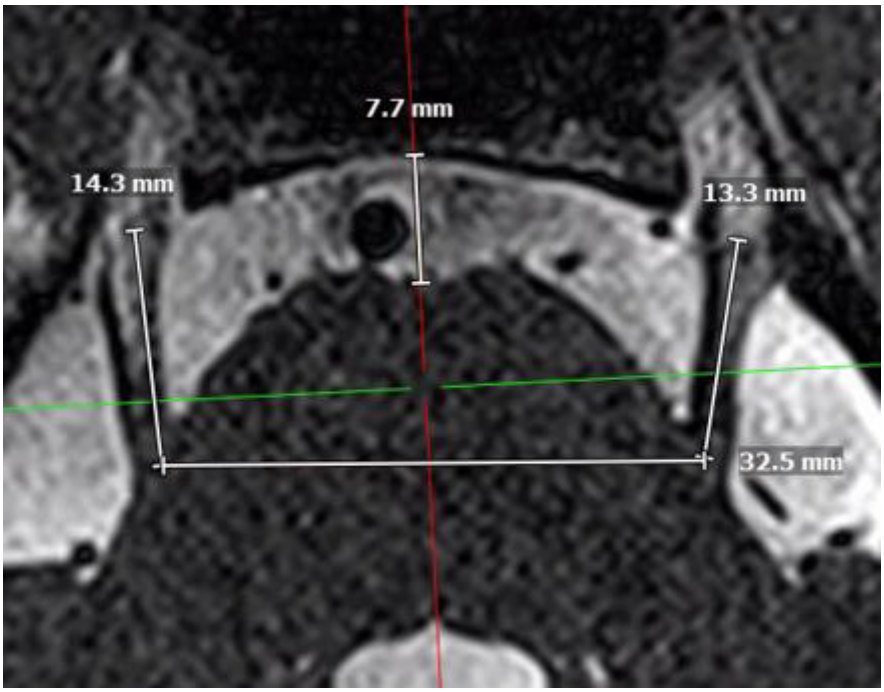
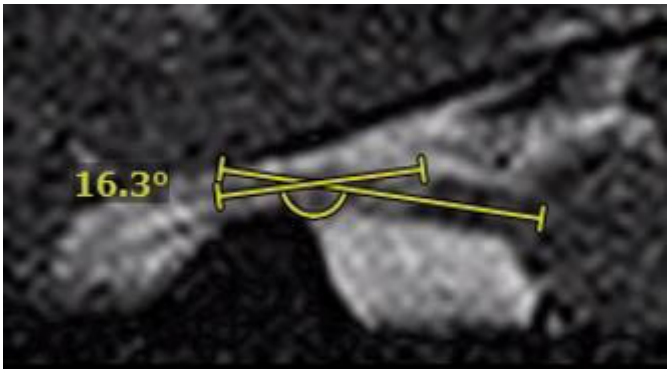



Abb. 2



# P164

## Frequenz-abhängige Modulierung der Motorneuron-Aktivität bei chronischen Schmerzpatienten unter thorakaler Rückenmarksstimulation

***Thoracic spinal cord stimulation using different waveforms does not modify motor unit behavior in the tibial anterior muscle in chronic neuropathic pain: preliminary findings***

C. Riera[1], D. S. de Oliveira[2], O. Schnell[1], A. Del Vecchio[2], T. Kinfe[1]

[1]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Neurosurgery, Erlangen, Deutschland
[2]Friedrich-Alexander University (FAU) Erlangen-Nürnberg, Artificial Intelligence in Biomedical Engineering, Erlangen, Deutschland

### Objective

Spinal cord stimulation involves the application of electrical currents to alleviate chronic neuropathic pain and most recently, activity-dependent spinal neuromodulation has been used for motor recovery of the lower limbs in spinal cord injuries. Despite its extensive use over decades, the precise mechanisms underlying the impact of burst spinal cord stimulation on motor neurons and muscle recruitment remains unclear. To investigate this, we employed different stimulation frequencies to explore its effects on motor neuron recruitment on individuals with chronic neuropathic pain.

### Methods

Participants performed isometric ankle-dorsal flexions at 15% and 30% of their maximum voluntary contraction force along with four isometric ramp contractions for each SCS waveform: off, tonic (130Hz), sham and burst (40Hz). We recorded muscle activity using high-density surface electromyography (HDs-EMG) with a 64-electrode grid placed on the tibial anterior muscle (TA). By decomposing the HDs-EMG signals into single motor unit action potentials, we evaluated motor unit recruitment and de-recruitment thresholds, discharge rate, inter-spike interval and common synaptic input to motor neurons (coherence). We analyzed the activity of the motor units tracked across all four stimulation types and compared their properties using a Friedman test (Fig.1).

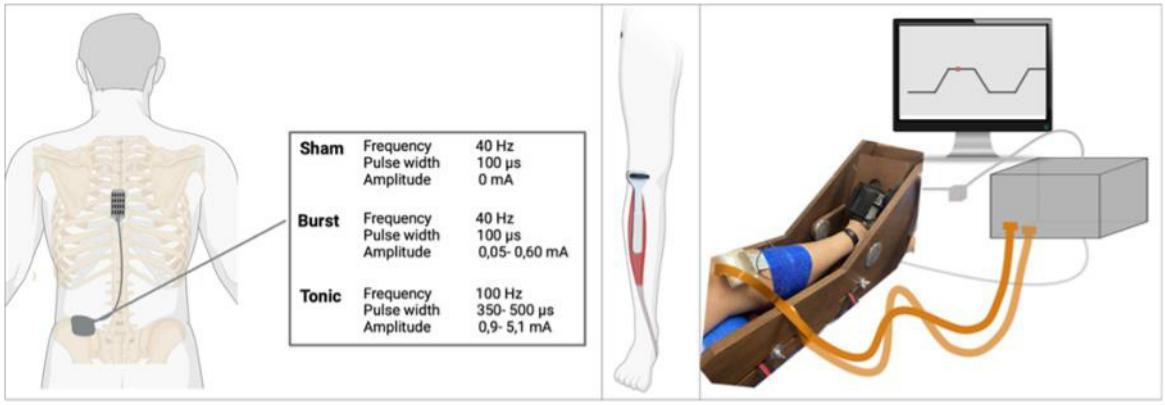
### Results

In this ongoing study, we included nine patients (5 females; 4 males; mean age 59 years) with chronic neuropathic pain (leg, lower back, or phantom limb pain), all with thoracic epidural stimulation at Th7 - Th8 spinal level. While a few subject-specific variations were observed, our study suggests that SCS across different waveforms (tonic versus burst versus sham) usually applied to treat chronic pain disorders does not significantly influence motor neuron recruitment in the TA muscle among the participants, considering short-term changes in the stimulation type.

### Conclusion

Contrary to reported activity-dependent, targeted spinal cord stimulation for lower limbs motor recovery, SCS using tonic and burst waveforms was found not to impact motor neuron activity. The data provided is of preliminary nature, however enlargement of the study cohort and an extended long-term follow up are on the way.

Abb. 1


Sham
Frequency
Pulse width
Amplitude
40 Hz
100 µs
0 mA
Burst
Frequency
Pulse width
Amplitude
40 Hz
100 µs
0,05- 0,60 mA
Tonic
Frequency
Pulse width
Amplitude
100 Hz
350- 500 µs
0,9- 5,1 mA

# P165

## Dreidimensionale Morphologie des Trigeminusnervs: Erforschung von Mustern und ihrer Rolle in der Pathogenese der Trigeminusneuralgie

***Three-dimensional morphology of the trigeminal nerve: Exploring patterns and their role in trigeminal neuralgia pathogenesis***

F. Wolff Fernandes[1], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland

### Objective

Neurovascular conflict (NVC) is the most common cause of trigeminal neuralgia, which paved the way for the success of microvascular decompression. While the correlation between severe neurovascular conflict and trigeminal neuralgia is established, a comprehensive understanding of the qualitative measures of trigeminal nerve distortion is lacking. Leveraging advanced imaging technology, we investigated the three-dimensional (3D) morphology of the trigeminal nerves in patients with trigeminal neuralgia, aiming to correlate deformities with the side, distribution of pain, and intraoperative findings.

### Methods

Patients with trigeminal neuralgia and an high-resolution magnetic resonance imaging (MRI) utilizing 3D constructive interference in steady state (CISS) were selected. Blinded evaluations of MRI scans were conducted, and trigeminal nerves were meticulously segmented using Brainlab Elements Software. The study included 41 patients with trigeminal neuralgia. Length, volume, and deformities in axial, sagittal, and coronal planes were blindly analyzed for each nerve.

### Results

The average age at the time of MRI was 58 years, with a mean pain duration of 4 years. Continuous pain components were observed in 9 patients, 4 patients had concomitant multiple sclerosis, and 9 patients presented with preoperative hypaesthesia. The mean slice thickness of scans was 0.5 mm (range 0.3-0.7). Painful side exhibited severe coronal deformities in 17%, moderate in 22%, and mild in 44% of patients, while non-painful side had 17% moderate, and 51% mild deformities. Sagittal deformities was present in 56% of nerves on the painful side, and in 39% of the nerves on the non-painful side. Coronal and sagittal deformities were associated with side and distribution of pain. Arachnoid adhesions contributed in sagittal and axial deformity of the trigeminal nerve.

### Conclusion

This study establishes that deformities in coronal, sagittal, and axial planes of the trigeminal nerve are associated factors in the pathogenesis of trigeminal neuralgia. Understanding these morphological nuances contributes to a better comprehension of the disorder and may aid in refining treatment approaches.

Abb. 1

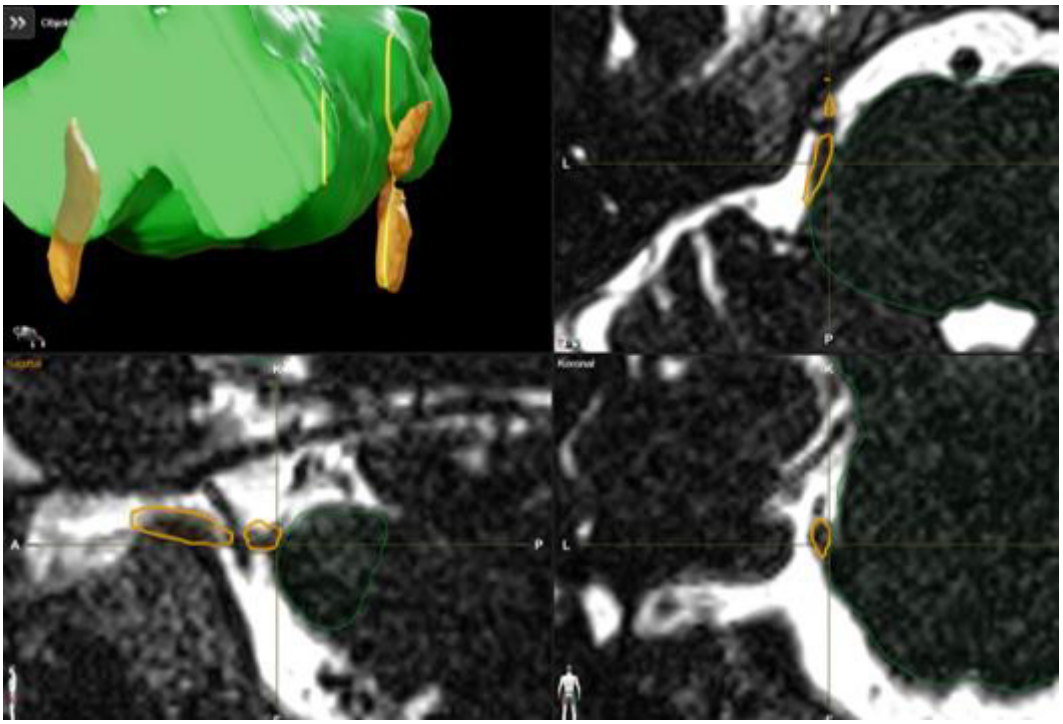
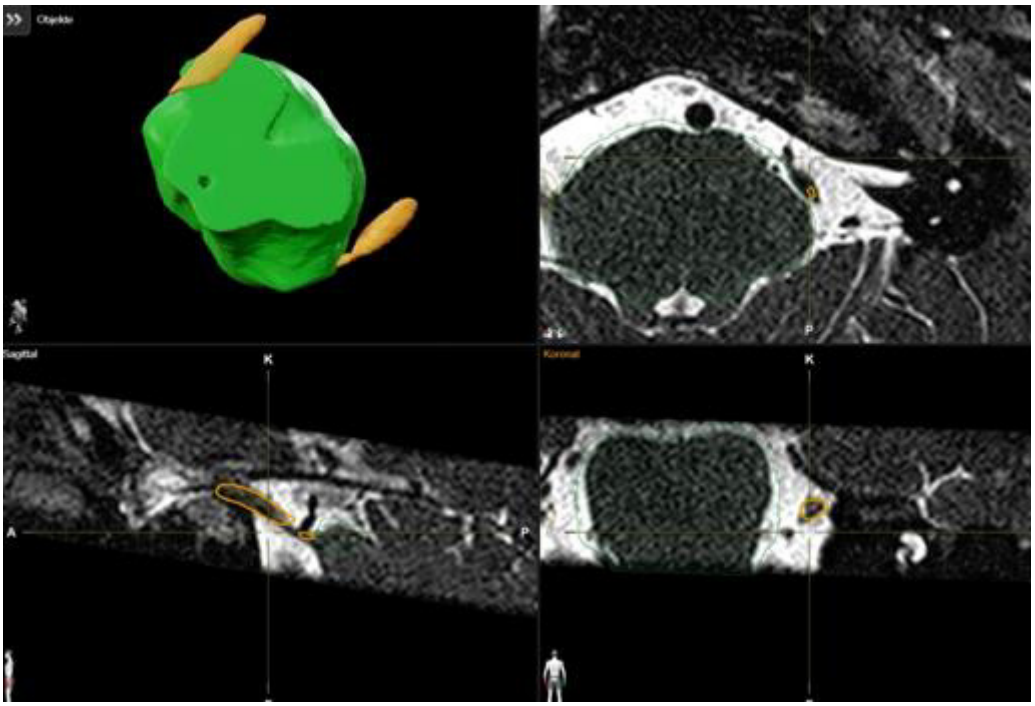


Abb. 2



# P166

## Einfluss hochenergetischer Protonenbestrahlung auf intrathekale Infusionspumpen
*The impact of high energy proton radiation on intrathecal infusion pumps*

M. Plettenberg[1,2], F. P. Schwarm[3], H. G. Zaunick[2], M. M. Meier[1], M. A. Kolodziej[3], E. Uhl[3], K. T. Brinkmann[2]

[1]Deutsches Zentrum für Luft- und Raumfahrt, Institut für Luft- und Raumfahrtmedizin, Köln, Deutschland
[2]Justus-Liebig-Universität Gießen, II. Physikalisches Institut, Gießen, Deutschland
[3]Justus-Liebig-Universität Gießen, Klinik für Neurochirurgie, Gießen, Deutschland

### Objective

Exposure to radiation environments such as in radiation therapy, is associated with malfunctions in active implanted medical devices. These errors are most likely caused by single subatomic particles hitting the device memory and altering information. However, there is little information on the response of intrathecal infusion pumps to particle radiation.

### Methods

8 explanted and fully functioning intrathecal infusion pumps were irradiated with a radiation therapy proton beam with an energy of 150 MeV and a total particle fluence of 1.1E9 protons/cm². One device was irradiated twice. The pumps were read out before and after irradiation and all changes in the programmed parameters were documented.

### Results

In the post-radiation analysis, devices were found in safety mode and set to a minimum flow rate in 6 cases. This was mostly caused by resets of the devices due to memory errors. Subsequently, all but one pump could not be easily reprogrammed to pre-irradiation settings.

### Conclusion

The analysis shows a distinct sensitivity of intrathecal infusion pumps to high energy proton radiation. This provides important information for the possible exposure of the devices in proton radiation therapy. However, further research is required to quantify the probability of malfunction.

# Funktionelle Neurochirurgie – Schmerz | Functional Neurosurgery – Pain

## P167

### Auswirkungen einer Operation auf die Schmerzsymptomatik bei Patienten mit peripheren Nerventumoren - Ergebnisse aus dem multizentrischen peripheren Nerventumorregister (PNTR)

***The effect of surgery on pain in patients with peripheral nerve tumors – Results from the multicentric Peripheral Nerve Tumor Registry (PNTR)***

N. Grübel[1], G. Antoniadis[1], R. König[1], A. Pala[1], C. R. Wirtz[1], N. Dengler[2], A. K. Uerschels[3], M. Pedro[1]

[1]Universitätsmedizin Ulm, Neurochirurgie, Günzburg, Deutschland
[2]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[3]Universitätsklinikum Essen, Neurochirurgie, Essen, Deutschland

#### Objective

Peripheral nerve tumors (PNT) are a heterogeneous subgroup of soft tissue tumors in association with peripheral nerves and are rare diseases. Clinical presentation can be versatile and include stress and rest pain, sensory and motoric deficits, or they can be found as incidental findings on imaging without any symptoms.

#### Methods

In total, the PNTR contains up-to-date data of 290 surgical treated patients from three high-volume centers. Patient characteristics (age, sex) as well as disease (affected nerve, tumor location, histopathology), surgical treatment (type of treatment, pre-and postoperative symptoms), radiological imaging, diagnosis of neurofibromatosis (NF), and long-term follow-up data including life quality data using a standardized questionnaire (EQ-5D-5L) were analyzed. In this sub-study, the effect of surgery on pain in patients with PNT was analyzed.

#### Results

In total data of 290 patients were included with schwannoma (58.6 *%*, *n*= 170) and neurofibroma (17.2 *%*, *n*=50) being the most prevalent histopathological diagnoses. Upper extremity was affected in 158 cases (54.4 %) whereas lower extremity was affected in 132 cases (45.5 *%)*. Plexus brachialis was in 16.8 *%* (*n*= 49) the most affected nerval structure. Patients were treated by complete tumor resection (*n*=245) in 84.1 *%,* biopsy in (*n*=27) 9.3 *%,* and partial tumor removal in (*n*=18) 6.2 *%*. 24 patients (8.2 %) were genetically proven with neurofibromatosis 1, 2, or schwannomatosis.

Prevailing preoperative clinical symptoms were pain during stress in 206 (71 *%)* and rest pain in 109 (37.5 *%*) patients. After surgery, patients benefited from highly reduced pain, only in 80 patients (27.5 *%*) pain was still present. These results are confirmed by a subgroup analysis of 171 patients analyzing their quality of life using the EQ-5D-5L questionnaire. In the domain of pain, the overall cohort benefited significantly from surgery ($p<0.001$).

#### Conclusion

In our cohort rest and stress pain were at initial diagnosis the most common clinical symptoms- not only in malignant tumors but also in benign PNT. The dimension of pain predominantly affected the overall life quality and was significantly improved by surgery. In summary, surgical therapy led to excellent pain relief.

# P168

## SIGNIFIKANTE VERBESSERUNG DER SCHMERZERGEBNISSE DURCH DEN EINSATZ EINER ALL-IN-ONE-RADIOFREQUENZ-INJEKTIONS ELEKTRODE IN EINER MULTIZENTRISCHEN, EUROPÄISCHEN FALLSERIE ZUR BEOBACHTUNG

***Significant improvement in pain outcomes using a disposable all-in-one radiofrequency injection electrode in a multicenter, observational european case-series***

F. Occhigrossi[1], G. Kyriakopoulos[2], G. Edward[3]

[1]Ospedaliera San Giovanni Addolorata, U.O.S.D. Terapia del Dolore, Rome, Italien
[2]St. Marien Hospital Hamm, Orthopaedics and Traumatology, Hamm, Deutschland
[3]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

### Objective

Developing radiofrequency technology that allows for maximizing practical efficiencies while maintaining clinical efficacy and patient safety is thus of great interest to relevant stakeholders. In this report, we describe our clinical experience using a disposable, all-in-one RF injection electrode (i.e., cannula, electrode, and injection tube) in patients with chronic pain as part of a multicenter European case-series.

### Methods

This is a real-world, retrospective, observational, case-series study of patients in Europe who underwent a radiofrequency-based procedure for chronic pain and were treated using a disposable, "all-in-one" RF injection electrode with combined cannula, electrode, and injection tube (Unified RF, Boston Scientific, Valencia, CA USA). Key data and clinical assessments include demographic characteristics, pain diagnosis, baseline, and post-treatment pain scores (Numeric Rating Scale, NRS), and percent pain relief.

### Results

To date, 111 enrolled subjects (mean age = 72.5 ± 13.1 years) who underwent an RF procedure for chronic pain using a disposable, all-in-one electrode have been assessed. Mean overall NRS pain score at baseline was 8.1. Patient-reported pain locations were the following: joints (26.1%), back (72.1%), hip (3.6%). The mean follow-up duration among all patients assessed was 259 days. Evaluation of overall pain demonstrated a mean NRS pain score improvement of 3.9-points ($p<0.0001$) representing a mean overall NRS pain score of 4.2 at last-follow-up. Additional data is being collected and updated results are to be reported.

### Conclusion

Results obtained in this evaluation demonstrate that use of a disposable, "all-in-one" RF injection electrode is associated with clinically meaningful pain relief outcomes in patients undergoing radiofrequency procedures for treatment of chronic pain.

# P169

## SCS bei neuropathischen Schmerzsyndromen, die mit Restless Legs Syndrom assoziiert sind
## *Spinal Cord Stimulation (SCS) for chronic neuropatic pain associated with Restless legs syndrome (RLS)*

J. Vesper[1], P. J. Slotty[1], P. McPhillips[2], A. Dreyer[2], Z. Krause Molle[1]

[1]Heinrich-Heine-Universität Düsseldorf, Sektion Stereotaktische und Funktionelle Neurochirurgie, Düsseldorf, Deutschland
[2]University Medical Center, Heinrich Heine University, Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland

### Objective

Spinal cord stimulation (SCS) is a well-established therapy for chronic neuropathic pain syndromes, only a few is reported about other conditions like gait disturbances (for PD e.g.) or other movement disorders. Restless legs syndrome (RLS) very common (3.9-14% prevalence)². It"s treatment consists usually in dopmaninergic medication. RLS can be a devastating painful and affecting sleep and patient's quality of life. We found in patient"s with SCS for PSPS I and II, which were associated with RLS, that their RLS symptoms improved as it was leg and back pain. We hereby present the first larger case series of patients with chronic neuropathic pain with associated RLS.

### Methods

We retrospectively reviewed the charts of 19 (9m, 10f) consecutive RLS patients, who underwent SCS implantation for PSPS I or II with concomitant targeting of RLS. Electrode (Octrode Abbott, Pleno) tip was placed in the midline Th7 under local anesthesia. One female patient did not responded during the trial, electrode was explanted. 18 patient remained for for follow-up.

### Results

The responder rate was very convincing. Beside the improvement in overall mean VAS baseline 9 vs. 3 at 1 mo follow up, Patients completed the International Restless Legs Syndrome Scale questionnaire to objectively quantify the severity of his symptoms. Follow up RLS Score is available in 4 patients yet. It improved after implantation from 35 (31-40) to 22 (10-34) on the 40-point scale.

### Conclusion

To our knowledge, this is the first reported case series using SCS as a potentially long-lasting, safe, and highly effective therapy for RLS. This effect may be explained by increased inhibition from hypothalamic cells controlling dopaminergic input to the spine. SCS turned out to be a potential alternative treatment for improving medical refractory RLS. Further prospective studies are warranted to proof the evidence.

# P170

## Sicherheitsparameter für die mikrowellenbasierte quantenmagnetische Messung mittels Stickstoff-Leerstellen in Diamanten in der neuronalen Mikroumgebung

***Safety parameters for microwave-based nitrogen vacancy diamond-based quantum magnetic sensing in the neural microenvironment***

V. D. Jariwala[1], A. N. Anisimov[2], C. I. Geiser[1], A. Wickenbrock[3], L. Hilfiger[4], U. G. Hofmann[1], T. Ball[1], A. Vlachos[4], O. Schnell[5], J. Beck[1], V. Ravi[1], G. V. Astakhov[2], K. Joseph[1]

[1]Department of Neurosurgery, Medical Center, University of Freiburg, Germany, Freiburg i. Br., Deutschland
[2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Deutschland
[3]Helmholtz Institute, Mainz, Deutschland
[4]Department of Neuroanatomy, Institute of Anatomy and Cell Biology, Faculty of Medicine, University of Freiburg, Freiburg, Freiburg i. Br., Deutschland
[5]Department of Neurosurgery, Universitätsklinikum Erlangen, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Deutschland

### Objective

Surgical removal of brain tumors necessitates a high degree of accuracy in safeguarding healthy tissue, particularly eloquent regions. In addition to existing neuronavigational techniques, quantum sensing technologies, which employ highly sensitive magnetic sensors based on nitrogen vacancies (NV) in diamonds, can be used. However, concerns have been raised regarding the safety of the sensor's application, which relies on the usage of additional microwave (MW) frequencies, particularly with the use of 2.86GHz. Further investigation is essential to evaluate the potential impact of MW on human neural tissue.

### Methods

A tailor-made configuration comprised of a millimeter-wave (MMW) antenna situated beneath *in-vitro* cultures (Microglia, Astrocytes, and GBM cells) at 1 mm. The cultures were exposed to MW at 2.86 GHz at 15 watts, selected based on a dosing curve, with exposure durations of 5/30 mins, followed by a 24-hour post-incubation period to investigate long-term effects. Functional changes to cells and network architecture were assessed using an established calcium imaging pipeline. A customized cell segmentation and analysis pipeline facilitated morphometric analysis and lactate dehydrogenase (LDH) cytotoxicity assays were conducted to assess the potential cytotoxic effects.

### Results

Morphometric analysis revealed no significant changes in morphology or cellular distribution post-MW exposure. Functional calcium signaling analysis revealed no changes in signaling activity nor network architectures due to exposure to MW. Our results reveal that exposure to MW at the chosen settings did not lead to a significant change in cytotoxicity across all studied cell types.

### Conclusion

The overall results of our study allowed us to determine safe MW limits for brain-based applications, with multimodal measurements including cellular motility, morphology, signaling, and cytotoxicity.

# P171

## Konsekutive Datenanalyse von telemedizinisch betreuten und programmierten Patienten
***Real- world data collection using remote programming for DRG and SCS patients***

A. Dreyer[1], P. McPhillips[1], Z. Krause Molle[2], J. Vesper[2]

[1]University Medical Center, Heinrich Heine University, Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland
[2]Heinrich-Heine-Universität Düsseldorf, Sektion Stereotaktische und Funktionelle Neurochirurgie, Düsseldorf, Deutschland

### Objective

Spinal cord and dorsal root ganglion stimulation (SCS and DRG-S) are standard of care for patients with chronic neuropathic pain. Travel times, lack of financial resources and transportation options strongly influence the individual"s decision on seeking healthcare. Telehealth in general refers to the exchange of medical information through electronic communication. However, it is usually restricted to video conferences, without interfering with implanted medical devices. A digital platform was recently introduced to enable remote programming in Neuromodulation. It is accessible via tablets/smartphones and allows direct contact between a patient and their doctor/pain nurse.

### Methods

We designed a prospective cohort to evaluate safety and performance of remote care in patients with SCS or DRG-S. Between January and October 2023, 28 patients were included. We assess up pain scores (VAS), EQ5D, pain Detect, Patient Global Impression of Care (PGIC) and telehealth usability questionnaire (TUQ) to evaluate the preoperative status, the status at implantation of the system, and the postoperative course. The postoperative data are assessed in the context of video conferences for remote programming.

### Results

This is an ongoing study. No travel or waiting time was assessed, since all patients received their appointment right in time at their home. The overall satisfaction with the telehealth system is high. TUQ 7/7 in all pats., mean PGIC 5 (4-6), mean VAS baseline/6mo (9/3). No lack of efficacy of stimulation or pain relief was found. In two out of the SCS patients, a mechanical problem was suspected, which led to an additional on-site visit, which was solved. Two patients reported technical difficulties dialing in due to limited abilities with smart devices.

### Conclusion

The general convenience with the system is high, which is conform to previously published data regarding telehealth in general. Previous publicationsl showed that wearables can be used for an objective quantification of symptoms without the need for clinic facility time. The use of remote programming offers . reduced travel times and costs, which allow simplified and more frequent programming. Especially in a pandemic or in case of travel limitations, it is a very helpful tool.

# P172

## REALE ERGEBNISSE DER THERMISCHEN RADIOFREQUENZABLATION BEI CHRONISCHEN SCHMERZEN IN DER LUMBOSAKRAL REGION

***Real-world outcomes using thermal radiofrequency ablation for chronic pain of the lumbosacral region***

G. Kyriakopoulos[1], F. Occhigrossi[2], G. Edward[3]

[1]St. Marien Hospital Hamm, Orthopaedics and Traumatology, Hamm, Deutschland
[2]Ospedaliera San Giovanni Addolorata, U.O.S.D. Terapia del Dolore, Rome, Italien
[3]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

### Objective

Minimally invasive interventional pain procedures, such as thermal radiofrequency (TRF) ablation, have steadily progressed to become a key segment of the therapeutic armamentarium now available to the chronic pain patient population. Conventional monopolar or bipolar TRF uses the application of heat (temperature up to 85°C) to thermo-coagulate and ablate branches of spinal nerve roots or other neural tissue, thus interrupting pain signal transmission. Here, we report real world-collected outcomes from a study of patients treated with TRF for management of chronic pain.

### Methods

This is a real-world, retrospective, observational, case-series study of patients in Europe who underwent a radiofrequency-based procedure for chronic pain and were treated using a variety of disposable Electrodes and Cannulas with the G4 Generator (Boston Scientific, Valencia, CA USA) such as: the Flextrode for the intervertebral disc, Side Kick RF cannulas and the Palisade guide for the RF of the sacroiliac joint and the medial branch of the facet joints, the RCE Electrode and RF cannulas with blunt active tip for the (epidural) pulsed RF of the nerve roots and epidural space. Key data and clinical assessments include demographic characteristics, pain diagnosis, baseline, and post-treatment pain scores (Numeric Rating Scale, NRS), and percent pain relief.

### Results

Eighty-four patients who received thermal RF for treatment of chronic pain of the facet joints, the intervertebral disc, and thesacroiliac joint have been assessed to date. Significant improvement ($p<0.0001$) in NRS pain scores was noted at mean last follow-up visit (mean duration: 296 days). This consisted of a reduction in NRS pain scores from 8.0 at baseline to 3.3 at last follow-up. An 81% responder rate (proportion of patients with >30% pain relief ) was also noted at mean last follow-up. Additional data to be presented

### Conclusion

Preliminary data from this ongoing, European, multicenter, observational case-series of 84 chronic pain patients (no new onset of pain at follow up) who utilized thermal radiofrequency demonstrate significant reduction in pain (4.8-points NRS score reduction, $p<0.0001$) at last follow-up (mean = 296 days).

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P216

### Charakterisierung verzögerter Shunt-Nichtansprechbarkeit bei idiopathischem Normaldruckhydrozephalus (iNPH): Prädiktive Faktoren und Verlauf der Erkrankung über einen Nachbeobachtungszeitraum von 10 Jahren

***Characterising late shunt non-response in iNPH: Predictive factors and disease course over a 10-Year follow-up period***

S. G. Thavarajasingam[1,2], M. El-Khatib[2], V. K. Sajeenth[2], K. V. Vemulapalli[2], A. Salih[2], D. Jankovic[1], A. Kramer[1], M. Ottenhausen[1], D. Kalasauskas[1], F. Ringel[1]

[1]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland
[2]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich

#### Objective

Positive shunt response (S-R) is the gold standard for diagnosing idiopathic normal pressure hydrocephalus (iNPH). Due to multiple pathologies mimicking iNPH symptoms up to 40% of shunted patients do not exhibit clinical improvement within 12 months. With improved monitoring, the phenomenon of late shunt non-responders (S-NR) has become more evident in practice, with patients demonstrating delayed deterioration several years after shunting. The aim of this study is to define the clinical course and predictors of late S-NR.

#### Methods

In this retrospective study, we included patients that underwent ventriculoperitoneal (VP) shunt surgery for iNPH between December 2006 and December 2016. All patients received a lumbar puncture (LP) prior to surgery. Patients were stratified as early (3 years) S-NR. Time series plotting, chi-squared tests, stepwise and regularisation-boosted multivariate regression analyses were used for data analysis.

#### Results

Sixty-five iNPH patients who were treated with VP shunting at a tertiary care center were included in this study, with a mean follow-up of 3.75 years. Overall, 30 (46%) patients were S-R, and 35 (54%) were considered S-NR. Within the S-NR group, 10% were considered early S-NR, 6% intermediate S-NR, 28% late S-NR and 26% very late S-NR. Compared to all response groups, the strongest differentiator of S-NR groups was post-LP improvement in urinary incontinence (58% in very late S-NR, 0%-5% in early and late S-NR, $p<0.001$), as well not having an Antisiphon device (58% in very late S-NR, but 0%-5% in early and late S-NR, $p<0.05$). Having a Codman Hakim shunt ventile was associated with late and very late S-NR ($p<0.05$). Hygromas were present in 29% of very late S-NR and 11% late S-NR, but not in early S-NR ($p<0.05$).

#### Conclusion

Strong predictors of very late S-NR are found to be post-LP improvement in urinary incontinence and the absence of an Antisiphon device, as well as having a Codman Hakim shunt ventile. Late S-NR in iNPH is a clinical phenomenon that remains poorly understood. This is partly due to the extended follow-up period required for detection. Further prospective research is required to characterise this iNPH subtype.

Abb. 1

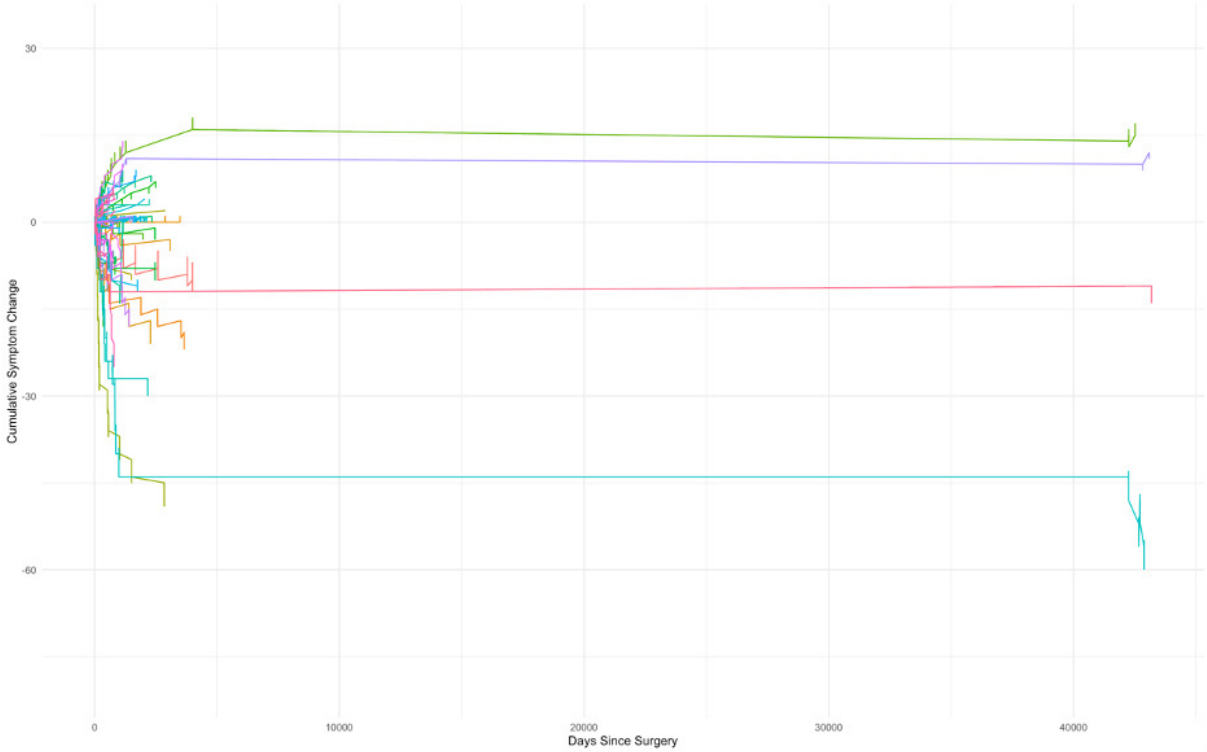
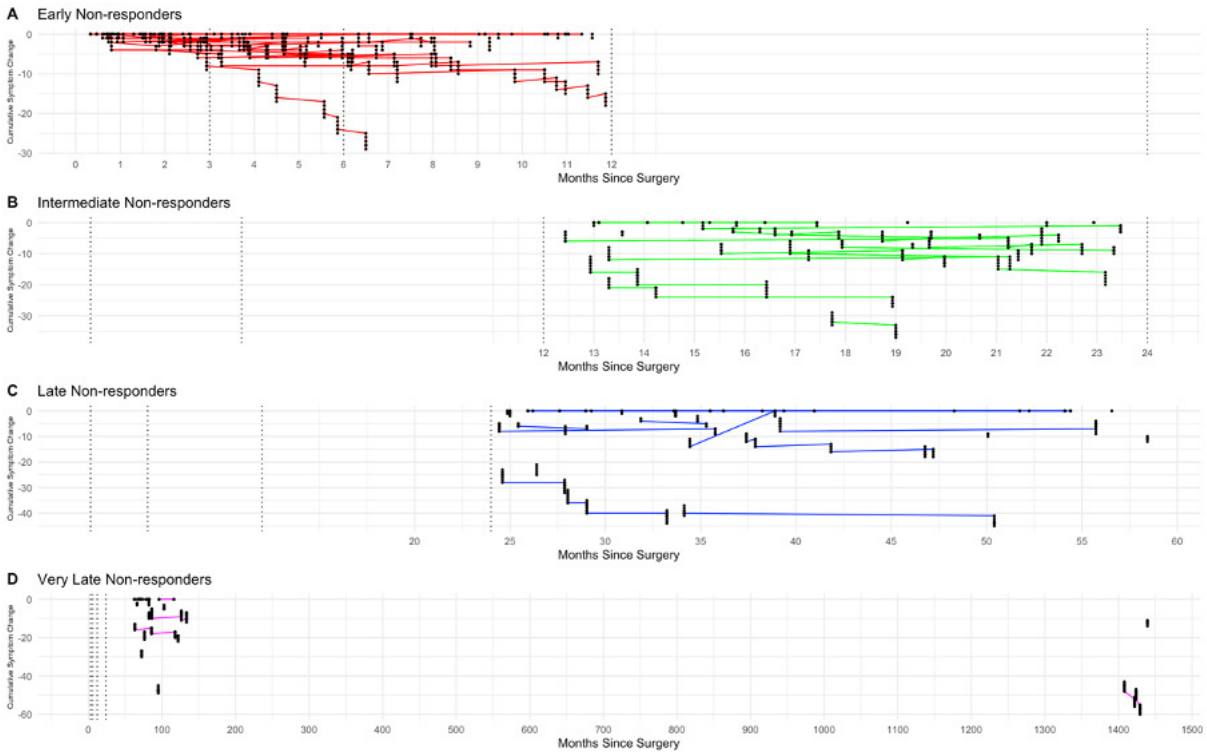

Cumulative Symptom Change
Days Since Surgery

Abb. 2


A Early Non-responders
B Intermediate Non-responders
C Late Non-responders
D Very Late Non-responders
Months Since Surgery

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P217

### Die Wertigkeit des CT-gesteuerten epiduralen Bloodpatches in der Behandlung der spontanen intrakraniellen Hypotension

*CT-guided epidural blood patching for the treatment of spontaneous intracranial hypotension*

M. Polemikos[1], F. Donnerstag[2], H. Lanfermann[2], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Medizinische Hochschule Hannover, Diagnostische und interventionelle Neuroradiologie, Hannover, Deutschland

#### Objective

Spontaneous intracranial hypotension (SIH) is a disorder characterized by incapacitating postural headaches resulting from a spontaneous spinal cerebrospinal fluid (CSF) leak. While Epidural Blood Patching (EBP) is a well-established intervention in the treatment of SIH, the optimal approach remains uncertain due to the diverse techniques employed. The aim of this study was to evaluate the efficacy of CT-guided EBP in the treatment of SIH.

#### Methods

All patients with SIH who were treated from 2010 to 2022 in our hospital were retrospectively analyzed. A 22G Tuohy needle was advanced under CT-guidance in the epidural space using the loss-of-resistance technique. To confirm accurate needle tip placement in the epidural compartment, a small amount of contrast medium was injected. EBP procedures were conducted as either non-targeted or targeted deliveries. The volume of sterile autologous blood injected varied and was primarily determined by patients" feedback during the procedure or through retrograde blood flow when the procedure was performed in general anesthesia.

#### Results

Among forty-eight patients (37 women and 11 men) treated for SIH, 16 underwent not-targeted and 32 underwent a targeted EBP at a median age of 49 years (range 40-74 years). In the targeted EBP group, 15 patients received single-level EBP, 14 had a two-level procedure and 1 underwent a three-level EBP. The median duration of symptoms prior EBP was 4 weeks (range 2 days - 215 weeks). The response rate after the first EBP was 75% (12/16) in the not-targeted and 90% (29/32) in the targeted group. In the not-targeted group, 3/4 patients exhibited improvement after a second EBP, resulting in an overall response rate of 94%. In the targeted group, each one patient improved after a second and a third EBP, leading to an overall response rate of 97% (31/32). Adverse events included 2 cases of transient rebound intracranial hypertension and one instance of transient radiculopathy.

#### Conclusion

Our results emphasize the efficacy of CT-guided EBP in managing SIH, with a minimal incidence of transient adverse events.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P219

### Evaluation neuroendoskopischer intraventrikulärer Trainingsmodelle.
*Evaluation of neuroendoscopic intraventricular training models*

S. Senger[1], M. Lepshokov[1], G. Colombani[1], T. Tschernig[2], G. Cinalli[3], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Universität des Saarlandes, Institut für Anatomie, Zellbiologie und Entwicklungsbiologie, Homburg a. d. Saar, Deutschland
[3]Ospedale Pediatrico Santobono Pausilipon, Pädiatrische Neurochirurgie, Neapel, Italien

#### Objective

A structured surgical education has become more and more important over the last years. Intraventricular neuroendoscopic procedures have been widely established. However, the training of the surgical skill with these techniques are crucial for young residents due to the potential harms to the adjacent tissue. Therefore, we evaluated two different training models.

#### Methods

Participants in two different international workshops were trained on a prefixed cadaver model and on a living murine intrabdominal model. Crucial neuroendosopic techniques like membrane perforation and tissue biopsy were performed. A blinded questionnaire evaluated both models.

#### Results

Sixty-three participants were trained on the animal model. Forty of these trained on the cadaver model in addition. The training effect was evaluated almost equally with 8.5/10 for the animal and 8.9/10 for the cadaver model. The tissue properties were rated higher regarding realism in the animal model whereas the anatomic learning effect was rated higher in the cadaver model.

#### Conclusion

The animal model is a valid alternative to cadaver models for teaching endoscopic neurosurgical skills. This model benefits from the simulation of a real surgery regarding tissue properties including bleeding simulation. The low costs and availability makes it more ubiquitous available and can help to train further generations of neurosurgeons.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P220

### Vom frühen Nutzen zu langfristigen Veränderungen: Effekte der Shunt Operation bei idiopathischem Normaldruckhydrozephalus

***From early gains to long-term varicanes: Assessing shunt surgery impact on idiopathic normal pressure hydrocephalus***

H. Spielmann[1], B. Beck[1], S. Senger[1], C. Sippl[1], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

Treatment effect in normal pressure hydrocephalus is traditionally measured with changes of symptoms within the Hakim triad. Here the authors report their long-term results with a test battery for evaluation of cognitive function, quality of life and motor skills after shunt treatment for normal pressure hydrocephalus.

#### Methods

This study focusses on long-term follow-up of 30 individuals diagnosed with idiopathic normal pressure hydrocephalus and treated with ventriculoperitoneal shunting. The cohort's assessments were conducted at one, two, and three years post-shunt surgery, utilizing a comprehensive test battery that measured psychomotor skills, gait, neuropsychological abilities, and quality of life.

#### Results

Over the three-year period, the cohort of idiopathic normal pressure hydrocephalus patients exhibited a complex diverging outcome pattern. While certain parameters displayed sustained and progressive improvements, it is noteworthy that some specific aspects showed fluctuating results. While the quality of life slowly deteriorated, the motor skills shows a constant improvement. Neuropsychology showed many fluctuations. While some neuropsychological tests shows consistent improvement like the Stroop Test. Mini Mental Status Test and DemTect showed deterioration. Despite these fluctuations, the overall long-term result for the majority of participants remained positive.

#### Conclusion

This shows that also for quality of life and cognitive function a long-term benefit after shunt placement for normal pressure hydrocephalus can be seen. However, some aspects show an individual variability in response to shunt surgery. This highlights the need for personalized approaches in managing the long-term outcomes of idiopathic normal pressure hydrocephalus patients.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P221

### Vaskuläre Risikofaktoren bei idiopathischem Normaldruckhydrocephalus: Häufigkeit und Effekt auf das Behandlungsergebnis nach Shuntanlage

***Vascular risk factors in idiopathic normal pressure hydrocephalus: frequency and effect on outcome after shunting***

P. Ertl[1], G. Lütjens[1], E. J. Hermann[1], H. E. Heissler[1], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland

#### Objective

Idiopathic normal pressure hydrocephalus (iNPH) has received renewed attention more recently after some clinicians having even doubted its existence. Aetiology and pathophysiology still remain unclear to date. There is conflicting data on the frequency of vascular risk factors in patients with iNPH. Here we analysed the frequency of arterial hypertension, diabetes mellitus and coronary heart disease in a large contemporary cohort of patients.

#### Methods

Over a 9-year period 204 patients underwent shunt surgery for iNPH at our institution and 182 patients were available for follow-up. Preoperative and follow-up data were prospectively recorded and retrospectively analysed. The influence of risk factors on both short and long-term outcome after shunting was evaluated.

#### Results

Arterial hypertension was by far the most frequent finding (139 patients, 77%), followed by coronary heart disease (40 patients, 22%), and diabetes mellitus (38 patients, 21%). There was no significant influence of these findings on short (p=0,25) or long-term outcome (p=0,92) after shunting.

#### Conclusion

Strikingly common and by far the most prevalent finding in our study was arterial hypertension. Although it has been postulated that arterial hypertension might be causally involved in the development of iNPH, it appears that there is no clear effect on outcome after shunting.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P222

### Latente Hydrocephalus nach Resektion einer Metastase in der hinteren Schädelgrube: Inzidenz, risiko Faktoren und Evaluation der Notwendigkeit der Anlage einer prophylaktischen präoperativen EVD

***Transient hydrocephalus following resection of brain metastasis located in the posterior fossa: Incidence, risk factors and the necessity of perioperative external ventricle drainage placement***

E. Shabo[1], A. L. Potthoff[1], T. Zeyen[2], M. Hamed[1], F. Lehmann[3], A. Radbruch[4], M. Banat[1], D. Peach[4], U. Herrlinger[2], V. Borger[1], H. Vatter[1], M. Schneider[1]

[1]Universitätsklinikum Bonn, Klinik mit Poliklinik für Neurochirurgie, Bonn, Deutschland
[2]Universitätsklinikum Bonn, Division of Clinical Neuro-Oncology, Department of Neurology, Bonn, Deutschland
[3]Universitätsklinikum Bonn, Department of Anesthesiology and Intensive Care Medicine, Bonn, Deutschland
[4]Universitätsklinikum Bonn, Department of Neuroradiology, Bonn, Deutschland

#### Objective

Prophylactic insertion of an external ventricular drain (EVD) prior to the resection of intracranial metastases in the posterior fossa is a common approach to address potential postoperative transient hydrocephalus. However, predicting transient hydrocephalus in the preoperative phase continues to be a challenge. This study aims to identify risk factors for the development of postoperative transient hydrocephalus, thereby ascertaining the necessity and effectiveness of prophylactic EVD in surgery for posterior fossa metastases.

#### Methods

Between 2015 and 2021, 130 patients underwent surgery for posterior fossa metastases at the authors" neuro-oncological center. Transient hydrocephalus was defined as a cerebrospinal fluid (CSF) cumulative drainage of ≥ 50 ml/d in the early postoperative phase. Tumour volume, edema volume, and 4th ventricle volume were assessed on preoperative magnetic resonance imaging scans using the TumorTrackingTool via the IntelliSpace Portal 5.0. A multivariable logistic regression analysis was performed to identify predictors for postoperative transient hydrocephalus occurrence.

#### Results

Transient postoperative hydrocephalus occurred in 14 of 130 patients (11%). Multivariable analysis and receiver operating characteristic (ROC) analysis revealed a 4th ventricle to tumor volume ratio ≤ 0.02 (OR 33.1, 95% CI 3.8-284.3, p=0.001), an edema to tumor volume ratio ≤ 0.85 (OR 10.6, 95% CI 2.4-47.4, p=0.002), an imaging-morphological contact to the 4th ventricle (OR 5, 95% CI 1.4-18, p=0.013), and multiple intracranial metastases (OR 2.4, 95% CI 1-5.9, p=0.045) as independent predictors for the development of transient postoperative hydrocephalus.

#### Conclusion

The present study identifies preoperatively collectable risk factors for the occurrence of transient hydrocephalus in the early postoperative phase following surgery for posterior fossa metastases. These findings may guide the decision-making process regarding the need for prophylactic EVD placement.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P225

### Der LMQ 20 Fragebogen – ein mögliches Instrument zur ambulanten Nachsorge von iNPH Patienten mit bereits einliegendem Shunt

***The LMQ 20 questionnaire – A potential outpatient follow-up tool for iNPH patients treated with shunt placement***

M. Sitz[1], R. Heinz[1], M. Danne[1], J. Lemcke[1], P. Schuss[1], A. Hadjiathanasiou[1]

[1]BG Klinikum Unfallkrankenhaus Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

#### Objective

A new patient-oriented questionnaire is to be introduced for follow-up of patients suffering from idiopathic normal pressure hydrocephalus (iNPH) who have been treated with shunt placement. The Late-onset hydrocephalus Monitoring Questionnaire (LMQ 20) questionnaire is to be implemented as a self-assessment tool to detect worsening of symptoms at an early stage and to seek professional assistance.

#### Methods

A total of 43 outpatients received the LMQ 20 questionnaire between 07/2022 and 04/2023 prior to examination. The questionnaire was completed by the patients themselves and their accompanying relatives. The questionnaire explored bladder function, mobility and gait disturbances, mental and memory function and consists of 16 questions to be answered by the patients and 4 to be answered by an accompanying person. The LMQ 20 was then compared to the Kiefer score, which was determined by a physician. The subgroups of both questionnaires were dichotomized in good and poor function and subsequently compared with each other.

#### Results

Overall, there were no significant differences between subgroup analysis with regard to the quantification of symptoms. The LMQ 20 and the Kiefer score provided comparable results in terms of iNPH symptoms. 51% of the patients in the LMQ 20 vs. 47% patients in the Kiefer score questionnaire showed symptoms of incontinence (p=0.67). 49% of the patients in the LMQ vs. 33% of the patients in the Kiefer score reported mobility and gait disturbances (p= 0.19). 9% of the patients in the LMQ 20 vs. 3% patients in the Kiefer score demonstrated relevant mental and memory function deficits (p=0.36).

#### Conclusion

The LMQ 20 is comparable with the Kiefer score for assessing the neurological status of patients with iNPH treated with shunt. The questions are formulated in such a way that no medical knowledge is required and therefore a simple assessment by the patients themselves seems feasible. The LMQ 20 may prove to be a valuable additional tool for the detection and monitoring of early neurological deterioration in iNPH outpatients.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P226

### Nicht-invasive MRT Messungen bei idiopathischer intrakranieller Hypertension
*Non-invasive MRI measurements in idiopathic intracranial hypertension*

F. Volz[1], A. El Rahal[1], W. Lagreze[2], M. Reisert[3], A. Camp[2], T. Bleul[2], M. Shah[1], H. Mast[4], S. Küchlin[2], S. Elsheikh[4], N. Lützen[4], J. Beck[1], H. Urbach[4], K. Wolf[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[2]Universitätsklinikum Freiburg, Augenheilkunde, Freiburg i. Br., Deutschland
[3]Universitätsklinikum Freiburg, Klinik für Radiologie, Abteilung Medizinphysik, Freiburg i. Br., Deutschland
[4]Universitätsklinikum Freiburg, Klinik für Neuroradiologie, Freiburg i. Br., Deutschland

#### Objective

Patients with idiopathic intracranial hypertension (IIH) typically present with positional headaches and visual disturbances. Commonly, therapy is monitored by the course of the papilloedema. However, mounting evidence of IIH patients displaying CSF leaks, IIH without papilledema, rebound hypertension following CSF leak closure, chronic headaches unrelated to ICP evolution, underscores the need for noninvasive patient monitoring. Spinal cord motion mainly reflects the pulsatile changes of different pressure gradients derived from CSF, blood and breathing. It can be measured by non-invasive phase-contrast MRI. A recent study showcased raised spinal cord motion using MRI-based assessments in patients with CSF leaks (Wolf et al. 2023). We hypothesized decreased spinal cord motion in patients with raised ICP.

#### Methods

We performed a prospective, controlled study on 20 IIH patients, 100% female, with proven elevated CSF pressure $^{3}$25cmH2O and papilloedema without loss of visual acuity (age: 36 ± 9 years), and 30 female healthy controls (age: 38 ± 12 years). All subjects received ECG-triggered phase-contrast MRI measurements at the spinal level C2/C3. Analysis was fully automated (www.nora-imaging.org). The velocity range (mm/s) and the total displacement (mm) of the time-resolved velocity curve was used as the main parameter. Additionally, comparison was conducted using parameters adjusted to age based on previously reported data (Beltran et al. 2023) Pairwise comparisons were made by Mann-Whitney U test; correlation was determined using regression models.

#### Results

Spinal cord velocity range and total displacement was significantly lower in IIH patients as compared to controls: 3.9 ± 1.5 mm/s vs. 5.4 ± 1.1 mm/s, p=0.002; 0.5 ± 0.1 mm vs. 0.7 ± 0.2 mm, p=0.002 (Figure), adjusted velocity range and adjusted total displacement: 6.3 ± 1.3 mm/s vs. 7.7 ± 1.1 mm/s, p=0.002; 1.0 ± 0.2 mm vs. 1.3 ± 0.2 mm, p<0.001. Opening pressure and BMI showed no significant impact on dynamic parameters in IIH patients.

#### Conclusion

We present evidence that in conditions associated with heightened ICP, the natural oscillations of the spinal cord are subdued. Consequently, this non-invasive method could aid in resolving clinical and diagnostic uncertainties and further studies are warranted.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P227

### Chronische Erweiterung des Ventrikelsytems in Patienten mit posttraumatischem Hydrozephalus nach schwerem SHT. Nur chronisch oder Unterdrainage?

***Persistent enlargement of ventricular system in patients with posttraumatic hydrocephalus after severe TBI. Only chronic underdrainage?***

A. Alaid[1], R. Martinez[1]

[1]Bergmannsheil Bochum, Neurochirurgie, Bochum, Deutschland

#### Objective

Posttraumatic hydrocephalus is a well-known complication after severe head injury and typically occurs after few weeks of trauma. Usually, a CSF resorption anomaly underlies this situation. Patients mostly undergo ventriculoperitoneal shunting (VPS) with programmable valves. Nevertheless, persistent enlargement of ventricular system can be frequently observed in mid-term follow-up in TBI patients after hemicraniectomy, even though in absence of shunt underdrainage or malfunction of the valve.

#### Methods

We performed a retrospective analysis of all severe TBI patients (initial GCS <7) who had undergone a VP shunt implantation because of posttraumatic hydrocephalus between 2013 und 2023. Analyzed parameters included age, hemicraniectomy, traumatic findings on CT scans as t-SAB, SDH, and contusions . Ventricle width was measured on CT scan using the biventrucular width and diameter of the third ventricle at presentation as well as during follow-up at 3 and 6 months postoperatively.

#### Results

25 patients with severe TBI with fully available follow-up data were included in this analysis. The median age was 48 years. 88% of the patients were male. 68% of the patients (n=17) had undergone decompressive hemicraniectomy. Initially, SDH was observed in 64% of the cases, t-SAB in 84%. Reprogramming of the shunt valve pressure was necessary in 50% of all patients. Measurements of enlargement of ventricular system were performed by assessment of biventricular diameter as well as 3rd. ventricle diameter on CT scans. Overall, 12 patients (48%) showed significant chronic enlargement in the diameter of the third- or biventricular diameter (more than 3 mm for third ventricle- and more than 10 mm of biventricular- diameter). Enlargement of ventricular system was observed in 76% of all TBI patients who needed decompressive hemicraniectomy whereas in the group of patients without hemicraniectomy only 37% developed enlargement of CSF system during follow- up.all 4 patients diagnosed of diffuse axonal injury in MRI showed enlargement of ventricular system

#### Conclusion

Our findings suggest that severe TBI patients undergoing hemicraniectomy are prone to developchronic enlargement of ventricular system regardless of multiple valve pressure reprogramming. Whether this phenomenon is associated with underlying neuroinflammatory processes emerging after severe TBI or instead, with negative pressure associated disruption of brain microstructure and stiffness remains to be elucidated with large series of TBI patients.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P228

### Palliiatiive Liquorableitung bei Meningeosis Carcinomatosa: Eine Analyse chrirurgischen und Überlebens-Outcomes in Ventriculoperitoneal Shunt vs. Rickham Reservoir Patienten.

***Palliative CSF drainage in leptomeningeal metastasis: An analysis of surgical and survival outcomes in ventriculo-peritoneal shunt vs. Rickham reservoir patients***

O. Alhalabi[1], L. Klein[1], C. Büsken[1], T. Juratli[2], C. Buszello[2], I. Y. Eyüpoglu[2], A. Mellal[3], M. Messerer[3], D. Wasilewski[4], G. Cossu[3], M. Misch[4], P. Vajkoczy[4], A. El Damaty[1], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgische Klinik, Dresden, Deutschland
[3]Lausanne University Hospital, Department of Neurosurgery, Department of Neuroscience, Lausanne, Schweiz
[4]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland

#### Objective

Leptomeningeal metastasis (LM) represents a condition of terminal disease in patients with extra-cranial malignancies. With improved survival rates under systemic therapy, the role of cerebrospinal fluid (CSF) drainage via ventriculo-peritoneal shunt (VPS) or Rickham reservoir placement for symptom control is gaining more relevance. This study aimed to describe surgical and survival outcomes of hydrocephalic LM patients after surgical drainage in a contemporary cohort.

#### Methods

A multi-center retrospective analysis of adult patients with VPS or Rickham reservoir placement for CSF drainage in the presence of LM between 2017 and 2022 was performed. Patients with occlusive hydrocephalus were excluded. Clinical, surgical and survival data were collected and compared.

#### Results

A total of 119 patients with a median age of 53 (42-77) years (40 males, 79 females) were included. Of those, 64 underwent VPS (54%) and 55 (46%) Rickham reservoir placement. The most common underlying oncological conditions were breast cancer (n=67, 56%) and non-small cell lung cancer (n=25, 21%). The median time between primary tumor and LM diagnosis was 23 months (0 to 180 months) and 44 patients (37%) had end-stage disease at primary tumor diagnosis. Moreover, in 79 (66%) patients, cranial metastases were detected, for which only 20 patients (17%) had received surgical resection. Most patients (n=95, 80%) presented with symptoms of intracranial hypertension which were relieved in 79% (n=51/64) after surgery. Compared to VPS placement, Rickham reservoirs were associated with lower complication (11% vs. 30%, p=0.01) and revision (9% vs. 23%, p=0.049) rates. Median overall survival from surgery was 90 (23 -148) days, and longer in VPS patients (107 days) compared to Rickham patients (83 days). However, this difference did not reach statistical significance (p=0.512).

#### Conclusion

While surgical CSF drainage in patients with LM dieseas relieves symptoms of intracranial hypertension in many cases, median survival remains expectedly low. Compared to Rickham reservoir placement, VPS bears higher rates of complications and revisions without a clear survival benefit. Nevertheless, decision-making regarding surgical CSF drainage and more importantly VPS or Rickham reservoir placement in LM patients retains an individual and palliative nature.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P229

### Niedrigdosis-Schädel-CT zur Beurteilung der Ventrikelweite (und darüber hinaus)
*Low-Dose cranial CT for assessment of ventricular width (and beyond)*

R. Pjontek[1], H. Ridwan[2], C. H. Na[1], B. Huffmann[1], A. Höllig[1], H. R. Clusmann[1], H. A. Hamou[1]

[1]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[2]Universitätsklinikum RWTH Aachen, Klinik für Diagnostische und Interventionelle Neuroradiologie, Aachen, Deutschland

#### Objective

Whole-body ultra-low-dose CT (ULD-CT) has replaced radiographic shunt series as the standard imaging method for CSF shunts at our institution. However, ULD-CT has limitations in assessing intracranial structures, and full-dose cranial CT (cCT) remains the standard for evaluating ventricular width and hygroma/subdural hematoma as potential signs of overdrainage. Patients with implanted CSF shunts often undergo multiple cCT scans, leading to high radiation exposure. Therefore, we developed a novel low-dose (LD) protocol primarily for evaluating ventricular width and retrospectively analyzed its feasibility.

#### Methods

Eighty-two cranial LD-CTs (100kV, 60mAs) were performed at our institution between January 15th 2021, and January 14th 2022. The DLP (dose length product) and calculated effective dose of LD-CTs were assessed and compared with full-dose CTs. Clinical performance, including therapeutic consequences, was also evaluated.

#### Results

The average age was 51 years (+/-19), with 46% being female. The most common diagnosis was post-hemorrhagic hydrocephalus (24%), followed by tumor-associated and congenital hydrocephalus. LD-CT was performed in an outpatient setting for 69%, 9% through the emergency department, and 22% in the inpatient setting. 85% of patients had a VP shunt, 3% a VA shunt, and 12% had no shunt (including monitoring for subdural/epidural effusions, pneumocephalus, or CSF cushions). In 17% of cases, hygromas/SDH were diagnosed as signs of overdrainage or primary pathology.

When compared with the pre-cCT examination, ventricular width was significantly regressed in 8%, slightly regressed in 21%, remained the same in 58%, slightly progressed in 8%, and significantly progressed in 4%. The valve pressure level was reduced in 18%, maintained in 41%, and increased in 10%. Surgical therapy was performed in 11% of cases, early follow-up in 16%, and other measures in 4%. Additional imaging (one cCT and one cMRT) was necessary for surgical planning in only 2 cases.

The median CT dose index of LD-CTs was 5.93 mGy, and the median DLP for the cranium was 77 mGy*cm (which corresponds to an effective dose of 0.16 mSv), reaching 9.5% of the radiation dose of standard cCT (median DLP: 808 mGy*cm).

#### Conclusion

LD-CT allows for accurate evaluation of ventricular width, sulcal relief, and subdural hygroma. This may be particularly relevant in younger patients. Further studies are needed to determine the optimal low-dose protocol for assessing subdural hematoma.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P230

### Intravenöse Dislokation eines ventrikuloatrialen Shunts - Fallbereicht
*Intravenous dislocation of a ventriculo-atrial shunt – Case report of a rare complication*

B. Reyes Medina[1,2], D. Keiner[1], S. Linsler[1,2], J. Oertel[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Klinikum Bayreuth, Klinik für Neurochirurgie, Bayreuth, Deutschland

#### Objective

Complications associated with VA shunt-insertion are infections, tromboembolic complications, catheter dislocation, exacerbation of pulmonary hypertension, and nephritis. We present the case of a 24-year-old patient with spontaneous intravenous dislocation of the atrial catheter after surgery 11 months prior.

#### Methods

A 24-year-old male patient presented with acute symptoms of increased intracranial pressure with less than 24 hours of onset. The patient´s medical history includes a neonatal posthemorrhagic hydrocephalus with immediate shunt insertion as a newborn. Over the past years, several revision surgeries were performed including aqueductoplasty and placement of a stent as well as various revisions of the shunt-system. In 01/2022, VA-shunt implantation was performed. The patient remained in regular clinical control with no signs of shunt-dysfunction. The last x-ray in 09/2022 revealed a regular position of the catheters. Unusual activities or body movements in the days prior to admission were not reported.

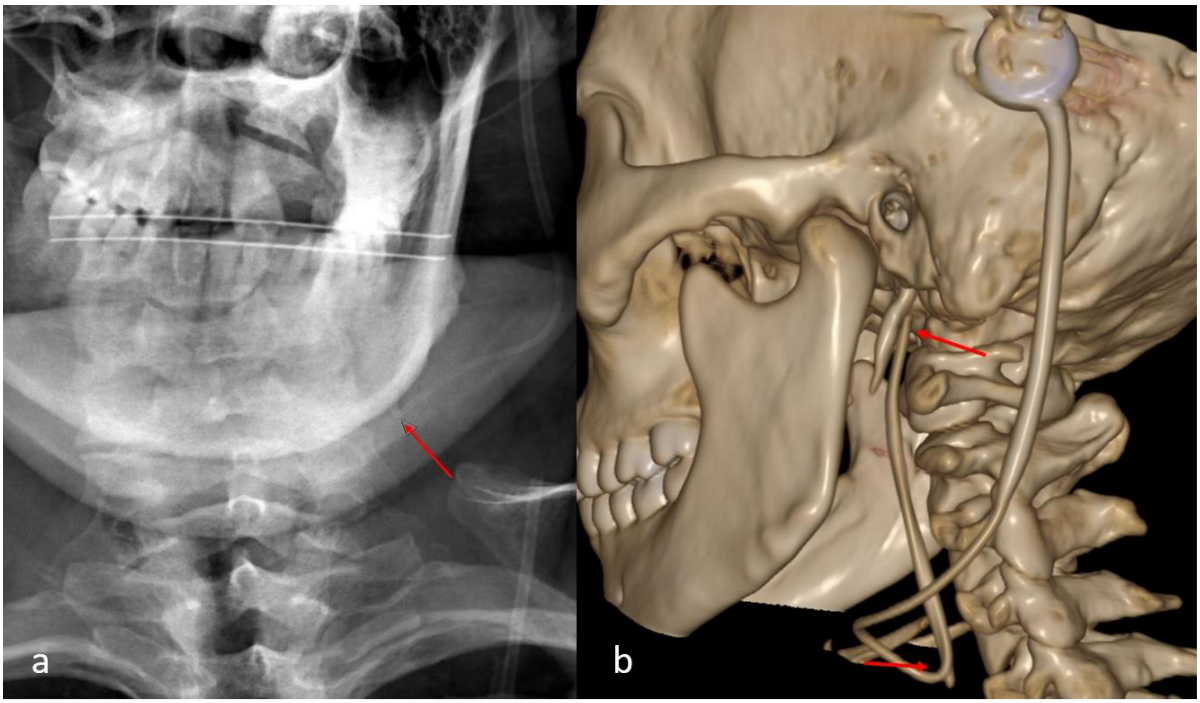
#### Results

The patient was suffering from severe and increasing headaches without new neurological deficits. The cranial CT-scan showed an enlargement of the ventricles compared to prior images. The radiographs of head and chest revealed a dislocation of the atrial catheter. For further evaluation, a CT scan of the neck was performed that showed a double flexion of the distal catheter inside the (intern jugular) vein, turning up and into cranial direction with another flexion back into caudal direction at the jaw angle. Revision surgery with placement of a new atrial catheter was performed with an uneventful postoperative course and correct placement of the catheter.

#### Conclusion

Intravenous dislocation of a VA shunt is a rare complication. An intravenous flexion in cranial direction has not been reported so far. The underlying pathophysiological mechanism remains unknown, but it might be attributed to implantation of the catheter into a big vein giving the catheter space to be able move to within the vessel presumably due to changes in the central venous pressure and/or intracranial pressure.

Abb. 1



# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 1 | Hydrocephalus and Paediatric Neurosurgery – Various 1

## P231

### Auswirkung von Läsionen des Nucleus fastigii auf Aufmerksamkeitsverhalten und frontale kortikale Aktivität bei Ratten

*Effect of lesions of the cerebellar nucleus fastigii on attention and frontal cortical activity in rats*

F. Decker[1], J. Jelinek[1], K. Korb[2], F. F. Kamgaing[1], M. Alam[1], J. K. Krauss[1], K. Schwabe[1], E. J. Hermann[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Universität Bremen, Institut für Theoretische Physik, Bremen, Deutschland

#### Objective

"Cerebellar Mutism" is a challenging problem after resection of pediatric tumors in cerebellar midline structures. Although the symptoms are mainly transient, children often have social and cognitive deficits later in life. Surgery-related lesions of midline structures, such as the fastigial nucleus, are regarded relevant. Previous studies showed that juvenile rats with lesions of the fastigial nucleus have behavioral deficits and altered neural activity in the medial prefrontal cortex (mPFC) in adulthood. We recorded prefrontal neural activity during testing in a behavioral oddball paradigm for learning and attention.

#### Methods

Rats (lesion [n=9], sham-lesion [n=6], naïve [n=9]) were trained in an auditory 3-tone oddball paradigm, where they had to nose poke to a rare target tone, while ignoring a rare distractor and a frequent standard tone of different frequencies. After training, electrodes were implanted in the mPFC, and local field potentials were recorded during behavioral testing in the oddball paradigm. Histological examination of the cerebellum verified successful lesioning of the fastigial nucleus.

#### Results

Analysis of the event related potentials showed higher amplitudes of the early and late component to the target as compared to the distractor and standard tones ($p<0.05$). Analysis of behavior in rats with fastigial lesions only showed subtle behavioral deficits. Lesioned rats overhear the target tone more often than naïve rats. Nevertheless, lesioned rats ignore the standard- and distractor tone more efficiently and poke less between trials. This is not a lesion-induced motor deficit, as the reaction time of rats with fastigial lesion do not differ from that of sham-lesioned or naïve controls.

#### Conclusion

Overall, this model provides an opportunity to investigate in more depth auditory processing with regard to attention and decision making, both in unaffected and in disease models.

# P173

## BRAF-V600E-Mutationsanalyse bei chirurgisch behandelten supraselläre Kraniopharyngeomen
*Analysis of BRAF V600E mutation in surgically treated suprasellar craniopharyngiomas*

M. Eördögh[1], L. Bárány[2], S. Vogelgesang[3], M. Peters[3], M. Vollmer[4], S. Marx[1], H. W. S. Schroeder[1]

[1]Universitätsmedizin Greifswald, Klinik mit Poliklinik für Neurochirurgie, Greifswald, Deutschland
[2]Universitätsklinikum Erlangen, Neurochirurgische Klinik, Erlangen, Deutschland
[3]Universitätsmedizin Greifswald, Institut für Pathologie, Greifswald, Deutschland
[4]Universitätsmedizin Greifswald, Institut für Bioinformatik, Greifswald, Deutschland

### Objective

Craniopharyngiomas pose a challenge in their neurosurgical treatment. Operative removal may cause serious endocrinological, ophthalmological or rhinological deficits. The novel chemotherapeutic inhibition of the BRAF V600E mutation in craniopharyngiomas shows promising early results. Here we retrospectively analysed our postoperative outcome data with a focus on this mutation.

### Methods

Our workgroup recently performed an outcome analysis of craniopharyngioma patients surgically treated in our department (Marx et al, 2021). In this study we compared the radiological, endocrinological, ophthalmological and rhinological data between patients with (N=9) and without (N=14) this particular mutation.

### Results

The BRAF V600E mutation was present in 9 individuals´ tumor tissue (39.1%) The mean follow-up period was 58 (M) vs. 74 (WT) months. The mean surgical duration was 405 (M) vs. 440 (WT) minutes, range: 352-527. The infiltrated pituitary stalk had to be removed in 22.2% (M) and 42.9% (WT). Consecutive surgical and/or adjuvant treatment was necessary in 25.0% (M) and 40.0% (WT). Among the wild type cases, 3 individuals underwent late revision surgery, another patient had 3 operations. Two of the mutated tumors were revised surgically. Complications occurred in 55.5% (M) and 50.0% (WT).

We observed a deterioration of the mostly already impaired adrenocorticotropic, thyreotropic and gonadotropic axes in 51.7% and the somatotropic in 43.9%, respectively (M). Diabetes insipidus persisted in 43.9% with one remission (M).

Comparison analyses focusing on the BRAF V600E mutation showed no significant differences from the aspects of gender, age, BMI, surgical duration, rate of persisting symptoms, intraoperative extent of tumor resection, recidive rate, necessity of adjuvant therapy, complications. QOL was comparable according to ASBQ and SNOT. The trends of the pituitary axis function were similar. The trends of visual acuity and perimetry were also without relevant differences.

### Conclusion

This study suggests no connection between BRAF V600E mutation status, QOL and various patient data. Future targeted oncological therapy based may improve the outcome results of craniopharyngioma patients, underlining the necessity of large scale analyses.

Abb. 1

**Abbreviations**

| | |
|---|---|
| *M* | Patients with BRAF V600E mutation in the tumor tissue |
| *WT* | Patients without BRAF V600E mutation (wild-type) in the tumor tissue |
| *ASBQ* | Anterior Skull Base Questionnaire-35 |
| *BMI* | Body mass index |
| *BRAF* | Proto-oncogenic human gene encoding B-Raf protein |
| QOL | Quality of life |
| *SNOT* | Sinonasal Outcome Test-22 |

## P174

### Lebensqualität und Outcome nach endoskopischer und mikroskopischer transsphenoidaler Resektion von Hypophysenadenomen – Ergebnisse der prospektiven randomisierten einfach verblindeten Studie

***Quality of life and endocrine outcome after endoscopic versus microscopic transsphenoidal resection of pituitary adenomas – A prospective randomized single blinded study***

A. Pala[1], N. Grübel[2], B. Mayer[3], B. Schmitz[4], G. Etzrodt-Walter[5], C. R. Wirtz[6], M. Hlavac[6]

[1]Universtiät Ulm, Neurochirurgie, Günzburg, Deutschland
[2]Universität Ulm, Standort Günzburg, Neurochirurgie, Günzburg, Deutschland
[3]Universitätsklinikum Ulm, Epidemiologie, Ulm, Deutschland
[4]Universität Ulm, Neuroradiologie, Günzburg, Deutschland
[5]Endokrinologie Ulm, Ulm, Deutschland
[6]Universitätsklinik Ulm am Bezirkskrankenhaus Günzburg, Abteilung für Neurochirurgie, Standort Günzburg, Günzburg, Deutschland

#### Objective

Transsphenoidal surgery has increasingly adopted the use of the endoscopic technique. Recent studies have indicated that endoscopic pituitary surgery may lead to improved endocrine outcomes compared to microscopic resection. We conducted a prospective, randomized, single-blinded study comparing patients diagnosed with pituitary adenoma who underwent either endoscopic or microscopic transsphenoidal surgery.

#### Methods

We conducted a single-center, prospective randomized, single-blinded study at our department from May 2018 to March 2022. The aim of the study was to compare the endocrinological outcomes of endoscopic and microscopic transsphenoidal surgeries. Unfortunately, due to slow enrollment, the study had to be discontinued prematurely. Out of 170 transsphenoidal pituitary surgeries performed during this period, only 36 patients were included in the study. The primary endpoint was to assess the presence of favorable or unfavorable endocrinological outcome between 3 to 6 months after surgery. Secondary endpoints included evaluating the extent of resections, complications, and assessing the quality of life (QoL) using EQ-VAS, EQ-5D3L, and SNOT-20GOV. One patient was excluded due to missing endocrine functional testing.

#### Results

In the study, the majority of patients (72.2%) had pituitary adenomas graded as Knosp 0-2. Endoscopic surgery was performed in 47.2%. A new hypopituitarism was found in 8.6% (n=3/35) patients and diabetes insipidus in one patient (2.8%). All of them underwent microscopic resection. Gross total resection was achieved in 94.4%, with no statistically significant difference observed between endoscopic and microscopic surgery techniques (p=0.935). No surgical complications or new neurological deficits were observed. There was a significant improvement in QoL after surgery, as measured by the EQ-VAS (p=0.003, median EQ-VAS=70 before surgery vs 85 after surgery). Additionally, when assessed using the EQ-5D3L, QoL improved or remained unchanged in almost all patients. There were no significant differences in QoL between the endoscopic and microscopic surgery groups, as measured by both the EQ-VAS (p=0.647) and the EQ-5D3L (p=0.330).

#### Conclusion

According to our results, it appears that the endoscopic technique for transsphenoidal adenomectomy in the treatment of pituitary adenomas may result in a better endocrinological outcome. Additionally, the study found that the extent of resection and postoperative QoL were excellent regardless of the surgical technique used.

# P175

## Beurteilung der Lebensqualität nach Hypophysenadenomresektion: Eine Studie basierend auf dem Patient Reported Outcome Measurement Information System

***Assessing patients' quality of life following pituitary adenoma resection: A study based on the patient reported outcome measurement information system***

V. Hubertus[1,2], L. Richter[1,3], L. Hesse[3], A. Rogge[4], M. Rose[4], L. Maurer[3], K. Mai[3], C. Strasburger[3], P. Vajkoczy[1], L. Haberbosch[2,3]

[1]Charité – Universitätsmedizin Berlin, Neurochirurgie, Berlin, Deutschland
[2]BIH – Berlin Institute of Health, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Endokrinologie, Berlin, Deutschland
[4]Charité – Universitätsmedizin Berlin, Psychosomatik, Berlin, Deutschland

### Objective

Pituitary adenomas/ pituitary neuroendocrine tumours (PitNETs) are common intrasellar tumours. Surgical tumour resection is the preferred treatment in symptomatic patients. Postoperatively, patients may experience endocrine disorders or other limitations affecting their health-related quality of life (HRQoL). Structured assessment of the patient`s HRQoL may help improving postoperative care. This study uses a new standardized app-based assessment of the gold-standard Patient Reported Outcome Measurement Information System (PROMIS), which was only recently translated into German, to record and visualize patient`s HRQoL following pituitary adenoma surgery.

### Methods

We performed prospective HRQoL measurements in a cohort of 30 patients who underwent pituitary adenoma resection. The German version of the PROMIS-33 questionnaire was used via app as a standardized measuring tool to assess various aspects of HRQoL postoperatively, including physical function, anxiety, depression, sleep disturbance, social activities, pain, pain interference and fatigue. The PROMIS-T-Scores were then compared to those of the general German population.

### Results

The participants had an average age of 60 (range: 30-83) with 13 females (43.3%) and 17 males (56.6%) included. Patients showed elevated T-Scores in the domains of pain interference (58.5, range: 42-76; healthy: 52.8, range: 38-65), fatigue (58.8, range: 34-76; healthy: 47.1, range: 33-60), sleep disturbance (54.3, range: 32-73; healthy: 48.3, range: 37-61), anxiety (55.8, range: 40-73; healthy: 51.8, range: 39-62) and depression (53.9, range: 41-69; healthy: 51.5, range: 38-62), while also achieving lower T-Scores in the domains of physical function (41.8, range: 27-57; healthy: 50.2, range: 39-63) and social activities (44.2, range: 34-64; healthy: 51.2, range: 40-65). The patients furthermore reported higher pain on an NRS-11 (3, range: 0-8; healthy: 0).

### Conclusion

We report our first experiences with a standardized app-based PROMIS-assessment in a cohort of postoperative pituitary adenoma patients in a German Pituitary Tumor Center of Excellence (PTCOE). Compared to the German population, the data indicate limitations in all aspects of HRQoL, particularly in relation to pain, pain interference and fatigue. Standardized HRQoL assessments in these patients is essential for the development of individualised treatment concepts and will enable the delivery of personalized precision medicine.

# Tumor – Selläre Tumore | Tumours of the sella region

## P176

### Kuriositäten und zystische Läsionen der Sellar-Region, die Hypophysenadenome imitieren.
*Curiosities and cystic lesions of the sellar region mimicking pituitary adenomas*

N. Grübel[1], M. Pedro[1], C. R. Wirtz[1], M. Hlavac[1], R. Becker[1], F. Sommer[1], A. Pala[2]

[1]Universitätsmedizin Ulm, Neuroradiologie, Günzburg, Deutschland
[2]Universitätsmedizin Ulm, Neurochirurgie, Günzburg, Deutschland

### Objective

Pituitary adenomas are the most common lesions of the pituitary gland. In rare cases, other tumor entities in the Sellar region can mimic pituitary gland macroadenomas, especially in imaging or clinically. We present 34 cases of rare and cystic intracranial midline lesions of the sellar region and describe their symptoms, radiological and pathomorphological features, and individual treatment.

### Methods

The cohort consists of 19 women and 15 men with a mean age of 52 years, who were treated surgically via endoscopic or microsurgical, transsphenoidal approach (*n*=32), endovascular therapy (*n*=1), or conservatively (*n*=1) from 2012 until 2023.

### Results

Data on histopathological results, radiological diagnosis, clinical and endocrinological symptoms, and surgical and non-surgical therapy details were collected in all cases.

Preoperative symptoms were versatile, encompassing headache, dizziness, ocular motility disturbances (*n*=5), and decreased visual acuity or scotomas (*n*=8).

Twenty-one patients exhibited pathological endocrinological findings, including the substitution of hydrocortisone. One patient received treatment with cabergoline, and one patient was diagnosed with secondary hypogonadism. Histopathological diagnoses varied, including Rathke cysts (n=9), colloid cysts (n=6), and single-represented cases such as plasmacytoma, internal carotid artery aneurysm, germinoma, chordoma, nasopharyngeal carcinoma and the rare diagnosis of a chloroma.

The single-represented cases, particularly, were frequently misinterpreted as macroadenomas before treatment. The Preoperative radiological diagnosis was incorrect in 16 of 34 pituitary lesions and remained unclear in 2 of 34 cases.

### Conclusion

Typically, masses in the sellar region are identified as pituitary adenomas. The definitive preoperative differentiation between pituitary macroadenomas and rare, intriguing lesions originating in the sellar region is often challenging. However, in the cases presented, subtle CT and MRI clues suggest the potential presence of a non-adenomatous lesion. In conclusion, the differential diagnosis should consider these unusual lesions more frequently. Warning signs may manifest as rapid growth or the abrupt onset of neurological deficits such as visual or ocular motility disturbances.

# Tumor – Selläre Tumore | Tumours of the sella region

## P177

### Die Wirkung der Strahlendosis auf das optische System und die gefährdeten Organe bei Patient*Innen mit radiochirurgisch behandelten Hypophysenadenomen

***Dose-response modeling of the optic system and organs at risk in radiosurgically treated pituitary adenoma patients***

L. Kohlmaier[1], S. Tögl[2], M. Schiebl[2], A. Ertl[1], C. Matula[1], M. Millesi[1], B. Gatterbauer[1], P. Dodier[1], A. Cho[1], J. Frischer[1]

[1]Medizinische Universität Wien, Universitätsklinik für Neurochirurgie, Wien, Österreich
[2]Medizinische Universität Wien, Universitätsklinik für Radioonkologie, Wien, Österreich

#### Objective

Gamma Knife radiosurgery is commonly used in the multimodal management of patients with pituitary adenomas. Regarding the radiation exposure of risk structures such as the optic nerve or the optic chiasm, a safety distance of two millimeters is often considered as crucial in treatment planning. Moreover, varying levels of radiation tolerance have been reported in the literature for organs at risk in close proximity to the pituitary adenoma. The aim of this study is to evaluate the effect of different radiation doses on the critical structures via the endocrinological, ophthalmological and neurological outcome.

#### Methods

A retrospective analysis of 139 patients with pituitary adenomas, who underwent at least one Gamma Knife radiosurgical treatment between 2000 and 2022, was performed. The radiation dose to the defined critical structures as well as the minimal distance between the pituitary adenoma and these structures were measured with the Elekta Planning System.

#### Results

The majority of the study population (134/139, 96%) underwent a previous surgical removal of the pituitary adenoma. The pituitary adenomas were hormone-active in 92/139 (66%) patients. The median treatment volume was 4.6 cm3 (0.5-16.7). In 3/139 (2%) patients, a compression of the optic chiasm or optic nerve could be observed.

Of 130/139 (94%) with available pre-radiosurgical planning data, the maximal radiation doses on the optic chiasm were 6.2 Gy (1.5-16.3). After Gamma Knife radiosurgical treatment, the majority of patients (95%) with radiological follow-up had a decreased tumor volume. Furthermore, the majority of the patients (96%) did not have any worsening of the ophthalmological deficits.

#### Conclusion

Radiosurgical treatment is a safe therapy option for pituitary adenoma patients without worsening of ophthalmological deficits.

# P178

## Mikroskopische vs. exoskopische transsphenoidale Operationen von Kraniopharyngeomen - eine retrospektive monozentrische Studie mit 102 Patienten.

***Microscopic vs. exoscopic transsphenoidal surgery for craniopharyngiomas – A retrospective single center study of 102 patients***

P. Sumislawski[1], P. Selhausen[2], A. Ryba[2], T. Huckhagel[3], J. Regelsberger[4], J. Aberle[5], I. Y. Eyüpoglu[1], J. Flitsch[2], R. Rotermund[4]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Klinik für Neurochirurgie, Hamburg, Deutschland
[3]Universitätsmedizin Göttingen, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Göttingen, Deutschland
[4]Diako Krankenhaus, Klinik für Neurochirurgie, Flensburg, Deutschland
[5]Universitätsklinikum Hamburg-Eppendorf, III. Medizinische Klinik und Poliklinik, Hamburg, Deutschland

### Objective

4K 3D orbital camera (Orbeye, Olympus) is a novel exoscopic system, which was described for skull base transsphenoidal operations, however structured analyses regarding application for craniopharyngioma resection are lacking. The aim of this study was to assess the utility of exoscopic transsphenoidal surgery (ExTS) and compare it to well established microscopic transsphenoidal surgery (MTS).

### Methods

Patients with confirmed histological diagnosis of craniopharyngioma and operated between 2013-2022 were enrolled into our retrospective monocentric study. Data regarding duration of surgery, length of hospital stay, recurrence rate, extent of resection and postoperative complications (diabetes insipidus, SIADH, anterior pituitary insufficiency, CSF-leak, meningitis, nonobstructive hydrocephalus) were assessed.

### Results

A total number of 102 patients, who underwent 122 operations were included. Mean(±SD) duration of surgery in minutes was significantly shorter for repeated ExTS (144(±50.5) minutes vs. 121.3(±50.2) minutes, p=0.028). Mean length of hospital stay was significantly shorter after ExTS comparing to MTS for repeated surgeries (6.9 days vs. 5.6 days, p=0.048). The incidence of postoperative complications like CSF-leak (11.3% vs. 9.5%, p>0.99), diabetes insipidus (25% vs. 23.8%, p=0.83), SIADH (2.5% vs. 2.4%, p>0.99), new pituitary insufficiency (38.8% vs. 35.7%, p=0.84), meningitis (2.5% vs. 0%, p=0.55), nonobstructive hydrocephalus (2.5% vs. 2.4%, p>0.99) was not significantly different between both groups. Recurrence rate was 36% and 25% (p=0.28) for MTS and ExTS respectively. Gross total resection rate was higher for MTS, however without statistical significance (47.5% vs. 40.5%, p=0.25).

### Conclusion

Our study confirmed the utility of ExTS for craniopharyngioma resection, as it revealed no statistically significant differences regarding complication rates, recurrence rate along with mean duration of surgery and mean length of postoperative stay for both all and first surgeries comparing to MTS. Moreover the mean duration of surgery and mean length of postoperative stay after repeated ExTS were significantly shorter than by MTS reoperations.

# P179

## Prädiktive Faktoren für biochemische Diskrepanz bei Akromegalie: eine Analyse von 156 Fällen
*Predictive factors for biochemical discrepancy in acromegaly: An analysis of 156 cases*

D. Emmanouilidis[1], E. Tsourdi[2], M. Gruber[2], I. Y. Eyüpoglu[1], T. Juratli[1], T. Pinzer[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Endokrinologie, Dresden, Deutschland

### Objective

The treatment goal of acromegaly, typically involving surgery, medication, or irradiation, is to achieve biochemical remission, indicated by normalized levels of growth hormone (GH) and insulin-like growth factor 1 (IGF-1). However, this is not always achievable. Besides persistent acromegaly (elevated GH and IGF-1 levels), biochemical discrepancies (elevated levels of either GH or IGF-1, but not both) are also observed. This study aims to identify predictive factors for such biochemical discrepancies.

### Methods

We conducted a retrospective analysis of 156 acromegaly patients due to pituitary adenoma, who underwent transsphenoidal microscopic surgery between 1984 and 2017 at our center.

### Results

The cohort of 156 patients (61.5% female) had a median age of 48.2 years and long-term follow-up (median: 64.5 months). Biochemical remission was achieved in 73.7% of patients, while 9.6% exhibited uncontrolled acromegaly, and 16.7% showed biochemical discrepancy. Patient´s age, tumor size and invasiveness had no significant impact on discrepancy rate. The two subgroups with biochemical discrepancy, characterized by elevated levels of either GH or IGF-1, consistently displayed the highest preoperative GH (median: 21.6 ng/ml) or IGF-1 (median: 386.1% above the normal upper limit). Preoperative use of somatostatin receptor ligands (SRLs), dopamine agonists (DA), or growth hormone receptor antagonists (GHRa) significantly increased the risk of biochemical discrepancy (discrepancy rate with preoperative medication: 21.7% vs. without: 7.3%; p=0.038). Overall use of these medications both before and after surgery also significantly raised the discrepancy rate (with medication: 21.7% vs. without: 2.4%; p=0.003). In five cases, discrepancy was attributed to the mechanism of GHRa, which increased GH levels in blood plasma. Within the discrepancy group (n=29), three patients underwent secondary surgery without biochemical status improvement. Among those receiving radiotherapy (n=12), 41.7% displayed biochemical discrepancy significantly higher than the 14.6% in non-irradiated patients (p=0.006).

### Conclusion

Our study indicates that preoperative or overall medication (SRLs, DA, GHRa) and irradiation might contribute to the occurrence of biochemical discrepancy in acromegaly patients, suggesting their potential as predictive factors. We recommend managing patients with biochemical discrepancy similarly to those with uncontrolled acromegaly, underscoring the need for personalized treatment strategies.

# P180

## Risikofaktoren für Einblutungen in Hypophysenadenomen
## *Predictors of hemorrhage within pituitary adenoma*

H. Hounchonou[1], G. Bajgora[1], J. M. Lang[1], J. K. Krauss[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland

### Objective

Pituitary apoplexy is a potentially life-threatening condition that usually results from hemorrhage in pre-existing intrasellar lesions (e.g. pituitary adenoma) and presents with acute headache, visual impairment and endocrine dysfunctions. In this study, we aimed to identify patient- and tumor-related predictors of such hemorrhage in a contemporary cohort.

### Methods

A series of 100 consecutive patients with pituitary adenoma was analyzed. We compared the demographic data (age, sex, BMI), comorbidities and tumor volume between patients presenting with hemorrhagic adenoma and those without hemorrhage.

### Results

A total of 19 patients presented with hemorrhagic pituitary adenoma. There was no difference in age, sex, BMI, smoking-status and diabetes between patients with hemorrhagic and non-hemorrhagic pituitary adenoma. The tumor volume was smaller (p=0.008) and arterial hypertension was more frequent (p=0.02) in patients hemorrhagic adenoma.

### Conclusion

Hemorrhage within pituitary adenoma occurs more often in rather smaller adenoma in patients suffering from arterial hypertension. Timing of surgery should deserve particular attention in those patients.

# P181

## Prädiktoren für eine postoperative Verschlechterung und Rezidive nach der Resektion von Hypophysenadenomen bei älteren Patienten

***Predictors of postoperative worsening and recurrence after resection of pituitary adenoma in elderly patients***

M. Desch[1], D. Jankovic[1], K. Kralik[2], C. Wüster[3], W. Omran[4], M. Weber[5], F. Ringel[1], J. Conrad[1]

[1]University Medical Center, Department of Neurosurgery, Mainz, Deutschland
[2]Faculty of Medicine, J.J. Strossmayer University, Department of Medical Statistics and Informatics, Osijek, Kroatien
[3]Hormone and Metabolism Center, Mainz, Deutschland
[4]Endocrinology Practice, Mainz, Deutschland
[5]University Hospital Center, Department of Endocrinology and Metabolic Disease, Mainz, Deutschland

### Objective

Considering the aging of the general population, brain tumors are recognized with increasing frequency in older patients. Earlier research has indicated the safety of surgery for elderly patients although the findings regarding pituitary tumors have been based on small sample sizes and have yielded mixed results in terms of risk and complication rates. This study aims to evaluate clinical and surgical factors influencing the risk of postoperative clinical deterioration and tumor recurrence.

### Methods

Data acquisition was conducted as a retrospective analysis. Demographic and clinical data, as well as surgical outcome of elderly patients (> 75 years) were compared to patients aged 75 or younger. Knosp grad, extent of resection, complications and outcome were analyzed and compared. Univariate and multivariate logistic regressions were used to evaluate the prognostic impact of age on extent of resection and surgical outcome.

### Results

In the study, 204 patients with pituitary adenoma were involved, with 41.2% (n=88) being over 75 years old. Visual impairment was the predominant symptom at admission (61%, n=51), followed by dizziness (10%, n=8), and headache (8%, n=7). In the elderly patients, cavernous sinus invasion was present in 78% (n=54), and extension into the sphenoid sinus was found in 23% (n=16, p=0.001). Total resection was achieved in 75% (n=63), followed by subtotal resection (24%, n=20), and partial resection (1%, n=1). Postoperatively, the clinical condition improved in nearly 80% of cases, remained unchanged in 12% (0) and worsened in 6% (4 patients) at the three-month follow-up.

Multivariate logistic regression identified preoperative hormonal insufficiency (OR 2.11, 95% CI 1.03-4.31, p=0.04) and tumor extension into the sphenoid sinus (OR 3.38, 95% CI 1.20-9.51, p=0.02) as significant predictors for worsening neurological function at the 3-month follow-up. Additionally, subtotal resection (p<0.001) was significantly associated with tumor regrowth, and cavernous sinus infiltration (p=0.01) was linked to clinical worsening at the last follow-up.

### Conclusion

Our study indicates that pituitary adenoma surgery in this age group is both safe and effective, with a high resection rate and low complication rate. However, patients undergoing subtotal resection require long-term follow-up due to the risk of tumor recurrence. Meticulous patient selection and thorough preoperative evaluations are essential for optimal outcomes in the elderly population.

# P182

## Psychische Belastung bei Patienten mit sellären Raumforderungen
*Self-reported psychological distress among patients with sellar processes*

D. Kalasauskas[1], A. Ernst[1], S. Mireri[1], W. Omran[2], C. Wüster[3], F. Ringel[1], J. Conrad[1]

[1]Universitätsmedizin Mainz, Klinik mit Poliklinik für Neurochirurgie, Mainz, Deutschland
[2]Endocrinological Medical Office Dr. Wael Omran, Mainz, Deutschland
[3]Hormone & Metabolism Centre Prof. C. Wüster, Mainz, Deutschland

### Objective

Diagnosis of pituitary tumor may induce psychological distress and have a significant impact on the quality of life. Among other factors, treatment strategy, tumor entity and hormonal dysregulation may have a significant factors on patient emotional well-being. The aim of this study was to evaluate the level of distress and quality of life in operated vs. non-surgically managed patients with pituitary tumors.

### Methods

We performed a prospective study in a tertiary neurosurgical center and two endocrinological medical offices in Mainz, Germany. Patients after surgical treatment with good functional neurological outcome and patients under conservative treatment (e.g. prolactinomas under medical therapy) as well as patients undergoing radiological follow-up without treatment were asked to participate in the study. Sociodemographic, clinical, and health-related quality of life and clinical data were assessed. Psychosocial factors were measured by the Distress Thermometer (DT), Hospital Anxiety and Depression Scale (HADS), Short Form (SF-36) and Sino-nasal outcome test (SNOT).

### Results

In total, 62 patients were recruited into the study (n=32 operative, n=30 conservative), mean age 52.4 (SD 18.1) years, 55.6% female. Prolactinomas were identified in 31.9%, Non-functioning pituitary adenomas in 18.8%, ACTH-producing adenomas were present in 6.3% of cases. In 14.5% of cases the entity was unknown, and the patients were followed up. 15.9% of patients reported increased anxiety and 14.5% elevated depression, although mean HADS scores were similar to the general population. The patients did not score low on SF-36 component scores (43% and 44%). The Mean DT score was 4.8 (SD 2.7), 38% of patients reported significant distress. There was no significant difference between the treatment groups except for increased *Role* limitations due to *emotional* problems in conservative group.

### Conclusion

In our cohort of patients with pituitary tumors, the level of self-reported distress seems to be comparable to the general population. Further assessment is necessary to identify the patients who need psychooncological support.

# Tumor – Selläre Tumore | Tumours of the sella region

## P183

### Metastasen der Sella: eine seltene intraoperative Beobachtung nach Vortäuschung eines Hypophysenadenoms im präoperativen MRT

***Sellar metastasis: A rare intraoperative finding after preoperative MR imaging of mimicing of a pituitary adenoma***

H. Sitoci[1], S. Saffour[2,1], C. Sippl[2,1], J. Oertel[1], S. Linsler[2,1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Klinikum Bayreuth, Medizincampus Oberfranken der FAU, Klinik für Neurochirurgie, Bayreuth, Deutschland

#### Objective

The sellar region is an unusual site for metastatic spread, but as patients with metastatic malignancy are living longer, it may become more prevalent. Compression of important anatomy adjacent to the sella may produce disabling symptoms and endocrine derangement, leading to significant morbidity. Furthermore, the preoperative imaging is probably often mimicing an adenoma in these cases.

#### Methods

To analyse the incidence of sellar metastasis, the authors reviewed their cases with sellar pathologies treated via an endonasal approach between January 2011 and Dezember 2023. Further investigation was performed to evaluate patient demographic, radiological and histological findings and outcome.

#### Results

Eight of 374 patients (2.1%) treated during this time period revealed in the final histopathology a metastasis. Thereby, malignant tumor history was known in one patient (14%). The preoperative MR and CT imaging suspected a malignant pathology or metastasis in two cases (28%). in 72% oif all cases the MR and CT imaging revealed a piuitary adenoma most likely preoperatively. The average age of the cases was 63.4 years, with histopathological diagnosis of two metastasis of lung cancer, one mestastasis of gastric cancer, one metastasis of kidney, one case of prostatic cancer, one lymphoma and one plasmocytoma. Adenohypophyseal dysfunction (3/7; 42%), abducens palsy (2/7; 28%) and visual field defects (2/7; 28%) were the most common findings at presentation. The mean follow up was 2.4 years. 5 of 7 patients (71%) died during this time period.

#### Conclusion

The sellar region should not be overlooked as a site of metastasis. Any biochemical or clinical sign of pituitary pathology in a patient with known cancer should raise suspicion for sellar metastasis even if the preoperative imaging argues for a pituitary adenoma most likely. Moreover, the fast development of hormonal dysfunction or ophthalmoplegia is suggestive of metastatic disease even in patients with no known primary.

# P184

## Einfluss der Tumorklassifikation bei Patienten mit Hypophysenadenomen auf die Riechfunktion nach endoskopisch transsphenoidaler Resektion

***The influence of tumor growth pattern on olfactory function in patients with pituitary adenomas undergoing endoscopic transsphenoidal approach***

S. Walbrodt[1], H. H. Gull[1], M. Gümüs[1], A. Engel[1], C. Rieß[1], T. F. Dinger[1], M. Darkwah Oppong[1], R. Jabbarli[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], Y. Ahmadipour[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

### Objective

Resection of pituitary tumors via endoscopic transsphenoidal surgery (ETSS) has become a standard procedure over the last decades. While the method has already been compared with the microscopic transsphenoidal skull base approach regarding olfactory outcome, there is a lack of data assessing tumor growth characteristics which possibly influence the olfactory system as well.

### Methods

46 Patients (24 female, mean age 53) who underwent binostril ETSS between 11/2016 and 07/2020 were included. Olfactory function of all subjects has been tested before surgery and at Follow-Up (FU) after 3-6 months by using a sniffing test kit with 12 sticks. Patients were divided in groups of lowly (Knosp < 2) and highly invasive sellar lesions (Knosp > 2) by the Knosp classification. A rmANOVA has been conducted to identify factors influencing the olfactory function.

### Results

rmANOVA shows that gender, age and Mb. Cushing did not significantly affect olfactory outcome after surgery. However, patients with former nose surgeries (n = 11) had a better preop olfactory mean test score (10.64 vs. 9.08), while at FU mean values slightly decreased and were close to individuals with no prior nose surgery (9.55 vs. 9.19). Patients with highly invasive pituitary adenomas (n = 18) showed slightly better mean olfactory results at baseline (9.89 vs 9.14) and even further improved after surgery (10.33 vs 8.57). In addition, a higher Knosp score significantly influenced the postoperative outcome after ETSS (p = 0.027).

### Conclusion

Our findings are in line with several other studies suggesting that olfactory impairment after ETSS will recover soon. In addition, we did not find significant differences for patients with Cushing"s disease regarding olfactory performance. However, the influence of highly invasive pituitary tumors on the olfactory system has not been investigated yet. Our findings suggest that the scope and impact of ETSS on the olfactory system is minimal due to its low invasive approach even in large tumors.

# Tumor – Selläre Tumore | Tumours of the sella region

## P185

### Das Outcome der endonasalen endoskopischen Eingriffe bei geringem Carotidenabstand
*The outcome of endoscopic endonasal transsphenoidal approach in patients with reduced intercarotid distance*

S. Saffour[1,2], J. Oertel[2], S. Linsler[1,2]

[1]Klinikum Bayreuth, Medizincampus Oberfranken der FAU, Klinik für Neurochirurgie, Bayreuth, Deutschland
[2]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

Endoscopic surgical techniques have been established as a method for transnasal transsphenoidal approaches in the resection of sellar region pathologies. It has generally been assumed that the transnasal transsphenoidal approach is unfavorable when the distance between the internal carotid arteries (ICAD) is reduced. We aim in our study to examine the influence of reduced ICAD on the outcome of these surgeries.

#### Methods

This is a retrospective study from January 2013 to January 2023. A total of 222 patients (mean age 54.63 ± 16.89 years) undergoing transnasal transsphenoidal endoscopic surgery for resection of sellar region pathologies were included in this study. Patients were categorized into subgroups based on ICAD, with n = 131 patients having an ICAD greater than 15 mm and n = 91 patients having an ICAD of less than 15 mm. Follow-up assessments were conducted up to 6 months post-surgery, involving magnetic resonance imaging and collaboration with ophthalmologic and endocrinologic specialists.

#### Results

The data revealed no significant correlation between reduced ICAD and the occurrence of complications. Furthermore, tumor size was not a significant factor in total resection when ICAD was reduced (p-value = 0.005). Although recurrence in cases of reduced ICAD was not statistically significant (p-value = 0.036).

#### Conclusion

Our results suggest no association between reduced ICAD and the outcomes of endoscopic procedures. Skilled surgeons can perform endoscopic procedures with comparable outcomes even in cases of narrow ICAD.

# Tumor – Selläre Tumore | Tumours of the sella region

## P186

### Ergebnisse nach transsphenoidaler Resektion sellärer Pathologien: Verschlusstechnik

***The outcome of intraoperative cerebrospinal fluid leak after transsphenoidal resection of sellar neoplasms: Technique of closure***

B. Reyes Medina[1,2], S. Linsler[1,2], J. Oertel[1], K. H. Sitoci-Ficici[1]

[1]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Klinikum Bayreuth, Klinik für Neurochirurgie, Bayreuth, Deutschland

#### Objective

We evaluated the outcome and efficacy of a multilayer closure technique of the sellar floor after transsphenoidal endoscopic approaches for sellar pathologies in correlation to the intraoperative grading of CSF leak and in correlation to the usage and possible benefit of a lumbar drain postoperatively.

#### Methods

We reviewed retrospectively 280 patients who underwent endonasal transsphenoidal endoscopic surgery for pathologies in the sellar region from January 2011 to April 2020 in our hospital. Among them, 87 patients had an intraoperative CSF leak and were included in the study. The outcomes were evaluated based on development of postoperative CSF leak in correlation to the used closure material of dural and skull base reconstruction and use of lumbar drainage, association with the intraoperative CSF leak grade, pathology and the demographics of the patients.

#### Results

From the 87 patients, there was a total of 54 women(62%) and 33 men(38%). The mean age was 56. The most frequent diagnosis was non-secreting adenoma in 40 cases (45%), followed by secreting adenomas with 16 cases(18%), 8 cases of meningioma(9%), 6 cases of Rathke"s cleft cyst(7%), 6 cases of craniopharyngioma(7%), 8 other cases(9%). The intraoperative CSF grading was based on the classification by Esposito. Of the 87 patients with postoperative CSF leak, 20 were classified as grade 1, 37 as grade 2 and 30 cases as grade 3. The materials commonly used for the closure of grade 1 CSF leaks were primarily sealant sponge Tachosil(70%), dura patch(55%) and bone(55%). For the grade 2 CSF leaks, Tachosil(78%), bone(57%) and autologous fat(54%). In the grade 3 CSF leaks, lumbar drain(90%), autologous fat(87%) and fascia lata(60%) were mainly used. Only 9 patients developed a new postoperative CSF leak, and were treated conservatively with lumbar drains, but only 3 of them discontinued by this method. The remaining 6 patients with persistent postoperative CSF leak underwent revision surgery.

#### Conclusion

The analysed multilayer closure technique for the transsphenoidal surgery has been shown to be safe. We observed lower intraoperative CSF leak rate compared to other studies, a similar rate of postoperative CSF leak (3.1% vs 3.9%)compared to the pedicled vascular flap and other techniques. The presented study shows the effectiveness of our closure techniques including the intraoperative lumbar drain in different CSF grades. If a postoperative CSF leak appears, the use of lumbar drains to treat it has a poor benefit.

# P187

## Unüberwachtes maschinelles Lernen identifiziert neurophysiologische und anatomische Korrelate der Gesichtsfelddefizite bei Patienten mit Hypophysentumoren

***Unsupervised machine learning identifies neurophysiological and anatomical correlates of the visual field deficits in patients with pituitary tumors***

M. Omiros[1], M. Manu[1], M. Nakamura[1]

[1]Krankenhaus Merheim, Neurochirurgie, Köln, Deutschland

### Objective

Pituitary tumors present oftentimes with a combination of visual field defects and diminishing visual acuity. Despite the frequency of these symptoms, the neurophysiological and anatomical factors that best predict visual field defects remain unclear. We applied unsupervised machine learning techniques to electrophysiological and imaging features in order to determine those features that determine the observed visual field defects.

### Methods

29 Patients (median age=67, 10 female and 19 male) with non-functioning pituitary tumors where characterized so far retrospectively. For all patients that had a high-resolution MR of the sella, a formal ophthalmological evaluation in terms of visual field deficits (reported as mean deficit (MD) in dB) as well as measurement of visual evoked potentials (VEP) using LED pads we selected as variables of interest the latency and amplitude of the VEP, as wells as the chiasm angle, maximal and minimal height of the chiasm as evaluated independently by 2 observers on T2 MR Scans.

### Results

We observed 78% of visual field deficits defined as pathological (>3dB mean deficit) and in 60% of cases a visual field defect of at least 5dB. The mean chiasm angle (as measured in the coronar plane by drawing a line along the inferior edge from one side of the chiasm to midline and another from the midline to the contralateral side of the chiasm) was 121.87 degrees. The mean chiasma height was 1.9mm. Next, we performed a dimensionality reduction using principal components analysis (PCA) on the pooled data followed by k-means clustering along the dimensions with the 2 largest eigenvalue. The factors with the larges variance explaining the data where VEP latency (defined as the time from stimulus to N2 peak, p=0.02), the angle of the chiasm (p=0.00015) and the maximal chiasma height (p=0.02).

### Conclusion

Dimensionality reduction using PCA coupled with a clustering algorithm (k-means) revealed that severity of the visual field deficits in patients with pituitary tumors is largely represented in neurophysiological features (VEP latency) as well as anatomical characters (chiasm angle). Out study suggest that intraoperative monitoring of these features may improve outcomes for patients undergoing surgery.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P188

### Intrathekale Bupivacain-Monotherapie: Eine retrospektive Analyse der Wirksamkeit und Sicherheit in einem tertiären neurochirurgischen Zentrum (2004-2023)

***Intrathecal bupivacaine monotherapy: A retrospective analysis of effectiveness and safety in a tertiary neurosurgical care setting (2004-2023)***

A. Lawson McLean[1], S. Kubon[1], C. Senft[1], F. Schwarz[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

#### Objective

Intrathecal therapy, pivotal in the management of chronic pain, facilitate targeted drug delivery while minimizing systemic side effects. Bupivacaine's role as a monotherapeutic intrathecal agent, however, remains underdocumented, contrasting with its prevalent use in combination with other drugs. This study investigates the long-term effectiveness and safety of intrathecal bupivacaine monotherapy. We focus on its application over 19 years in a tertiary neurosurgical care center, delineating its distinct role from its traditional usage as a supplemental agent.

#### Methods

This retrospective study encompassed all patients who received intrathecal therapy pump fills at our center from September 2004 to August 2023. We extracted and analyzed data on patient demographics, initial and subsequent therapies, dosing patterns, and reasons for therapy discontinuation. Key metrics included the mean starting dose of bupivacaine, its variability, and rates and rationales for therapy cessation.

#### Results

Of 140 patients, 27 (19.3%, 20 females, 7 males) received bupivacaine monotherapy during the course of their treatment. Median age at initial pump placement was 52 years (IQR 45-59 years). Fifteen patients commenced therapy with bupivacaine, whereas 12 transitioned from other agents (7 from morphine, 3 from ziconotide, 2 from other agents), with a median switch time of 14 months (IQR 6-22 months) post-pump insertion. The average initial bupivacaine dose was 5.2 mg/d (SD 1.8 mg/d). Therapy discontinuation was noted in 10 patients (37%), attributed to insufficient pain control (5 patients), adverse effects (3 patients), and other factors (2 patients).

#### Conclusion

Conclusion: This investigation highlights bupivacaine's viability as an independent intrathecal therapy. Its effectiveness, alongside noted dosing variability and discontinuation reasons, underscores the imperative for tailored patient management strategies. The varied primary pain diagnoses and transitions from other therapies to bupivacaine suggest its versatile role in pain management. Future research should focus on long-term outcomes and efficacy comparisons with combined therapeutic approaches.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P189

### Auf maschinellem Lernen basierende Vorhersage des Serostatus bei Autoimmunenzephalitis anhand von MRT-Bildern der Amygdala

***Machine learning-based prediction of serostatus in autoimmune encephalitis using MRI images of the amygdala***

M. Musigmann[1], J. Stake[1], C. Spiekers[1], W. Heindel[1], M. Mannil[1]

[1]University Muenster and University Hospital Muenster, University Clinic for Radiology, Münster, Deutschland

#### Objective

Autoimmune encephalitides are non-infectious neurological diseases caused by misdirected immune responses against self-antigens of the central nervous system. Rapid diagnostic clarification enables early treatment, which in turn can improve the prognosis. Our aim is the machine learning based non-invasive prediction of serostatus in patients with autoimmune encephalitis using MRI images of the amygdala. Given the importance of serostatus for the final diagnosis of suspected cases of autoimmune encephalitis, machine learning models may be an important tool to speed up diagnosis in the future.

#### Methods

Our study cohort comprises 83 patients with confirmed autoimmune encephalitis and available MRI images of the amygdala. Autoantibodies associated with autoimmune encephalitis were detected in 43 of these patients. Bilateral image segmentation of the amygdala was performed semi-automatically using the 3D Slicer open-source software platform and the Segmentation Wizard plugin. The open-source PyRadiomics software was used to calculate 107 radiomic features. Feature selection was performed using recursive feature elimination and based on the determination of the most important features. We used automated machine learning (AutoML) to identify particularly promising machine learning algorithms. Subsequently, various generalized linear models (GLMs), a gradient boosting machine and a neural network were fine-tuned. The entire model development and the final model testing were performed 100 times for each model using 100 different data partitions. All performance values were calculated as mean values of these 100 runs using independent test data.

#### Results

We achieved our best results with a GLM including six features. This model yields a mean AUC of 90.2 %, a mean accuracy of 83.1 %, a mean sensitivity of 84.0 % and a mean specificity of 82.0 % in predicting serostatus. We also calculated the sensitivity separately for antibodies targeting intracellular antigens and those directed against extracellular antigens located on the cell surface. We found that the sensitivity for extracellular antigens is slightly higher than for intercellular antigens (90.7 % and 76.0 % respectively). In addition, our final model exhibits a very high degree of stability, both in terms of discriminatory power and feature composition.

#### Conclusion

Our results show that radiomics-based machine learning could be a promising tool for predicting the presence of antibodies in patients with suspected autoimmune encephalitis.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P190

### Mikrochirurgische Dekompression nach Jannetta mittels Implantation eines Goretex-Loops bei Trigeminusneuralgie –ein 13-jähriger monozentrischer Erfahrungsbericht

***Microsurgical decompression according to Jannetta by implanting a Goretex-Loop for trigeminal neuralgia – A 13 year single-center experience***

C. Wieckhusen[1,2], H. Bougrine[1,2], A. Unterberg[1,2], M. M. Hajiabadi[1,2], S. Krieg[1,2], R. Ahmadi[1,2]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[2]Ruprecht-Karls-Universität Heidelberg, Neurochirurgie, Heidelberg, Deutschland

#### Objective

Classic trigeminal neuralgia is based on a neurovascular conflict of the trigeminal nerve. Nowadays microvascular decompression according to Jannetta (MVD) is a standard therapy. The interposition using Teflon patches is most common in the literature. In our neurosurgica departement we use a Goretex-Loop for relocation and fixation of the compressive vessels. In this work we present one large cohort regarding Goretex-Loops in MVD.

#### Methods

The present study included all eligable patients who underwent MVD according to Jannetta due to trigeminal neuralgia in our clinic between 2010 and 2023. A retrospective analysis of patient records and perioperative data was performed. In addition, the patients were recently contacted to enable long-term follow-up. Collected data include demographic information, clinical symptoms, operative details and postoperative outcomes.

#### Results

Between 2010 and 2023 n=256 MVDs according to Jannetta were eligable. The averageage was 60 (+/-10) years. The ratio of female to men was 56:44. 8% were revision surgeries. The average time of surgery was 162 (+/-16.3) minutes, possible due to the used loop technique. With overall low complication rates, temporary hypoesthesia was the most common. The complication rate of 2% corresponds to the data in the literature. On average, 87% (n=224) of patients reported a significant improvement immediatly postoperatively, including complete regression of the pain. The pain medication could be discontinued after an average of 4.25 months. Recurrences (pain comparable to preoperative or worse) occurred in a total of 17% (n=44) over the long term follow-up. In addition, 27% (n=69%) patients experienced renewed pain, although this was significantly less severe than preoperatively. The median follow-up time is 66 months (2-162 months).

#### Conclusion

We present a large case series of microvascular decompression according to Jannetta for trigeminal neuralgia using a Goretex-Loop. A total of 257 surgical procedures were performed. We show using a Goretex-Loop with the aim of relocation of compressiv vessels and interposition is a safe and very effective method.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P191

### Morphometrische Evaluation von Foramen ovale und Cavum trigeminale und ihre Bedeutung für Ganglion Gasseri Rhizotomien

***Morphometric evaluation of foramen ovale and cavum trigeminale and its impact on ganglion Gasseri rhizotomies***

M. F. Oertel[1], G. Iliukhina[1], O. Bichsel[1], L. H. Stieglitz[1]

[1]Universitätsspital Zürich, Neurochirurgie, Zürich, Schweiz

#### Objective

Ganglion Gasseri rhizotomy is a well-known and established therapeutic option in the treatment of trigeminal pain (TP). However, the extent to which the morphology and size of the foramen ovale (FO) and cavum trigeminale (CT) potentially influence the procedure and its success is largely unknown. For this reason, the authors systematically evaluated the configurations and dimensions of FO and CT.

#### Methods

In 31 TP patients undergoing trigeminal rhizotomy, high resolution 3 Tesla magnetic resonance imaging-based three-dimensional quantitative volumetric analyses were performed for a morphometric study of FO and CT. In addition, patient data and surgical outcome were evaluated. Finally, the morphometric data and clinical results were compared.

#### Results

The shape of the FO was more often oval (19/31) than roundish (12/31). The longitudinal diameter was between 1.1 and 5.7mm (mean 2.8mm), and the transverse diameter ranged from 1.4 to 5.0mm (mean 3.2mm). While most patients had an oval shape of CT (19/31) and more frequently (11/31 vs. 8/31) improved in pain postoperatively, 9/31 patients showed a triangular CT shape and predominant reduction of TP (7/31 vs. 2/31), and 3/31 patients had a round shape of CT with improvement of TP in 2/31 vs. 1/31 cases. The volume of the CT ranged between 0.15 and 0.55cm$^3$ (mean 0.34cm$^3$). Most patients benefited clinically following surgery (20/31), 8/31 showed no improvement while 3/31 patients worsened. No significant correlation between clinical outcome and volume of CT was found.

#### Conclusion

Whereas influences of the study design and of various clinical or interventional factors on the results cannot be excluded, we did not find a clear association between FO dimensions and CT volumes and clinical outcome. However, our data suggests that predominantly a triangular shape of CT containing the trigeminal ganglion could contribute to improve postoperative rhizotomy results of TP patients. In addition, morphometry can be helpful in predicting possible difficulties such as an insufficient puncture size of the FO before the operation.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P192

### Mikrovaskuläre Dekompression bei Patienten mit Trigeminusneuralgie: Langzeitergebnis und postoperative Lebensqualität

***Microvascular decompression in patients with trigeminal neuralgia: Impact on long-term outcome and postoperative quality of life***

J. M. Nakagawa[1], Y. Voigt[1], J. Beck[1], C. Steiert[1], J. Grauvogel[1], C. Scheiwe[1]

[1]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland

#### Objective

Microvascular decompression (MVD) is usually considered as the treatment of choice for drug-resistant classical trigeminal neuralgia. This study aims to demonstrate the impact of microsurgical therapy on the clinical outcome and pain-related quality of life.

#### Methods

In a retrospective analysis of 142 surgeries for MVD in 126 patients (mean age at surgery 62.9 years; female 61.3%, male 38.7%) performed at a single institution between 2001 and 2020, clinical data, intraoperative findings, perioperative course and postoperative outcome were reviewed. To analyze the postoperative quality of life, 39 patients with a follow-up of at least 5 years could be recruited for additional assessment based on validated questionnaires: Numeric Rating Scale (NRS), Short Form (SF)-12, Penn Facial Pain Score (PFPS) and additional questions about dental health/perioperative issues. Mean duration of symptoms before surgery was 7.7 years; mean follow-up was 4.2 years. Preoperatively, more than 63% of the patients reported side effects due to pain medication and 94.4% suffered from intolerable pain despite maximal medication.

#### Results

Intraoperatively, a neurovascular conflict was identified in 92.3% (artery 39.4%, vene 10.6%, both 42.3%). Arachnoid adhesions affected the trigeminal nerve in 26.8%, no conflict was found in 4%. Perioperative complications occurred in 6.3% (n=9): Rhinoliquorrhea 2.1%, bleeding, infarction, CSF fistula 0.7% each. Neurological symptoms were persistent in 7.0% (n=10): Mild facial hypoesthesia 4.2%, hearing impairment 2.8%, dizziness/gait disturbance 1.4 %. There was no perioperative mortality. Facial pain resolved completely after surgery in 95.8%. Three months after surgery, 80% of the patients reported freedom of pain and additional 12.3% a significant reduction. Most patients had no need for further medical treatment, but 29.5% continued medication. In the long-term course, in 12.7% trigeminal pain recurred after a pain free mean period of 3.5 years. Re-MVD resulted in a favorable outcome. Pain assessment confirmed a significant improvement of facial pain systematically quantified by the NRS and PFPS. The quality of life (SF-12) due to pain control and medication retrieval also significantly improved after surgery.

#### Conclusion

MVD is an effective treatment in primary and recurrent trigeminal neuralgia with low permanent morbidity. Long-term pain control is favorable and is associated with a significant improvement of postoperative quality of life.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P193

### MULTIDIMENSIONALE ERGEBNISSE DER RÜCKENMARKSSTIMULATION BEI PATIENTEN MIT CHRONISCHEN SCHMERZEN: ERGEBNISSE EINER EUROPÄISCHEN PROSPEKTIVEN MULTIZENTRISCHEN BEOBACHTUNGSSTUDIE

***Multidimensional outcomes of spinal cord stimulation in patients with chronic pain: Results from a european prospective multicenter observational study***

S. Thomson[1], J. Vesper[2], G. Edward[3]

[1]Mid & South Essex University Hospitals (NHSFT), Pain and Neuromodulation Centre, Basildon, Vereinigtes Königreich
[2]Universitätsklinikum Düsseldorf, Klinik für Neurochirurgie, Sektion Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland
[3]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

#### Objective

Measuring the outcomes of SCS therapy via multidimensional assessments is valuable, so that the overall impact of the treatment on patients" daily life and global health is taken into account and measured.

#### Methods

RELIEF (clinicaltrials.gov identifier: NCT01719055) is a global multicenter prospective single-arm observational study designed to collect real-world data for neurostimulation systems utilized for chronic pain indications by patients within standard of care clinical practice.

A sub-set of patients who have been treated in European centers were analyzed. Study assessments include quality of life (EQ5D), disability (ODI/PDI), Global impression of change (P-GIC/C-GIC), percentage of pain relief (PPR), satisfaction with treatment (patient/clinician), and resource utilization inventory.

#### Results

To date, over 200 enrolled patients have been implanted. In those patients who reached their 6- and 12-month follow-up visits, substantial improvements have been recorded for various patient-reported outcome measures (PROMs). At 6-month and 12-month evaluation visits, patients" function improved by over 30% per Oswestry Disability Index (ODI), and substantial improvement in quality of life measures have been reported (EQ5D). Patient Global impression of change evaluations at 6- and 12-month follow-up visits show that more than 85% patients reported improvement. RELIEF study is ongoing and these preliminary results will be updated.

#### Conclusion

This ongoing prospective evaluation of real-world outcomes show that spinal cord stimulation using personalized therapies may provide substantial improvements in multiple domains such as quality of life, function, percent pain relief and global impression of change.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P194

### Reduzierte Reaktivität in peritumoralem Gewebe gemessen mit TMS-EEG
*Reduced reactivity in peritumoral tissue as measured by TMS-EEG*

M. Engelhardt[1,2,3], G. Meneghini[4,1], M. Burzlaff[1], P. Vajkoczy[1], P. Lioumis[5], M. Rosanova[6], T. Picht[1,2,7]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Charité – Universitätsmedizin Berlin, Einstein Center für Neurowissenschaften, Berlin, Deutschland
[3]Charité – Universitätsmedizin Berlin, Graduate School Medical Neurosciences, Berlin, Deutschland
[4]University of Padova, Padova Neuroscience Center, Padova, Italien
[5]Aalto University, Department of Neuroscience and Biomedical Engineering, Helsinki, Finnland
[6]Università degli Studi di Milano, Department of Biomedical and Clinical Sciences "L. Sacco", Milan, Italien
[7]Humboldt-Universität zu Berlin, Cluster of Excellence Matters of Activity, Image Space Material, Berlin, Deutschland

#### Objective

Effects of brain tumors may extend far beyond the structural boarders of the mass, modifying activity of adjacent brain areas or even disrupting distant functional networks. Consequently, tumors that appear identical on imaging may be associated with different functional impairments and postoperative outcomes. TMS-EEG offers the unique potential to study these functional alterations by measuring the brains response to direct perturbations, while not relying on behavioral or motor outputs.

#### Methods

In this proof-of-concept case series we included five patients with high-grade gliomas (n=2), low-grade gliomas (n=2) or meningiomas (n=1) close to the midline before surgical resection of the tumor. Prior to TMS-EEG measurements, patients underwent a detailed neurological examination including assessment of motor and cognitive function. For TMS-EEG, three cortical points were targeted with approximately 200 TMS pulses each: one tumoral, one peritumoral and one matched contralateral control point. Stimulation intensity was defined based on the amplitude of early TMS-evoked potential (TEP) components (<50ms) in the contralateral control point and kept constant for the other sites. The TMS-associated click was masked with a tailored masking noise.

#### Results

In three patients with gliomas, stimulation of the tumoral spot did not produce a functional TEP. In accordance with our hypothesis, the peritumoral stimulation produced a TEP dominated by a sleep-like low-complexity slow-wave suggesting dysconnectivity of the tissue. The fourth glioma patient presented with smaller, yet simple, sleep-like TEPs for both the tumoral and peritumoral spot. In all glioma patients, stimulation of the contralesional hemisphere led to a preserved, complex TEP. Interestingly, the meningioma patient had a preserved complex TEP for all stimulation sites, however alongside a reduced amplitude of the oscillations compared to healthy controls.

#### Conclusion

For the first time, we show that TMS-EEG can detect alterations of cortical reactivity in the perilesional tissue in patients with brain tumors. A more detailed assessment of these alterations can aid the quantification of a structural and functional reserve in patients before surgery by measuring the degree of network impairment. Importantly, this is independent of the functional network at question as the method does not require a behavioral readout during stimulation.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P195

### Umfang und Grenzen feingliedriger Kategorieinformationen im ventralen visuellen Pfad
*The scope and limits of fine-grained category information in the ventral visual pathway*

M. Badwal[1,2], J. Bergmann[2], M. Hebart[2], C. Doeller[2]

[1]Universitätsklinik Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland
[2]Max-Planck-Institute for Cognitive and Brain Sciences, Psychology, Leipzig, Deutschland

#### Objective

The ventral visual stream, spanning from early visual regions to the hippocampal formation, is a hierarchical pathway responsible for processing visual information related to object recognition and categorization. Previous research has suggested that functional magnetic resonance imaging (fMRI) at nominal resolutions carries remarkably fine-grained information about individual objects. Our objective was to investigate the extent to which such fine- grained information is encoded in the multi-voxel pattern representations of the ventral visual cortex, as measured through fMRI. Clarifying the granularity of these representations can support functional mapping and localization as used in presurgical planning, for example for epilepsy surgery.

#### Methods

Each adult participant (N = 15) had their brain scanned using fMRI while viewing object images. The study took part across three sessions to increase statistical power within each participant. All 96 object images used in this study were from the animal subcategory of terrestrial, non- flying mammals, i.e. mammals that live on the land, which constituted a large homogenous class of objects. The regions of interest included early visual cortex (EVC), lateral occipital cortex (LO), posterior fusiform gyrus (pFus), Hippocampus (HC) and perirhinal cortex (PRC). We used optimized model-fitting (least square separate) as well as advanced feature selection methods (reliability-based voxel selection). For our analyses we used decoding with linear support vector machines, representational similarity analysis as well as variance partitioning with deep neural networks.

#### Results

Our results provide strong evidence for stable image-specific representations in EVC ($r=0.26$, $p<0.001$) and LO ($r=0.14$, $p<0.001$), while there is only very little evidence for higher concept- specific representations anywhere along the ventral visual stream ($r<0.07$, $p>0.01$). This indicates that low-level visual features are reliably represented in fMRI, whereas conceptual information at the basic-category level is not reliably encoded in the multi-voxel patterns of fMRI.

#### Conclusion

Our results challenge the view that fMRI patterns at nominal resolutions can reveal fine- grained distinctions between different objects. Instead, they are rather dominated by image- specific visual or coarse-grained category information. These limitations should be considered when using fMRI in a clinical setting as they restrict the granularity at which fMRI is reliable.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P196

### Vorstellen eines three-tone auditory oddball-Paradigmas zur Untersuchung der Verarbeitung von akustischen Reizen bei Ratten

*Using a three-tone auditory oddball paradigm to investigate processing of auditory stimuli in rats*

J. Jelinek[1], F. Decker[1], K. Korb[2], F. Fogaing Kamgaing[1], M. Alam[1], J. K. Krauss[1], K. Schwabe[1], E. J. Hermann[1]

[1]Medizinische Hochschule Hannover, Neurochirurgie, Hannover, Deutschland
[2]Universität Bremen, Institut für Theoretische Physik, Bremen, Deutschland

### Objective

The oddball paradigm allows to investigate the processing of behaviorally relevant auditory target events. In this study, we recorded cortical local field potentials (LFPs) within the medial prefrontal cortex (mPFC) in rats performing an auditory oddball paradigm to analyses sensory event-related potentials (ERPs), especially an early and a late component. Within a time range for the early component between 50-190 ms and a time range for the late component between 200-450 ms.

### Methods

Rats (n=9) were trained in a three-tone auditory oddball paradigm to respond correctly to a target tone (10%) that was rewarded with a casein pellet. The other tones of different frequencies had to be ignored. To analyse the event related response, electrodes were stereotactically implanted in the mPFC. The recording of the neuronal activity took place in the three-tone oddball paradigm as well as in a passive two-tone oddball paradigm with unfamiliar frequencies.

### Results

Analysis of the ERPs for three-tone oddball paradigm showed higher amplitudes of the early and late component to the target as compared to the distractor and standard tones. In the passive classic paradigm, the amplitude upon the distractor tone (10%) is higher ($p<0.05$) than the standard tone (90%) for the early component.

### Conclusion

Both paradigms can be well used to investigating processing of sensory auditory stimuli in the rat. However, in the three-tone oddball paradigm the difference between target and distractor tones are not as high as expected. It seems, that rats are over trained for the target tone.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P197

### Mikrovaskuläre Dekompression bei Trigeminusneuralgie: Eine umfassende retrospektive Analyse von 102 Patienten

***Outcomes and complications of microvascular decompression in trigeminal neuralgia: A retrospective single center study of 102 patients***

M. Alkhatib[1], T. Pinzer[1], G. Schackert[1], I. Y. Eyüpoglu[1], T. Juratli[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland

#### Objective

Trigeminal neuralgia is one of the most severe pain sensation of human beings and is often not sufficiently manageable with pharmacotherapy. Microvascular decompression (MVD) is the most effective procedure for the long-term management of classical trigeminal neuralgia (TGN). The present study addresses complications in patients with TGN who underwent MVD, and evaluate the short- and long-term outcomes.

#### Methods

clinical data, imaging results, surgical methods and treatment efficacies including pain relief according to the Barrow Neurological Institute pain scale, complications and the medical treatment during the follow-up period of 102 patients with classical TN from January 2000 to December 2022 were retrospectively analyzed and reviewed.

#### Results

A total of 102 patients (60 female and 42 male) with a mean age of 58.1 years and a mean follow-up of 78.6 months were included. 30 Patients (29.4%) had preoperatively a monotherapy with Carbamazepin or Oxcarbazepin, 63 (61.7%) with one add-on Therapy and nine patients with 3 or more drugs. The most common affected branches of the trigeminal nerve were the 2nd and 3rd in combination or alone in 98% of the cases. In all but one patient there was an evidence of neurovascular contact in the preoperative MRI. An osteoplastic trepanation was used in 22 patients and an osteoclastic one in 80 Patients. In 90 Patients an S-shaped incision was chosen and 12 Patients were operated through an c-shaped incision. 20 Patients showed muscle atrophy in the follow up. All of them were operated via an S-shaped incision. The most common vessel responsible for the neurovascular contact was the superior cerebellar artery in 68 cases. The most frequent complications were hypo- or anacusis in 6 patients, wound infection in 3, CSF fistula in 2, facial palsy in one and cerebellar hemorrhage in one patient. At the final follow-up visit, 89% of the patients had achieved significant relief of the pain (BNI Pain score 1 or 2) and 11% could reduce the medications significantly. The recurrence rate was 9%. After 4.7 years, 67.3% were still satisfied with no or occasional pain but without medications.

#### Conclusion

Microvascular decompression is an effective and safe therapy in patients with trigeminal neuralgia. Perioperative complications after MVD are comparable with the literature. Muscular atrophy, retroauricular hypoesthesia and headache are significantly more with S-shaped skin incision.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P199

### Bewertung der Sicherheit und Wirksamkeit eines neuartigen halbsynthetischen Duraersatzes in der cranialen Neurochirurgie: Eine kombinierte retrospektive und prospektive Studie

***Evaluating the safety and efficacy of semi-synthetic dural substitutes in cranial surgery: A combined retrospective and prospective study***

M. N. Bonk[1], C. Wolfert[1], P. Krauss[1], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Klinik für Neurochirurgie, Augsburg, Deutschland

#### Objective

The use of semi-synthetic dural substitutes in cranial surgery has garnered attention due to its potential in reducing complications, particularly cerebrospinal fluid (CSF) leakage. However, there is a lack of extensive research, especially in the form of randomized studies, to validate its efficacy and safety.

#### Methods

Our study was divided into two parts: a retrospective analysis of 30 patients who received semi-synthetic dural replacements from December 2022 to March 2023, and a prospective study of another 30 patients from March 2023 to September 2023. The inclusion criteria were patients over 18 undergoing neurosurgical procedures requiring dural replacement. The primary outcome measured was the rate of CSF leakages, with secondary outcomes including clinical and radiographic parameters to assess signs of infection or inflammation.

#### Results

Both the retrospective and prospective studies successfully included 30 patients each, with no adverse events reported in either group. No evidence of CSF leakage or inflammation was observed in the postoperative period. The average age of patients was 63.2 years in the retrospective group and 61.2 years in the prospective group, with a balanced distribution of male and female patients.

#### Conclusion

Our study supports the use of semi-synthetic dural substitutes as a safe and low-risk option in neurosurgery. While our results are encouraging, further large-scale randomized studies are necessary to conclusively determine its effectiveness in preventing CSF leakage.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P200

### Intraoperative Optical Imaging (IOI) ermöglicht eine spezifische funktionelle Traktographie motorischer, sensibler und visueller Bahnen

*Intraoperative optical imaging (IOI) allows a specific functional tractography of motor, sensory and visual tracts*

M. G. Prem[1], M. Oelschlägel[1,2], S. M. Fernandes Romualdo[1], N. Knobloch[1], G. Schackert[1], I. Y. Eyüpoglu[1], S. B. Sobottka[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik für Neurochirurgie, Dresden, Deutschland
[2]Technische Universität Dresden, Dresden, Deutschland

#### Objective

Identification of functionally active cortex areas and tractography from these areas by navigated transcranial magnetic stimulation (nTMS) is a well-established technique. Intraoperative optical imaging (IOI) represents a novel visualization method of cortex perfusion increase during task performance and/or stimulation and can therefore also identify functionally active cortex areas. It has been described for the motor, sensory and visual cortex. Tractography from these functionally active regions has not been performed so far. In this study we demonstrate the feasibility of tractography from IOI-positive cortex for visualization of corresponding white matter tracts.

#### Methods

IOI-positive cortex areas have been identified during surgery and mapped on a 3D-model of the patients" brains. Tractography has then been performed from these areas using Brainlab Elements software.

#### Results

16 patients were identified eligible for our study (IOI and DTI performed). The median age was 57 years (range: 26-83). Patients suffered from various tumor entities (meningioma n=1, oligodendroglioma n=2, astrocytoma n=7, GBM n=4, metastases n=9). In 13 cases no IOI positive areas were identified due to missing exposure of the functionally active regions or technical issues. In the remaining 10 cases tractography was successful and anatomically plausible tracts could be identified, including analysis of motor (n=1), sensory (n=9) and visual tracts (n=2).

#### Conclusion

This study provides a guide for tractography from IOI-positive cortex areas to visualize functional white matter tracts. It is a valuable tool to visualize subcortical tracts of specifically stimulated functional brain areas that need to be preserved during surgery.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P201

### Evaluation der Durchblutung des Sehnervs in Echzeit mit ICG-Angiographie und intraoperativen VEPs während Schädelbasiseingriffen

***Real-time evaluation of the vascular supply of the optic apparatus comparing indocyanine green video angiography to intraoperative visual evoked potential during skull base surgery***

F. Khafaji[1,2], G. Fischer[2], J. Oertel[2], S. Linsler[1,2]

[1]Klinikum Bayreuth, Medizincampus Oberfranken der FAU, Klinik für Neurochirurgie, Bayreuth, Deutschland
[2]Universitätsklinikum des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland

#### Objective

Any mass lesion around the optic apparatus can result in visual impairment by direct optic nerve compression, causing ischemia or demyelination. Improvement of visual function after tumor removal may be related to a change in the blood supply to the optic nerve (ON), which might be seen in the pial circulation during surgery. Our study aims to evaluate the effectiveness, reproducibility, and safety of using intraoperative ICG-angiography as a predictive factor for postoperative visual outcomes as well as preservation of vision.

#### Methods

Ten Patients with different perichiasmatic pathologies were selected for this analysis. Each patient completed image studies utilizing enhanced MRI, CT, ophthalmological examination, and ioVEP. Three control patients were selected assuming normal pial support of the ON in a patient who underwent an aneurysmal clipping for an ICA aneurysm. ICG was administered intraoperatively at 0,2mg/kg through peripheral vein access following a rapid of injection 10ml Nacl 0,9% before and after tumor resection using software for flow analysis ( means of flow 800 software, Kinevo, Carl Zeiss Co). The intervals between the first appearance of ICG in the internal carotid artery (ICA) and pial circulation of the ON to full saturation of both were measured at each pre-and postresection state.

#### Results

Ten patients (4 male, 6 female) were included. All patients showed improvement in visual outcomes postoperatively. Prolonged VEP latency was observed in all patients intraoperatively. The mean prolonged latency of P100 was 0.31±1.01 ms and 3.81±1.98 ms for the right and left eyes respectively, more on the tumor side. Peak time differences of ICA-ON before tumor resection was 2.77±2.65ms and 2.9±2.33ms after tumor resection ($r=0.863$, $p>0.05$, paired samples test). Mean time improvement of ON to ICA was 0.0389±1.34 ms. There was no time difference between the peak of the optic nerve and the internal carotid artery in our control.

#### Conclusion

Flow 800 seems to make a reproducible measurement to evaluate not only the real time perfusion of the optic nerve but also could provide information about improvement of blood circulation. iVEP, on the other hand, tends to prolong latency even if the optic nerve is not involved by a pathology, directly. Further studies are needed to evaluate the significance of the intraoperative flow changes.

# Funktionelle Neurochirurgie – Verschiedenes | Functional Neurosurgery – Various

## P202

### Neuronavigation in der hinteren Schädelgrube mittels intraoperativem Ultraschall
***Enabling neuronavigation support in posterior fossa surgery using intraoperative ultrasound***

M. Bopp[1,2], A. Grote[1], M. Pojskic[1], B. Saß[1], C. Nimsky[1,2]

[1]Universitätsklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Center for Mind, Brain and Behavior (CMBB), Marburg, Deutschland

#### Objective

In case of small and deep-seated lesions in the posterior fossa partially involving midline structures, surgery might be challenging and the choice of an optimal trajectory to assess the lesion while minimizing tissue dissection might be one relevant factor for obtaining optimal surgical results. Whereas neuronavigation has shown clear benefits for optimizing surgical resection and patient safety in supratentorial lesions, neuronavigation is not commonly used in posterior fossa surgery. Especially in case of surgery in the semi-sitting position, there are concerns of limited navigation. Navigated intraoperative ultrasound (iUS) can assist in identification of navigation inaccuracies, decision on its case-specific applicability and serve as opportunity to update navigation and compensate for navigation inaccuracies.

#### Methods

Data of ten patients who underwent neuronavigation supported microsurgical resection of suspected lesion within the posterior fossa in a semi-sitting position between January and October 2023 were analyzed (single surgeon study). Patient registration was performed using skin fiducials. Before durotomy, a 3D iUS data set was acquired covering the lesion completely. Navigation accuracy was determined based on the surgeon"s visual impression ("sufficient" vs. "insufficient") and evaluated using tumor outlines based on MRI and iUS data. Effects of probe-based and image-based registration were evaluated using the Dice similarity coefficient (DSC).

#### Results

The mean tumor volume was 15.24±10.93cm³ (MRI) and 14.59±10.17cm³ (iUS), showing no significant difference. The mean DSC for probe-based registration was 54.32±21.40%, 79.88±7.48% for image-based registration, with a significant ($p<0.005$) increase in spatial overlap of the outlined objects. Five cases were intraoperatively labeled as "sufficient" (mean DSC 69.01±17.26% vs. 81.43±5.39%) and five cases as "insufficient" (mean DSC 39.63±13.90% vs. 78.33±9.54%) followed by manual segmentation of the tumor in the iUS data intraoperatively.

#### Conclusion

IUS can be used prior resection to evaluate navigation accuracy matching preoperative MRI based tumor outlines and live iUS views depicting the lesion. Depending on the availability of registration techniques, 3D iUS acquisition and iUS based-tumor segmentation allow for an update of neuronavigation by either using only the iUS data set with iUS-based tumor segmentation or by intraoperative image-based fusion allowing for a significant improvement of navigation applicability.

# Education und diversity

## P203

### Elektronisches Kettengenehmigungssystem zur Dokumentation überwachter neurochirurgischer Schulungen unter Verwendung eines benutzerfreundlichen Tools in einer Umgebung mit geringen Ressourcen

***Chain electronic approval system for documentation of supervised neurosurgical training using a user-friendly tool in a low resource setting***

E. EL Refaee[1,2]

[1]Universitätsmedizin Greifswald, Neurochirurgie, Greifswald, Deutschland
[2]Cairo University, Department of Neurosurgery, Kairo, Ägypten

#### Objective

Documentation of surgical experience can be challenging without an electronic platform that enables recording and accreditation. Several systems exist that require surgeons to input their cases for certification purposes, however, most are technically complex, expensive, and tedious to use. We present our experience with developing a simple, low-cost online tool for recording and accreditation of neurosurgical operative experience where the Trainee-Supervisor experience is documented and blocked on the supervisors" decision

#### Methods

An online tool was used to create a form that was distributed among neurosurgical trainees at our institution. The trainees were asked to record some surgical details of the operated case. The trainee is required to designate a supervisor from a pool of faculty at our department who can approve the entry conforming the participation of the trainee in the submitted surgery and the validity of the entered details. The form is then automatically sent to the designated supervisor for decision: (approval, rejection, revision). If any concerns are expressed by the supervisor the form is returned through the electronic system to the trainee for revision. The result of each experience is blocked on the supervisors" final decision and cannot be changed again. The system administrator accredits the final report.

#### Results

All neurosurgical trainees used this system since its launch in 2021 for accreditation of their operative training. The database created allowed trainees to approve their surgical training in concrete terms and provided data for departmental usage on case distribution among different subspecialties, quality of training, consumables used, and case distribution among different affiliated hospitals. This data can be used for departmental development of its training program and improvement of clinical services provided. Based on this pilot data, a more sophisticated system is being developed providing the same user-friendly experience at a low cost.

#### Conclusion

Documentation of supervised operative training is important for the surgeon and the institution. Using a low-cost user-friendly platform with a reproducible and provable accreditation process can provide surgeons with a universal means for comparing their operative training across different institutions and countries. The collected data can help institutions gain better insight into their services and allow institutional development.

# Education und diversity

## P204

### *Beurteilung der Praktikabilität und Präzision von holographischer Navigation mit Unterstützung eines Laserkreuz-Simulators*
### *Evaluating the practicality and precision of laser crosshair simulator-aided holographic navigation*

Z. Qi[1,2], H. Jin[2,3,4], X. Chen[2], Q. Wang[2], Z. Gan[2,3], R. Xiong[5], S. Zhang[2,3], M. Liu[2,3], J. Wang[2,3], X. Ding[2,3], J. Zang[2], C. Nimsky[1,6], M. Bopp[1,6]

[1]Universitätsklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]First Medical Center of Chinese PLA General Hospital, Department of Neurosurgery, Beijing, China, Volksrepublik
[3]Medical School of Chinese PLA General Hospital, Beijing, China, Volksrepublik
[4]Army Medical University, NCO School, Shijiazhuang, China, Volksrepublik
[5]Kanazawa University, Graduate School of Med. Sciences, Department of Neurosurgery, Kanazawa, Japan
[6]Center for Mind, Brain and Behavior (CMBB), Marburg, Deutschland

#### Objective

To investigate a novel registration method for holographic navigation (HN) based on a laser crosshair simulator and to evaluate its feasibility and accuracy using a mixed-reality (MR) display.

#### Methods

A novel registration approach for HN in neurosurgery was introduced, utilizing two co-planar laser emitters and a computer-vision recognizable target pattern (Abb. 1). This system establishes a coordinate system aligned with computed tomography (CT) or magnetic resonance imaging (MRI) reference data sets, effectively replicating the scanner gantry"s position on the patient. A practical workflow for registration was developed, implemented in a Universal Windows Platform (UWP) software on the MR display of Microsoft"s HoloLens-2. To evaluate the method"s practicality and accuracy, 19 head phantoms, based on the preoperative CT/MRI data of 19 patients suffering from intracranial lesions (female/male: 7/12, average age: 54.4 ± 18.5 years) including six to seven markers attached to the skin, were 3D-printed at a 1:1 scale. These were used to measure and calculate the HN system"s fiducial localization error (FLE), fiducial registration error (FRE), and target registration error (TRE).

#### Results

The proposed HN registration method was successfully implemented among all 19 cases, enabling an immersive observation of the intracranial anatomical structures. Across all 124 attached markers analysis yielded a FLE of 1.9 ± 1.0 mm, a FRE of 2.0 ± 0.9 mm, and a TRE of 3.0 ± 1.1 mm (Abb. 2). When comparing different surgical positions (supine vs. prone vs. lateral), no statistically significant variations in FLE, FRE or TRE were discerned (FLE: 2.0 ± 1.0 mm vs. 1.8 ± 1.0 mm vs. 1.8 ± 1.1 mm, p = 0.685; FLE 2.1 ± 0.9 mm vs. 2.0 ± 0.9 mm vs. 2.0 ± 0.9 mm, p = 0.625; TRE 2.9 ± 1.1 mm vs. 3.1 ± 1.1 mm vs. 3.0 ± 1.3 mm, p = 0.673).

#### Conclusion

The detailed findings from the initial development and following assessments of the method demonstrate its promising combination of speed, user-friendliness, and accuracy. These improvements represent a significant step forward in creating cost-effective, self-contained, and user-focused HN systems. Furthermore, they showcase the inherent possibilities of enhancing precision and flexibility in neurosurgical procedures, which could lead to better surgical results.

Abb. 1

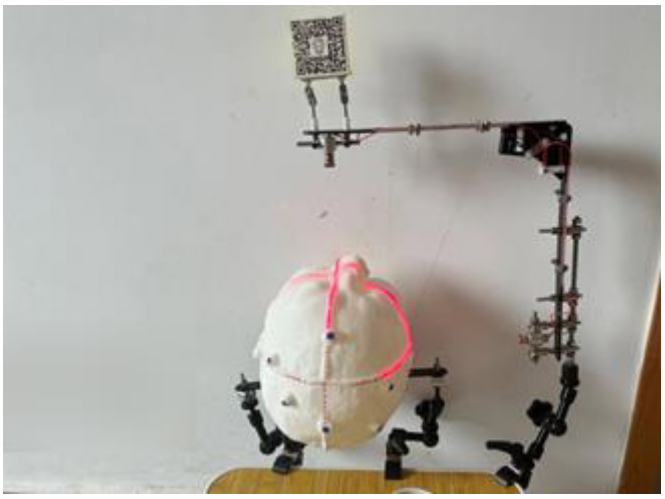
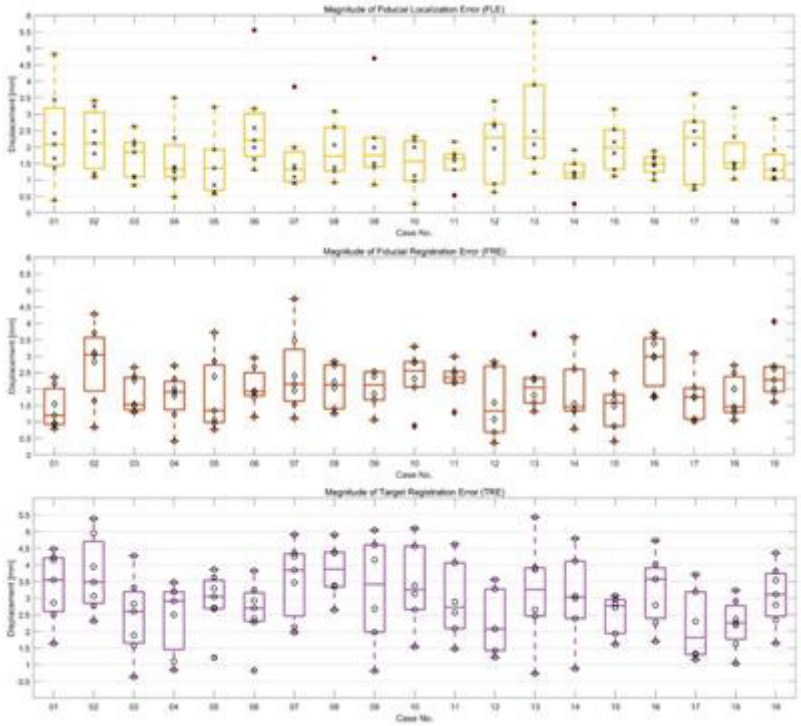


Abb. 2


Magnitude of Fiducial Localization Error (FLE)
Magnitude of Fiducial Registration Error (FRE)
Magnitude of Target Registration Error (TRE)
Displacement [mm]
Case No.

# Education und diversity

## P205

### Interprofessionelles Peer-Learning und Peer-Teaching in der Neurochirurgie
*Interprofessional peer-learning and peer-teaching in neurosurgery*

R. Pjontek[1], E. Schomacher[2], T. Schmidt[1], S. Jovic[1], B. Kremer[1], J. Ort[1], H. R. Clusmann[1], S. Sopka[3]

[1]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[2]Universitätsklinikum RWTH Aachen, Pflegedienst, Stabsstelle Weiterentwicklung und Koordination Praxisanleitung in der Pflege, Aachen, Deutschland
[3]Universitätsklinikum RWTH Aachen, Klinik für Anästhesiologie, Aachen, Deutschland

#### Objective

Interprofessional (IP) education has gained importance in recent years, with various faculties establishing interprofessional training wards and projects. We implemented an IP peer-learning and peer-teaching project for medical students and nursing trainees during their clinical placements on the neurosurgical ward. Participants met three times a week, working on self-defined learning objectives within an IP team under medical and/or nursing supervision. Finally, they presented their results to the peer group.

#### Methods

Participants from 2023 were requested to fill out the University of the West of England IP Questionnaire (UWE-IP) both at the begin and end of their placements. Additionally, they were invited to participate in a final project-specific process and outcome evaluation. The UWE-IP results underwent statistical analysis using the Mann-Whitney U Test.

#### Results

Eighty-three participants (57 female, average age 23.4 years) took part, including 43 medical students, 22 nursing trainees, 14 OR nurse trainees, and 4 representatives from other professions (e.g. physician assistants). On average, 4.7 learners were present per session. Participants' attitudes toward interprofessional learning were predominantly positive before the project, improving in all nine items during the project. Significant improvements were observed in two items: "Collaborative learning would be a positive experience for all healthcare students" ($p=0.007$) and "I would welcome the opportunity to learn with students from other healthcare professions" ($p=0.021$). Thirty participants completed the final evaluation. 92.6% rated peer-learning and all rated peer-teaching as good or very good. Interprofessional exchange and atmosphere were rated as good or very good by 96.4% of participants. All learners reported gaining knowledge through preparation of own presentation. 93.3% agreed they now feel less hesitant to approach other professions with questions or patient-related issues. Of the 13 learners with initial professional stereotypes, 11 were able to reduce them. 90% stated that good IP collaboration influenced their career decisions, and all agreed that it contributes to better patient outcomes. 97% of participants would recommend the program and participate again.

#### Conclusion

The innovative neurosurgically organized IP educational project was successfully implemented, well-received by learners, and resulted in improvements in learners' attitudes toward IP learning in various aspects.

# Education und diversity

## P206

### Einsatz von künstlicher Intelligenz in der Neurochirurgie - ChatGPT für neurochirurgische Arztbriefe und Operationsberichte

***Leveraging artificial intelligence in neurosurgery – unveiling ChatGPT for neurosurgical discharge summaries and operative reports***

D. Dubinski[1], S. Y. Won[1], S. Trnovec[1], B. Behmanesh[1], P. Baumgarten[2], N. Dinc[2], J. Konczalla[3], A. Chan[4], J. Bernstock[5], T. Freiman[1], F. Geßler[1]

[1]Universitätsmedizin Rostock, Neurochirurgie, Rostock, Deutschland
[2]Universitätsklinikum Jena, Neurochirurgie, Jena, Deutschland
[3]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik für Neurochirurgie, Frankfurt a. M., Deutschland
[4]MIT, David H. Koch Institute for Integrated Cancer Research, Cambridge, MA, Vereinigte Staaten
[5]Birgham and Women's, Harvard Medical School, Department of Neurosurgery, Boston, MA, Vereinigte Staaten

#### Objective

Chat generative pretrained transformer (GPT) is a novel large pretrained natural language processing software that can enable scientific writing amongst a litany of other features. Given this there is growing interest in exploring the use of ChatGPT models as a modality to facilitate/assist in the provision of clinical care.

#### Methods

We investigated the time taken for the composition of neurosurgical discharge summaries and operative reports at a major University hospital. In so doing we compared currently employed speech recognition software (i.e., SpeaKING) vs. novel ChatGPT for three distinct neurosurgical diseases: chronical subdural hematoma, spinal decompression and craniotomy. Furthermore, factual correctness was analysed for the above-mentioned diseases.

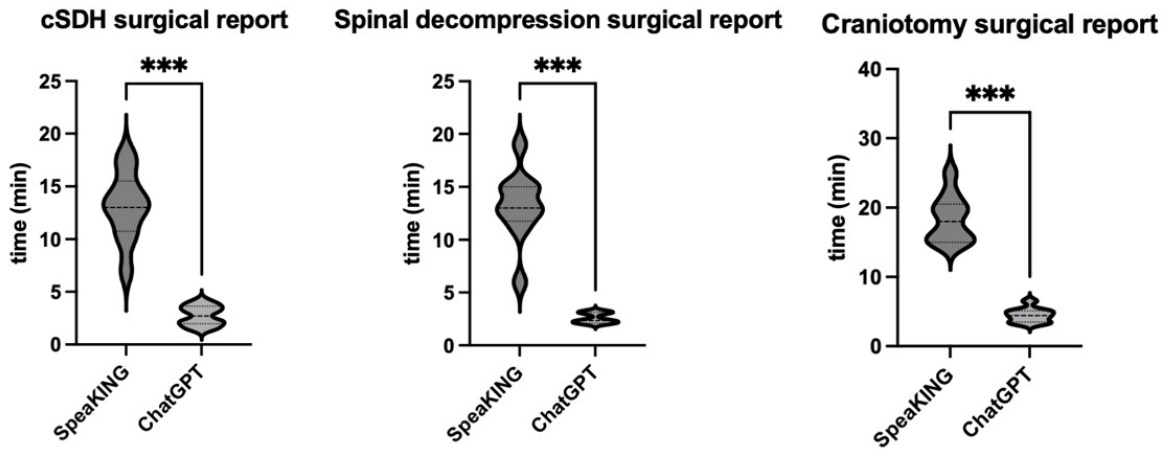
#### Results

The composition of neurosurgical discharge summaries and operative reports with the assistance of ChatGPT lead to a statistically significant time reduction across all three diseases/report types; $P<0.001$ for chronic subdural hematoma, $p<0.001$ for decompression of spinal stenosis and $p<0.001$ for craniotomy and tumor resection. However, despite a high degree of factual correctness, the preparation of a surgical report for craniotomy proved to be significantly lower ($p=0.002$).

#### Conclusion

ChatGPT assisted in the writing of discharge summaries and operative reports as evidenced by an impressive reduction in time spent as compared to standard speech recognition software. While promising, the optimal use cases and ethics of AI-generated medical writing remains to be fully elucidated and must be furthered explored in future studies.

Abb. 1


cSDH surgical report
Spinal decompression surgical report
Craniotomy surgical report
time (min)
***
SpeaKING
ChatGPT

# Education und diversity

## P207

### *Multimodale neurochirurgische Ausbildung in der Ära von COVID-19: Verbesserung der neuroanatomischen Kenntnisse und Anwendung der Neuronavigation*
### *Multimodal neurosurgical education in the era of COVID-19: Enhancing neuroanatomical knowledge and neuronavigation skills*

F. Corr[1], D. Grimm[1], C. Nimsky[1,2], M. Bopp[1,2]

[1]Universitätsklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Center for Mind, Brain and Behavior (CMBB), Marburg, Deutschland

#### Objective

Neurosurgical operations require a complex, deep anatomical knowledge, orientation and a robust 3-dimensional (3D) imagination. However, many educative resources at the beginning of a neurosurgical training quickly reach their limits, as complex neuroanatomical spatial relationships can only be mapped to a certain extent. Many routinely used supportive tools, such as neuronavigation and intraoperative imaging modalities, are difficult to use outside of direct patient care in a protected environment with clinically plausible training materials, especially in terms of reusability. In addition, the ongoing COVID-19 pandemic, is uncovering new hurdles also in limiting elective surgeries that have a direct impact on education of students and residents. Therefore, alterative clinically plausible, feasible and sustainable educative set ups need to be investigated.

#### Methods

To set up a clinical educative training environment a phantom model (PterionalBox, UpSurgeOn, Milano, Italy) was used. Furth neurosurgical training incorporating neuronavigation and intraoperative imaging, it was positioned in an in-house built object holder and fixated in a standard carbon head clamp. Navigated computed tomography images were obtained for "patient" registration. Embedded intracranial structures were manually segmented and refined within the data. Outlined anatomical structures were then visualized in the surgical microscope. Filled with fluid also the application of intraoperative ultrasound is enabled.

#### Results

Besides embedded right and left internal carotid artery (ICA) and anterior cerebral artery (A1 and A2 segment), the right middle cerebral artery (M1 and M2 segment), also the optic nerves, optic chiasm and infundibular stalk could be segmented. Segmentation allowed for a simulated intraoperative test environment of neuronavigation and augmented reality, visualizing deep-seated anatomical structures of the surgical trajectory. Additional application of intraoperative ultrasound, even not revealing sufficient simulated tissue contrast allowed for training of handling of the probe and acquiring 3D ultrasound data sets.

#### Conclusion

The reusable, inexpensive, hyperrealistical neurosurgical educative set up supports not only gaining a better 3D understanding of anatomy and access trajectories, but also allows for practical training with routinely used supportive tools. Especially in light of the Covid-19 pandemic, this enhanced training capabilities of various aspects outside clinical practice.

# Education und diversity

## P208

### Was man im Medizinstudium nicht lernt aber als Berufsanfänger braucht - Leaderhip, Kommunikation und Career Management Skills für PJ-Studierende

***Not taught in medical school but needed for the clinical job – leadership, communication and career management skills for final year medical students***

F. Behling[1], S. D. Adib[1], M. Tatagiba[1], J. Griewatz[2]

[1]Eberhard-Karls University Tübingen, Department of Neurosurgery and Neurotechnology, Tübingen, Deutschland
[2]Tübingen Institute for Medical Education, Tübingen, Deutschland

#### Objective

Starting the first job as a young physician is a demanding challenge. Certain skills are important to master this transformation that go beyond the theoretical knowledge and practical skills taught in medical school. Competencies such as communication, leadership and career management skills are important to develop as a young physician but are not taught in medical school in a structured and comprehensive way.

#### Methods

We performed an online survey among final year medical students regarding how they perceive their current competency level in communication, leadership and career management skills. We also assessed how they rate the importance to acquire these competencies and the current emphasis during their medical school education regarding these topics.

#### Results

Of 450 final year medical students 80 took part in the survey and 75 complete datasets were returned (16.7%). The majority of respondents rated different communication skills, leadership skills and career management skills as important or very important for their later clinical work. However, most students felt to be poorly or very poorly prepared by the current medical school curriculum, especially for certain leadership and career management skills. Overall, 90.7% of participants expressed interest in an educational course that covers subjects of communication, leadership and career management skills during the later stage of medical school, preferably as a hybrid in-person session that also offers synchronous online participation.

#### Conclusion

Final year medical students in Germany express the need to address communication, leadership and career management skills in the medical curriculum to be better prepared for the demands of residency.

# Education und diversity

## P209

### Die Sichtweise der Chirurgen zur Zeiterfassung: Bewertung der Auswirkungen der Arbeitszeiterfassung in deutschen Krankenhäusern

***Surgeons' perspectives on time tracking: Evaluating the impact of work hour recording in german hospitals***

R. Kramer[1], I. Y. Eyüpoglu[1], S. Günther[2], W. H. Polanski[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]HTW Dresden, Wirtschaftsingenieurwesen, Dresden, Deutschland

#### Objective

Time tracking in German hospitals is the focus of this study, which examines the impact and perceptions of surgeons on legally required working time recording, exploring its effects and consequences among surgical staff.

#### Methods

This study, based on situational theory, conducted an online survey over three months, using a 24-question format and ANOVA analysis. It targeted German hospital surgeons, with responses from 188 participants between September and December 2023.

#### Results

The survey shows strong support for working time recording among surgeons, with 79.3% overall approval and consensus across all levels, from residents to medical directors, favoring transponder-based tracking.

However, 70.6% of surgeons aged 60-70 years identify staffing and time off as key challenges, a concern less prevalent among younger surgeons (41.4%). Perceptions of fairness vary, with 28% of women and 37.17% of men viewing time recording as fair, particularly among younger surgeons (60% of 20-30 year-olds), though this declines with age.

Medical professionals have mixed views on the transparency of time recording: less than half of residents (45%) and specialists (50%) see an enhancement in transparency, compared to senior physicians (29.4%) and medical directors (14.3%) (p=0.03). Additionally, compensatory time off poses more of a burden for residents (52.5%) and senior physicians (53.2%), particularly in larger hospitals (60% in large vs. 42.6% in small).

40% of residents face difficulties in taking compensatory time off, a problem reducing with skill levels (31.3% specialists, 19.3% senior physicians, 9.3% medical directors, p=0.019). A majority (72.1%) usually have the opportunity for time off, often limited by staff shortages. Transparency in working hours is perceived differently (p=0.009), with 76.2% of medical directors noticing increased transparency, in contrast to 30% of residents, and this varies across different hospital sizes.

#### Conclusion

The study reveals the complex impact of electronic working time recording in surgery. Although popular, particularly among surgeons with long hours, its effectiveness and preference for transponder-based systems vary. However, it doesn't fully address fairness and staffing concerns, indicating a gap between management's efforts and surgeons' experiences. The issues of transparency and compensatory time off, often tied to staffing shortages, emphasize the need for enhanced communication and strategic planning.

# Education und diversity

## P210

### Der Einfluss von Hands-On Kursen für die Ausbildung von Medizinstudierenden – eine prospektive multizentrische Studie über optimale Kurscharakteristika

***The Influence of implementing neurosurgical hands-on courses for medical students – A prospective multicenter study on optimal course characteristics***

B. D. Chandra[1], S. Ricchizzi[1], P. Warnke[1], P. Fehringer[1], J. Berndt[1], S. Suvak[1], K. Kersting[1]

[1]Connectome - Student Association for Neurosurgery, Neurology and Neurosciences, Berlin, Deutschland

#### Objective

Due to the implementation of model studies, medical students are exposed to more practical courses. However, smaller specialties are granted only limited space there. A recent analysis of student-organized extracurricular hands-on courses in neurosurgery could show a high demand for these courses in Germany. For the optimization of such courses and the identification of quality indicators, a prospective multicenter study is conducted.

#### Methods

The study includes hands-on courses in the period from 05.05.2023 to 05.05.2024, for this sub-analysis courses taken place from 05.05.2023 to 31.12.2023 are included. Participants agreed to answer a questionnaire (soscisurvey.de) before and after the course. It includes demographic questions and Likert-Scale assessments (1 very little, 5 very good) for practical and theoretical skill assessment. The primary outcomes of the study are the learning experience measured by Likert-Scale assessment and its correlation to parameters such as group size and composition. Demographic data and learning experience (paired t-tests) were analyzed for this sub-analysis using Microsoft Excel 2023 and Graph Pad Prism Version 10.

#### Results

Six hands-on courses with 10 to 50 participants are included in this sub-analysis. Out of 187 applicants, 140 students could get a place for the courses. Questionnaires were filled out by 81 participants (62.96% female). With 39.51% most of them were in their 4th year of studies, followed by 27.16% in their third year, 23.46% in the two first years, and 9.88% in the fifth year. Prior experience in neurosurgery was low with 41.98% not having any experience and only 14.81% with practical courses in their university. Overall, practical and theoretical skills improved significantly with one point on the Likert-Scale (Theoretical: pre-course median 2, IQR 1-3; post-course 3, ICR 2-3 ($p < 0.0002$); Practical: pre-course median 1, ICR 1-2; post-course 2 ICR 2-3($p < 0.0001$); $n = 21$ matching questionnaires).

#### Conclusion

Extracurricular hands-on courses in neurosurgery are highly requested by students in Germany. Therefore the offer should be extended and adapted to the student's needs. The influence of course characteristics needs to be further analyzed within the course of the study and should be implemented. Besides the influence on career choice and the impact on educating the next generation in subspecialties could be assessed.

# Education und diversity

## P211

### Die mittlere Schädelgrube: Untersuchung der Effektivität von digitalen Tools in der modernen Lehre der Neuroanatomie

*The middle cranial fossa: Effectiveness of digital tools in modern teaching of neuroanatomy*

J. R. Kremer[1], E. F. G. Lorrain[1], Y. Wang[1]

[1]MSB Medical School Berlin – Hochschule für Gesundheit und Medizin, Berlin, Deutschland

#### Objective

The middle cranial fossa is one of the most complex regions in neurosurgery. Understanding the skull base requires the highest level of knowledge in applied neuroanatomy. One of the greatest challenges in training medical students and neurosurgeons is the teaching of 3D-dimensional competence concerning topographical relationships in the CNS. The foundation for understanding functions and topography is based on effective teaching strategies. In this study, we address the value of digital tools in the teaching of the central skull base.

#### Methods

49 medical students (30 female, 19 male) of the preclinical segment were offered virtual teaching over a period of one semester in addition to classical teaching on models and cadaver plastinates: Using digitally prepared presets on a virtual dissection table, M1 (= "Physikum", equivalent to USMLE Step 1) relevant structures such as the pterygopalatine fossa were visualized in a targeted manner. Implementation of the supplementary teaching was exclusively digital: Onboarding was via QR code and teaching was given at a virtual dissection table. A performance evaluation survey was used to investigate the level of knowledge and expectations prior and after tutorial.

#### Results

Our questionnaire evaluated the perfomance as followed: 1= high performance/very likely, 5=low performance/very unlikely. Evaluations have revealed the following: The usage of virtual dissecion table for self-study prior to our tutorial was estimated poorly (4,8 points). The level of knowledge in neuroanatomy was rated with 4,0 points. Post tutorial both ratings increased: Using virtual tools for self-study was now rated with 2,1 points and the level of knowledge improved (1,9 points). In general, teaching with digital features was universally accepted among students with an 2,3 rating.

#### Conclusion

Using a digital scalpel on a virtual cadaver, dissection steps can be peformed repeatedly at will and anatomical relationships can be individually designed. The brains of body donors can be virtually displayed together with vascular, nervous, osseous and other surrounding structures. Our virtual teaching shows that medical students have improved with regard to topographical competence. The use of customizable, digital tools will continue to grow in modern teaching and will pave the way for innovation in educational institutions. In conclusion, we propose this method should also find its way into the anatomical training of young neurosurgeons.

# Education und diversity

## P212

### Endoskopisch gestütztes Vorgehen ermöglicht eine bessere Operabilität und minimiert die Notwendigkeit der Retraktion des Vermis cerebelli bei telovelaren Zugängen zum Boden des vierten Ventrikels: eine anatomische Studie mit chirurgischen Implikationen

***Endoscopic assistance improves operability and reduces vermian retraction requirements during telovelar approaches to the floor of the fourth ventricle: An anatomical study with surgical implications***

L. Serrano-Sponton[1], E. Archavlis[2], A. Nimer[3], B. Fangmeier[4], E. Januschek[1], A. Ayyad[5], D. Jussen[6], M. Czabanka[6], S. Schumann[4], S. R. Kantelhardt[2,7]

[1]Sana Klinikum Offenbach, Neurochirurgie, Offenbach am Main, Deutschland
[2]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgie, Mainz, Deutschland
[3]Charing Cross Hospital - Imperial College Healthcare NHS Trust, Department of Neurosurgery, London, Vereinigtes Königreich
[4]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Institut für Anatomie, Mainz, Deutschland
[5]Hamad Medical Corporation, Department of Neurosurgery, Doha, Katar
[6]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Neurochirurgie, Frankfurt a. M., Deutschland
[7]Vivantes Klinikum im Friedrichshain, Neurochirurgie, Berlin, Deutschland

#### Objective

Approaching the floor of the fourth ventricle (FFV) constitutes a neurosurgical challenge. Telovelar approaches (TLV) enter the FFV without transecting neural tissue. However, the ventricular entrance is narrow, and pronounced microscope tilt or excessive vermian retraction is required, especially to operate along the upper ventricular portion. The wider ventricular access provided by transvermian approaches (TRVE) must be, however, tailored against the risks of neurological deterioration associated with vermian disruption (i.e., cerebellar mutism). To date, anatomical studies assessing putative advantages of neuroendoscopy to improve operability, reduce retraction and enable equal effectiveness as TRVE when approaching the FFV through a TLV are lacking.

#### Methods

We compared operability and retraction requirements between TRVE and TLV performed microsurgically (TLV_Micro) or endoscopically-assisted (TLV_Endo) to the FFV in 8 formalin-fixed heads.

#### Results

TLV_Endo enabled obtaining significantly higher operability scores than TLV_Micro, especially along the middle and superior FFV ($p<0.01$), and comparable to those obtained with TRVE. Also, significantly lower amounts of vermian retraction were required during TLV_Endo to achieve maximal operability within the middle ($p<0.01$) and superior ($p<0.001$) portions of the FFV in comparison to TLV_Micro.

#### Conclusion

TLV_Endo allows improving FFV surgery, especially within the middle and superior ventricular areas, conferring the advantage of minimal vermian manipulation. Furthermore, the steeper approach angles needed during TLV are easier to get with the endoscope, avoiding excessive and unergonomic microscopic tilt. Some shortcoming of TLV_Endo like narrow vision, long operating distance, two-dimensional image guidance, may be overcome through advances in technology and equipment.

# Education und diversity

## P213

### Entwicklung eines Behandlungserwartungsfragebogens im neurochirurgischen Setting
***Development of a treatment expectancy questionnaire in the neurosurgical setting***

L. Schock[1,2,3], O. Gembruch[1,2,3], R. Jabbarli[1,2,3], T. F. Dinger[1,2,3], M. Chihi[1,2,3], K. H. Wrede[1,2,3], P. Dammann[1,2,3], H. H. Gull[1,2,3], U. Sure[1,2,3], Y. Ahmadipour[1,2,3]

[1]Department of Neurosurgery and Spine Surgery, University Hospital Essen, Essen, Germany, Essen, Deutschland
[2]German Cancer Consortium (DKTK), Essen, Deutschland
[3]Center for Translational Neuro- & Behavioral Sciences (C-TNBS), University Duisburg Essen, Germany, Essen, Deutschland

#### Objective

There is a requirement for validated subjective outcome measurements, that are adapted to the needs and characteristics of the neurosurgical clientele and neurosurgical care (Ghimire et al., 2018). The aim was to evaluate the treatment expectancy of patients with a tumor of the central nervous system (CNS) pre- and post-surgery.

#### Methods

In the first step of the construction process, on the basis of expert and patient judgement, the questionnaire held three different theme complexes: *physical functioning, emotional and mental impairment, activities of daily living/ profession*. Additionally, information gain via pre-treatment consultation of the physician was asked. In total, there were 10 item-complexes, each consisting of 5 parts reflecting the gravity of the impairment (actual state, burden, expected treatment outcome) as well as timeline (impairment onset, expected impairment persistance after surgery); judgements were given on a 5-point Likert scale, ranging from 0 to 4 on a visual analog scale (Fig. 1). The questionnaire was given to n=23 patients with tumors of the CNS prior to surgery. Some patients were not able to fill out all items due to stress symptoms before surgery or non-applicability (e.g. retirement). We excluded missing data listwise and extreme outliers as well as the item-complex job. We correlated physical and psychological Health Related Quality of Life (HRQoL) obtained by the SF-36 survey (Stieglitz, 1999; Ware & Sherbourne, 1992) with our questionnaire.

#### Results

As a first result, we received significant positive correlations ($p<.01$) of the physical HRQoL score with the item *strength* and of the psychological HRQoL score with the item *cognitive performance* ($p<.01$) and *communication* ($p<.05$).

Figure 1: a) Example of an item complex of the neurosurgery treatment expectancy questionnaire **pre-surgery**, b) **post-surgery**

#### Conclusion

In conclusion, the results indicate a first step into construct validity. We will obtain postoperative data for the comparison of expectancy and outcome to evaluate quality of our surgical treatment. On the basis of item analyses the questionnaire will be adjusted and given to a validation sample of at least n=100 patients.

Abb. 1

Fig. 1a)

**1. Körperliche Funktionen**

**Wie schätzen Sie Ihre Kraft (hinsichtlich aktueller Erkrankung) ein?**

| | | | | | |
|---|---|---|---|---|---|
| Aktueller Ist-Zustand | ☐ | ☐ | ☐ | ☐ | ☐ |
| *Wie belastet fühlen Sie sich dadurch?* | ☐ | ☐ | ☐ | ☐ | ☐ |
| Erwarteter End-Zustand | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ***keine*** | **Tage** | **Wochen** | **Monate** | **Jahre** |
| Beeinträchtigungen seit? | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ***Trifft n.* zu*** | **Tage** | **Wochen** | **Monate** | **Jahre** |
| *Erwartetes Fortbestehen nach OP?* | ☐ | ☐ | ☐ | ☐ | ☐ |

*nicht

Fig. 1b)

**1. Körperliche Funktionen**

**Wie schätzen Sie Ihre Kraft (hinsichtlich aktueller Erkrankung) ein?**

| | | | | | |
|---|---|---|---|---|---|
| Aktueller Ist-Zustand | ☐ | ☐ | ☐ | ☐ | ☐ |
| *Wie belastet fühlen Sie sich dadurch?* | ☐ | ☐ | ☐ | ☐ | ☐ |

# Education und diversity

## P214

### Optoakustische Aufzeichnung in der Neurochirurgie: Ein neuer Ansatz zur Echtzeit-Tumordifferenzierung mittels Geräuschen von OP-Saugern

***Optoacoustic recording in neurosurgery: A novel approach for real-time tumor differentiation using operation suction cevice sounds***

M. N. Bonk[1], C. Wolfert[1], P. Krauss[1], E. Shiban[1]

[1]Universitätsklinikum Augsburg, Klinik für Neurochirurgie, Augsburg, Deutschland

#### Objective

Cranial oncological surgery has long faced challenges in real-time differentiation between tumor and healthy brain tissue. Traditional methods like fluorescence-based techniques have limitations, necessitating innovative approaches for enhanced surgical precision.

#### Methods

This study explored the feasibility of optoacoustic recording using an operation suction device during tumor resections. Conducted with 10 patients (6 with glioblastoma, 4 with metastases), the research involved capturing intraoperative sounds, which were then processed by an AI system for pattern recognition.

#### Results

The AI successfully identified reproducible sound patterns correlating with different tissue types. The technique was effective even during complex scenarios, such as awake craniotomies, demonstrating its robustness and versatility. The setup required minimal preparation time, suggesting its feasibility in standard surgical workflows.

#### Conclusion

This study proves the viability of optoacoustic recording in neurosurgery as a groundbreaking method for real-time data acquisition. This novel technique has the potential to revolutionize tumor differentiation in neurosurgical procedures, enhancing surgical accuracy and patient outcomes. The findings lay the groundwork for further research and development in AI-assisted surgical technologies.

# Education und diversity

## P215

### Intraoperative konfokale Laserbildgebung – Erfahrungen aus Sicht eines Erstanwenders
*Intraoperative confocal laser imaging – Experiences from a beginner's perspective*

I. Skambath[1], J. Kren[1], J. Matschke[2], M. M. Bonsanto[1]

[1]Universitätsklinikum Schleswig-Holstein, Klinik für Neurochirurgie, Lübeck, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Hamburg, Deutschland

#### Objective

In recent years, intraoperative confocal laser imaging (CL imaging) has been presented as a pioneering alternative tool to conventional frozen section diagnostics, as it eliminates the need for physical biopsies. The frozen section procedure typically takes between 20 and 30 minutes from the time the biopsy is taken to the transmission of the diagnosis. The biopsy has to be frozen, sectioned and stained. CL imaging could be particularly useful in cases where large-scale tissue samples cannot be taken, which is often the case in brain tumor surgery. In a pilot project, a commercially available system was evaluated for its applicability and suitability for diagnosing brain tumors.

#### Methods

The confocal laser system was purchased in June 2022. By December 2023, 20 patients had been examined with the system. In addition to CL imaging, a biopsy was taken in the scanned areas and a frozen section was made. Questions about user-friendliness included the user interface, the artifact adhesion of the images, the duration of imaging and the product training offered.

#### Results

We found that the application time differs significantly from that of a conventional frozen section. Image interpretation was hardly possible for experienced neuropathologists despite having undergone all available product training courses. In two out of twenty cases, the neuropathologist was able to provide a diagnosis for the transferred CL images. In both cases, the diagnosis was consistent with the final neuropathologic diagnosis. In 19 of the 20 cases, the neuropathologist was able to provide a diagnosis based on the frozen section, which was consistent with the final neuropathological diagnosis.

#### Conclusion

With CL imaging, it was possible to generate potentially suitable images within 5 minutes max, in contrast to at least 20 minutes for a frozen section. We also found that the artifact retention and rejection of CL imaging is very high at 90%. The idea of an optical biopsy is particularly interesting in brain surgery. In this project, an attempt was made to establish a commercially available CL system within a university cancer center. The cloud connection to the neuropathologist and the speed of image generation should be emphasized positively. We found that the non-comparability of the CL image modality with conventional frozen sections was a particular problem. It requires extensive training for the neuropathologist making the diagnosis in order to fully benefit from the technology.

# P232

## Anschlussfrakturen nach Hybrid-Wirbelsäuleneinstrumentierung im Zusammenhang mit Hounsfield Units
*Adjacent segment fractures after hybrid vertebral instrumentation in relation to Hounsfield units*

N. Aboud[1], C. Senft[1], F. Schwarz[1]

[1]Universitätsklinikum Jena, Klinik mit Poliklinik für Neurochirurgie, Jena, Deutschland

### Objective

Hybrid vertebral instrumentation (cement augmented pedicle screw fixation with kyphoplasty) is an evolving surgical approach to treat osteoporotic vertebral fractures. However, concerns have been raised about the potential risk of Adjacent Segment Fractures (ASF) following this procedure. The assessment of bone quality using Hounsfield Units (HU) in computed tomography (CT) scans has gained prominence in predicting fracture risk. This study aims to investigate the potential relationship between HU measured in the treated vertebral segment and the occurrence of ASF following hybrid vertebral instrumentation

### Methods

A retrospective analysis was conducted on a cohort of patients who underwent hybrid vertebral instrumentation procedures between 2012-2020. Hounsfield Units were measured in the vertebral segments both above and below the treated level using CT scans. Patients were divided into two groups: those who developed ASF and those who did not. The HU values in both groups were statistically analyzed to assess a potential correlation. The median follow-up was 51.9 weeks

### Results

Over the study period, 72 patients (49 female and 23 male) were included. Among them, 8 patients (11%) developed ASF after surgery (6 above und 2 under the index vertebra, including 7 women and 1 man (p = 0.4)). Mean age was 77 years in the group without ASF and 74 years in the group with ASF (p = 0.8). The mean HU value above the index vertebra was 87 HU in the group without ASF and 77 HU in the group with ASF (P= 0.3). The mean HU values below the index vertebra were 71 HU in the group without ASF and 57 HU in the group with ASF (P= 0.5). A logistic regression analysis was done to examine the influence of HU to predict the occurrence of ASF

### Conclusion

Our study suggests a potential association between low HU above and below the treated vertebral segment and the occurrence of ASF. Preoperative assessment of bone density using HU could be considered for patient selection and risk evaluation to improve the success rate of this procedure. However, it should be noted that the number of study participants may have been too small, potentially impacting the interpretation of the results. Nevertheless, there was no significant correlation between ASF and HU values, indicating that other factors may contribute to these fractures. Further prospective studies are necessary to validate these findings and assess their clinical applicability

# P233

## Computergestützte Anpassung perkutan eingebrachter Längsstäbe – Erfahrung mit einer VR-gestützten Software. Fallserie von 28 Patienten.

***Computer-assisted Bending of Percutaneuosly Implantet Rods. Experience with a virtual reality (VR)-driven process support. Case Series of 28 patients***

R. Moringlane[1], S. Antes[1], S. Kupsch[1], K. von Eckardstein[1]

[1]Westpfalz-Klinikum Kaiserslautern, Department of Neurosurgery, Kaiserslautern, Deutschland

### Objective

Percutaneous implantation of rods in mulitlevel stabilization procedures is often time-consuming and may lead to tension forces on the screw-rod connection which carry a risk of screw implant failure. A commercially available VR-driven application was developed to facilitate and accelerate the surgical steps of rod bending and adjustment. We report about our experience with that system based on a case series of 28 patients.

### Methods

A prospective evaluation of cases, treated at our institution was performed with descriptive statistics. Demographic parameters, extend of intervention, post-operative CT-scans, time of scanning and rod bending, as well as complications are reported. Follow-up with additional CT-scans was performed after three months.

### Results

Until December 2023 28 cases (16f, 12m) were treated. Mean age was 68 years (40 to 88 years). Indications were fractures, tumor instabilities, degenerative instabilities, as well as infections. Duration of surgery was 2h to 5h40, including decompression and tumor resection where needed. A mean of 8 screws were implanted (6 to 20 screws). Mean time of scanning and rod bending per side were 4.2 and 3.7 minutes, respectively. In the time to follow-up there were five cases of screw loosening (17.8 %) of which three (10.7 %) required revision surgery.

### Conclusion

In spite of long constructs in multilevel instrumentations scanning, rod bending, and tension-free rod implantation took only 7.9 minutes. In separate cadaver studies significant time differences between the VR-assisted system and non-assisted rod bending and rod implantation has been demonstrated. Here we have shown that the VR-assisted system appears to be time-sparing and cost-effective in the routine clinical setting as well. However, the assumed clinical long term improvement with lower failure rates due to tension-free implantations have to be evaluated in further studies.

# P234

## Kann künstliche Intelligenz die Diagnose und Prognose bei traumatischen Rückenmarkverletzungen präzise stellen?

***Can artificial intelligence accurately diagnose and prognosticate patients with traumatic spinal cord injury?***

S. Gierzstein[1], H. Subbiah Ponniah[1], D. S. C. Ramsay[1], S. Vishnu K[1], J. Neuhoff[2,3], A. Kramer[4], S. G. Thavarajasingam[4,1]

[1]Imperial Brain & Spine Initiative, Imperial College London, London, Vereinigtes Königreich
[2]Berufsgenossenschaftliche Unfallklinik Frankfurt am Main, Center for Spinal Surgery and Neurotraumatology, Frankfurt a. M., Deutschland
[3]Spondylodiscitis Study Group, EANS Spine Section, Brussels, Belgien
[4]University Medical Center Mainz, Department of Neurosurgery, Mainz, Deutschland

### Objective

Novel artificial intelligence (AI) models have been developed for the diagnosis and prognostication of traumatic spinal cord injury (tSCI). However, the accuracy and applicability of these models in clinical practice remain unknown

### Methods

This study aims to evaluate the performance of AI algorithms in the diagnosis and prognostication of tSCI. Outcomes of interest included the area under the receiving operator curve (AUC), sensitivity, specificity, accuracy, precision and F1 score. Studies were identified on all major databases and included if AI models were used and evaluated in the diagnosis and/or prognostication of tSCI. Qualitative synthesis followed the Synthesis Without Meta- Analysis (SWiM) reporting guidelines.

### Results

The initial search identified 12306 studies, wherein 14 articles were included in the study. AI models predicted prognosis in 11 studies (78.6%), and diagnosis in 3 studies (21.4%). Prognostic patient sample sizes ranged from 210 to 72132. 2273 radiological images were used for model training, validation and testing in diagnostic models. Improved American Spinal Injury Association Abbreviated Injury Scale (AIS) was the most predicted prognosis (36.4%), followed by mortality (27.3%). Diffusion- weighted imaging (66.7%) and plain radiography (33.3%) were used for diagnostic models. The number of input features ranged from 4 to 97, most commonly age (100%), AIS score on admission (100%) and sex (72.7%). Only one diagnostic study compared their model to physician performance and found worse model accuracy. The reported AUC varied across prognostic studies, ranging from 0.682 to 0.902, however, the majority (72.7%) reported an AUC between 0.800 to 0.900, suggesting moderate model accuracy. When testing AUC was reported, overfitting was observed across models.

### Conclusion

Our study found promising applications for the integration of AI in prognosticating tSCI, however, a lack of robust samples and external validation currently restricts its clinical utility. Future AI models should be built using a multi-modal approach including imaging, patient and disease characteristics and relevant examination data as input features, as well as comparison with clinicians' judgement, to build truly clinically apt models.

# P235

## Klinisches Outcome nach chirurgischer Behandlung von spontanen spinalen Epiduralblutungen (SSEH) - eine retrospektive Kohortenstudie

***Clinical outcome after surgical management of spontaneous spinal epidural hemorrhages (SSEH) – A retrospective cohort study***

C. Kissling[1], L. Häni[1], R. Schär[1], A. Raabe[1], C. M. Jesse[1]

[1]Inselspital – Universitätsspital Bern, Neurochirurgie, Bern, Schweiz

### Objective

A spontaneous spinal epidural hematoma (SSEH) is a rare pathology characterized by a hemorrhage in the spinal epidural space without any prior surgical or interventional procedure. Recent literature reported contradictory findings regarding the clinical, radiological and surgical factors determining the outcome, hence the objective of this retrospective analysis was to re-assess these outcome-determining factors in a homogenous SSEH patient collective.

### Methods

26 patients surgically treated for SSEH at our institution from 2010 – 2022 were included and retrospectively assessed regarding the management, especially the time-to-treatment, the pre-and post-treatment clinical status, the radiological findings as well as other patient-specific parameters. The outcome was assessed using the modified McCormick scale. Statistical analyses included binary logistic regression and Fisher"s exact test.

### Results

The analysis yielded 17 male (65%) and 9 female (35%) patients aged 70 in median (interquartile range 26.5) with cervical (31%) and cervicothoracic (69%) SSEHs. 69% of the patients underwent surgery after less than 12h, 31% of the patients after more than 12h. Neither the craniocaudal hematoma expansion (p = 0.49) nor the axial hematoma occupation of the spinal canal (p = 0.58) , nor anticoagulation (p = 0.67) or antiaggregation (p = 0.74), nor the preoperative clinical status (p = 0.99), nor the time-to-surgery (p = 0.24 / 0.74) were significantly associated with the patient"s outcomes. (P-Values for binary logistic regression.) The outcome was generally good as 58% of the patients had a postoperative modified McCormick scale grade of 1 (no residual symptoms) and 31% had a grade of 2 (mild symptoms) – only 12% remained with a modified McCormick scale grade of 4 or 5 (severe motor deficits / paraplegic).

### Conclusion

Surgical evacuation of SSEH leads to a good clinical outcome regardless of the severity of symptoms and the symptom-to-treatment interval. Surgical treatment should thus be generously indicated in patients with SSEH.

# P236

## Klinische, radiologische und operative Charakteristika der radikulär bedingten Eversionsparese.
*Clinical, radiological, and operative characteristics of radicular eversion paresis*

C. Janz[1], R. Buhl[1]

[1]Städtisches Klinikum Solingen, Neurochirurgie, Solingen, Deutschland

### Objective

It came to the authors" attention, that in radicular eversion paresis (REP), compression is frequently located behind the L5 vertebral body or at the L5 foramen. These regions might not be included in axial MRI scans often restricted to the disc level. Furthermore, eversion is not tested routinely by all examiners. Being at double risk to remain undiagnosed, it is thus the objective of this observational study to raise clinicians" awareness of REP.

### Methods

We retrospectively analyzed case files and MR scans of 70 patients consecutively operated in our department with REP. To rule out inter-observer-variability, the study was restricted to a single surgeon. $H_0$-hypothesis "Compression in REP is equally distributed to the 5 compartments "A: above the – and B: at the L4/5-disc level-C: behind the upper half of L5-D: behind the lower half of L5 and -E: at the L5 foramen" was tested by the $\chi^2$ goodness-of-fit test.

### Results

REP was accompanied by radicular pain in all but two cases of imminent nerve root death. It occurred as an isolated entity in only 5 but combined with paresis of the foot extensors in 43, toe extensors in 52, gluteal muscles in 11, quadriceps femoris in one, and plantar flexors in 18 cases. 18 patients displayed no sensory deficit. 22 suffered from sensory loss following the L5-, 11 the S1-, and 19 mixed dermatomes. Surgery revealed direct disc compression for the L5 root in 61 and the S1 root in 6 cases. It was in compartment A in 8, B in 9, C in 29, D in 9, and E in 15 cases, i.e. caudal of the L4/5-disc in 76%. Out of the remaining 17 cases, 11 were combined with lumbar stenosis, recurrent disc herniation, transitional vertebrae, mass herniation, or spondylolisthesis. In 43 patients, the onset of REP was less than a week before and in 14 on the day of admission leading to emergency surgery. In 8 patients, REP remained unchanged during hospital stay, 47 gained less than one, and 15 at least one MRC grade for all affected muscles. $H_0$ could be rejected, the result being significant at $p<.05$, providing strong evidence that compression in REP is not equally distributed to the 5 compartments but located predominantly in C and E.

### Conclusion

REP is a typical compression symptom of predominantly the L5 root, frequently associated with sudden onset and often combined with further motor deficits. With compression located most frequently behind the vertebral body of L5 or at the L5 foramen, special attention should be focused on these regions evaluating the MRI scans.

# P237

## Entschlüsselung der kindlichen Rückenmarkskompression: Eine retrospektive Einzelzentrum-Studie über Ätiologie, Klinik, therapeutische Strategien und Outcomes.

***Decoding pediatric spinal cord compression: A single-center retrospective study on etiology, presentation, therapeutic strategies, and outcomes***

P. Lenga[1], D. Kühlwein[2], M. Grutza[2], M. Issa[2], F. Hinz[3], F. Sahm[3], F. Selt[4], T. Milde[4], P. Günther[5], A. Unterberg[1], S. Krieg[1], A. El Damaty[1]

[1]Universitätsklinikum Heidelberg, Klinik für Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Klinik für Neuropathologie, Heidelberg, Deutschland
[4]Universitätsklinikum Heidelberg, Pädiatrische Onkologie, Heidelberg, Deutschland
[5]Universitätsklinikum Heidelberg, Klinik für pädiatrische Viszeralchirurgie, Heidelberg, Deutschland

### Objective

Spinal cord compression caused by tumor related process (SCC) often results in dire prognosis, carrying risks such as permanent paralysis, sensory loss, and sphincter dysfunction. Data on the incidence and etiology of SCC caused by tumorous process in pediatric populations are markedly scant. Our study investigates the etiology, clinical manifestation, treatment, and outcomes of pediatric SCC patients inflicted by various tumor types and provides a comprehensive review of the existing literature on this subject.

### Methods

We conducted a retrospective review of our institutional pediatric oncology and neurosurgery database, examining 14 patients under 18 years admitted with SCC due to oncological diseases since 2005. We analyzed the clinical presentations, evaluations, molecular diagnostics and treatments for these patients.

### Results

14 pediatric patients, each diagnosed with distinct spinal tumor entity were included. The mean patient age was approximately 19.6 ± 10.1 months. Severe spinal cord pain was observed in 13 patients, while acute neurological deterioration manifested in 7 patients. As a first-line intervention, 13 patients underwent decompressive surgery through laminectomy and tumor resection, and only one patient received chemotherapy solely. Before surgery, seven patients were unable to walk; post-surgery, six of them regained their ability to ambulate. The diagnosis encompassed a range of neoplasms: two instances of Ewing sarcoma, 3 instances of teratoma, one case presenting an atypical teratoid Rhabdoid tumor, two instances each of low-grade astrocytoma and neuroblastoma, and single instances of ependymoma, meningioma, rhabdomyosarcoma, and embryonal tumors with multilayered rosettes (ETMRs). Three patients succumbed two years after initiating therapy.

### Conclusion

Despite their rarity, intraspinal tumors in pediatric patients pose substantial therapeutic challenges. The intertwined complexities of the disease entity and the patient's neurological status demand swift initiation of an individualized therapeutic strategy. This crucial step helps optimize outcomes for this patient cohort, who frequently grapple with debilitating health conditions. Inclusion of these patients within a registry is mandatory to optimize treatment outcomes due to their rarity in pediatric population.

# P238

## Diagnosestrategien, klinisches Management und Ergebnisse bei Patienten mit spinaler duraler arteriovenöser Fistel (SDAVF)

***Diagnostic strategies, clinical management, and outcomes in patients with spinal dural arteriovenous fistula (SDAVF)***

A. Filis[1], S. Romualdo[1], K. Engellandt[2], I. El-battrawy[3], D. Podlesek[1], G. Schackert[1], T. Juratli[1], I. Y. Eyüpoglu[1], M. M. Hijazi[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Neuroradiologie, Dresden, Deutschland
[3]Universitätsklinikum Bochum, Kardiologie, Bochum, Deutschland

### Objective

Spinal dural arteriovenous fistulas (SDAVF) are rare vascular malformations of the spine, which nevertheless account for around 80% of all arteriovenous malformations of the spine. Our aim was to characterize patient demographics pre-treatment, diagnostic history, and neurological outcomes of surgically and endovascularly treated patients.

### Methods

The medical records of 81 patients who underwent surgical (n = 70, 86.4%) and endovascular (n = 11, 13.6%) treatment for SDAVF at a university hospital between 2002 and 2023 were retrospectively analyzed.

### Results

SDAVF was observed more frequently in men than women (61, 75.3% vs. 20, 24.7%) with a mean age of 63.5 ± 12.7 years and a mean duration of symptoms to diagnosis of 12.0 ± 12.8 months. The most common first symptom was gait disturbance (36, 44.4%), followed by sensory disturbance (24, 29.6%). The location of the fistula point was most common in the lower thoracic region (36, 44.5%), followed by the lumbar region (23, 28.4%). Incomplete or failed occlusion of the fistula occurred in 8 patients (9.9%), with 6 patients (7.4%) undergoing further treatment either surgically or endovascularly. Treatment- or hospital-related complications were observed in 16 patients (19.8%). Laminectomy was the most common approach (31, 44.3%), followed by hemilaminectomy (28, 40.0%) and fenestration (11, 15.7%). Back pain or radiculopathy was observed in 58% of patients (47/81) pre-treatment and had already decreased to 24.7% on hospital discharge, with no significant change in sensory disturbances over the course of the disease. The median motor score (MS) was 94 [82.5 - 100] at admission, 98 [86.5 - 100] at hospital discharge, 100 [90 - 100] at the first, second, and third follow-up ($p$ = 0.019). The median modified Aminoff-Logue scale of disability (mALS) was 5 [2 - 7] at admission, 3 [1 - 6] at hospital discharge, 2 [1 - 5] at the first follow-up, 2 [0.5 - 5] at the second follow-up and 2 [1 - 7] at the third follow-up ($p$ = 0.006).

### Conclusion

SDAVF occurs predominantly in males in the 6th decade of life, which can be safely and effectively treated surgically and endovascularly, leading to improvement in symptoms such as pain and motor, sensory, and gait disturbances.

# P239

## Digitaler OP-Prozessmanager (SPM) zur Erleichterung des Arbeitsablaufs und Etablierung von Standard-Operationsverfahren am Beispiel der navigierten TLIF

***Digital surgical process manager (SPM) to facilitate the workflow and establish standard surgical procedures using the example of the navigated TLIF***

D. Tkatschenko[1], L. Truckenmüller[1], D. Daaboul[2], U. C. Schneider[3], P. Vajkoczy[1], N. Hecht[1]

[1]Charité – Universitätsmedizin Berlin, Klinik für Neurochirurgie, Berlin, Deutschland
[2]Johnson & Johnson AG, Zug, Schweiz
[3]Luzerner Kantonsspital, Klinik für Neurochirurgie, Luzern, Schweiz

### Objective

Standard operating procedures can improve training of OR teams and facilitate workflow. Here, we analyzed the workflow and OR times using a digital surgical procedure manager (SPM) for real-time visually-assisted guidance of OR staff in a neurosurgical operating room environment.

### Methods

For this single-center observational study, an interprofessional team of OR nurses, digital product specialists and neurosurgeons systematically subdivided and categorized the surgical steps of an image-guided, mono-segmental lumbar spinal fusion procedure. Individual steps and sub-steps were photo-documented and recorded onto a modular digital surgical procedure manager (SPM) platform. During surgery, the SPM platform was operated by a circulating nurse using a wireless footswitch to advance or reverse through the pre-defined surgical workflow steps. Individual steps and sub-steps were visualized on ceiling-mounted video screens for appreciation by the entire OR team. Intraoperative workflow was reviewed and time in the OR during Q1+2 (November 2021 to April 2022) of the implementation phase was compared to time in the OR during Q3+4 (May 2022 to November 2022).

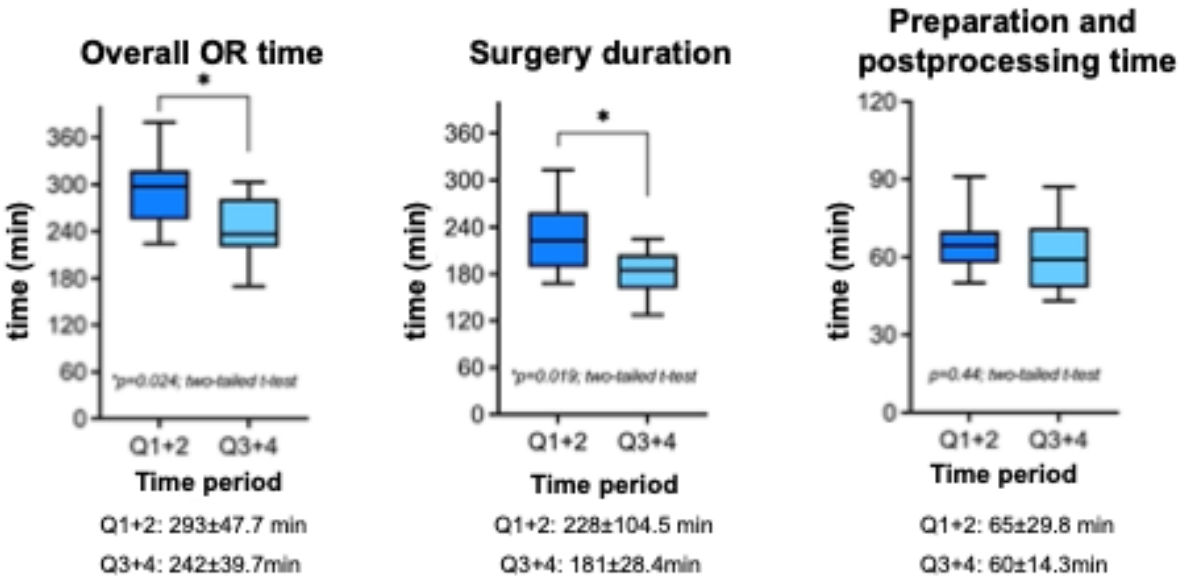
### Results

During the 12-month implementation period, 18 patients (median age 72.5 years, range 43-48; Q1+2: n=8, Q3+4: n=10) underwent image-guided mono-segmental transforaminal lumbar interbody fusion using SPM. In all procedures the SPM software module was successfully and independently implemented and run by the circulating OR staff with full integration into the regular OR setup without affecting regular workflow. Although OR preparation and postprocessing times did not differ (Q1+2: 65±29.8min vs. Q3+4: 60±14.3min; p=0.44), both the overall OR time (Q1+Q2: 293±47.7min vs. Q3+Q4: 242±39.7min, *p=0.024) and surgery duration (Q1+2: 228±104.5min vs. Q3+4: 181±28.4min, *p=0.019) were significantly reduced during the second half of the implementation period.

### Conclusion

The intraoperative utilization of a digital SPM platform for real-time visualization of surgical standard operating procedures was easy to implement and gained acceptance by the OR team. In our experience and within this limited cohort, the reduction of the surgery duration without affecting preparation and postprocessing times indicates a successful learning curve that in the future could benefit staff and patients by facilitating workflow and reducing OR time.

Abb. 1


Overall OR time
*
time (min)
360
300
240
180
120
60
0
*p=0.024; two-tailed t-test
Q1+2
Q3+4
Time period
Q1+2: 293±47.7 min
Q3+4: 242±39.7min
Surgery duration
*
time (min)
360
300
240
180
120
60
0
*p=0.019; two-tailed t-test
Q1+2
Q3+4
Time period
Q1+2: 228±104.5 min
Q3+4: 181±28.4min
Preparation and postprocessing time
time (min)
120
90
60
30
0
p=0.44; two-tailed t-test
Q1+2
Q3+4
Time period
Q1+2: 65±29.8 min
Q3+4: 60±14.3min

# Spinal – Verschiedenes 3 | Spinal – Various 3

## P240

### Experimentelle und numerische Untersuchung der biomechanischen Eigenschaften von Pedikelschrauben mit doppeltem Gewinde bei Osteopenie und Osteoporose

***Experimental and numerical investigation of the biomechanical properties of pedicle screws with dual thread in osteopenia and osteoporosis***

M. A. Mahmoud[1], C. Horstmann[2], D. Kleber[2], M. Praster[1], M. Teuben[2], C. Herren[1], F. Hildebrand[1], M. Pishnamaz[1], R. Sobottke[2]

[1]Universitätsklinikum RWTH Aachen, Orthopädie und Unfallchirurgie, Aachen, Deutschland
[2]Rhein Maas Klinikum, Zentrum für Orthopädie und Unfallchirurgie - Klinik für Wirbelsäulenchirurgie, Würselen, Deutschland

#### Objective

Pedicle screws are a common surgical treatment for spinal disorders. However, screw loosening and failure are a major complication, especially in osteoporotic vertebrae. This can lead to poor clinical outcomes and increased patient morbidity. This study compared the biomechanical properties of mono-threaded (ST) and double-threaded (DT) pedicle screws without cement augmentation. A numerical model was also validated

#### Methods

Two commercially available, polyaxial pedicle screws were biomechanically tested and compared. The dimensions of the screw hole and screw (l:45 mm, dm: 6.5 mm) were standardized. Pull-out strength and holding strength were determined and compared in normal bone (n=12), simulated osteopenia (n=12), and osteoporosis (n=12). The force-displacement curves were used to determine the numerical parameters of the cohesive zone model.

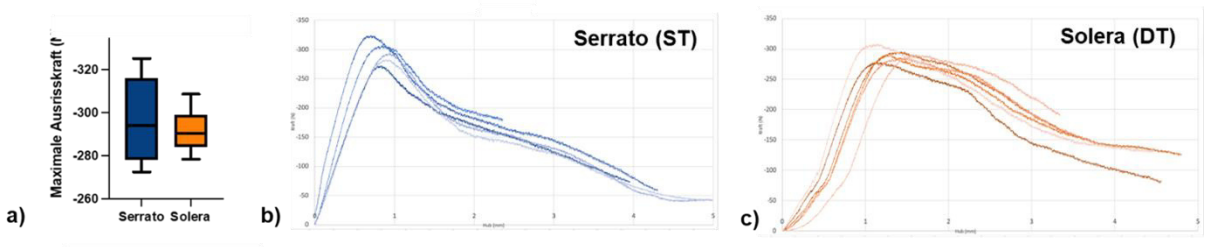
#### Results

The maximum holding force (F max) did not show a statistically significant difference in normal bone between the groups (ST: 2271N ± 197N and DT: 2196N ± 178N, p=0.5). However, in osteoporotic bone, the force-displacement curves of the two screws exhibited significant differences. F max for ST was -296.4N ± 20.46N, and for DT, it was -291.7± 10.10N, as shown in Fig. 2a). Nevertheless, up to screw failure, the ST screw demonstrated a noticeably steeper gradient compared to the DT screw.

#### Conclusion

The study demonstrated variations in biomechanical properties. Through the conducted experiments, a numerical cohesive zone model was developed and validated, enabling the identification of the optimal selection of pedicle screws for patients.

#### Abb. 2



# P241

## Monosegmentale unilaterale zervikale Foramenstenose: die Rolle der Virtual-Reality-Technologie bei der Bewertung der chirurgischen Strategie und des Ergebnisses

***Monosegmental unilateral cervical foraminal stenosis: The role of virtual reality technology in the evaluation of surgical strategy and outcome***

S. Zawy Alsofy[1,2], E. Wilbers[1,2], M. Nakamura[2,3], T. Fortmann[1,2], A. Salma[4], M. Lewitz[1,2], C. Ewelt[1], R. Stroop[2]

[1]St. Barbara-Klinik Hamm-Hessen, Neurochirurgie, Hamm, Deutschland
[2]Witten/Herdecke University, Department of Medicine, Faculty of Health, Witten, Deutschland
[3]Academic Hospital Koeln-Merheim, Neurochirurgie, Köln, Deutschland
[4]St. Rita's Neuroscience Institute, Department of Neurosurgery, Lima, OH, Vereinigte Staaten

### Objective

Foraminal cervical nerve root compression can be caused by lateral disk herniation or osteophyte formation of the vertebrae. Improved diagnosis and evaluation can be achieved using different imaging techniques: radiographs, computed tomography (CT), and magnetic resonance imaging. We retrospectively evaluated the potential influence of a virtual reality (VR) visualization technique on surgery planning and evaluation of postoperative
results in patients with monosegmental, unilateral osseous cervical neuroforaminal stenosis.

### Methods

Seventy-three patients were included. Ventral decompression of the neuroforamen was performed in 41 patients, dorsal decompression in 32 patients. Patients" files were evaluated. CT scans were visualized via VR software to measure the smallest cross-sectional area of the intervertebral neuroforamen in the lateral resection region. A questionnaire evaluated the influence of VR technique on surgical planning and strategy.

### Results

The VR-technique had a moderate influence on the choice of the approach (ventral or dorsal), a significant influence on the ventral approach strategy, and no influence on the positioning of the patient or the dorsal approach strategy. A significant difference was found in the size of the smallest cross-sectional area of the intervertebral neuroforamen in the lateral resection region between ventral and dorsal approaches, with no correlation to the clinical outcome.

### Conclusion

Reconstruction of pre- and postoperative 2D-CT images of the cervical spine into 3Dimages, and the spatial and anatomical reconstructions in VR models, can be helpful in planning surgical approaches and treatment strategies for patients with cervical foraminal stenoses, and for evaluation of their postoperative results.

Abb. 1

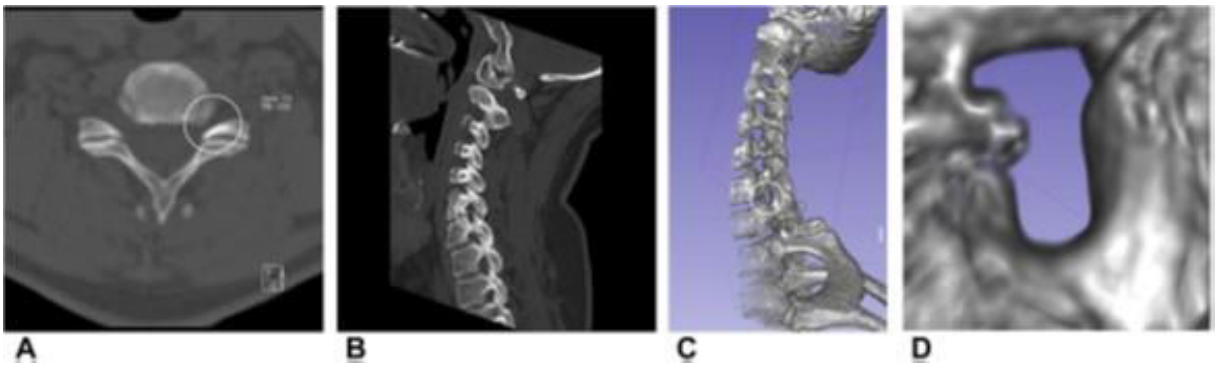
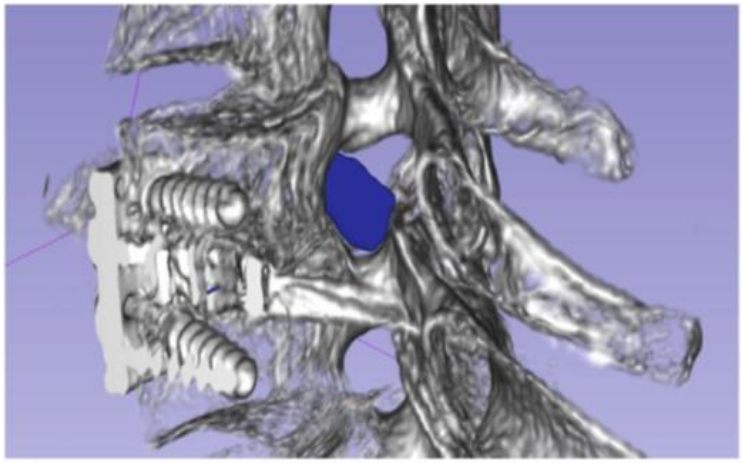
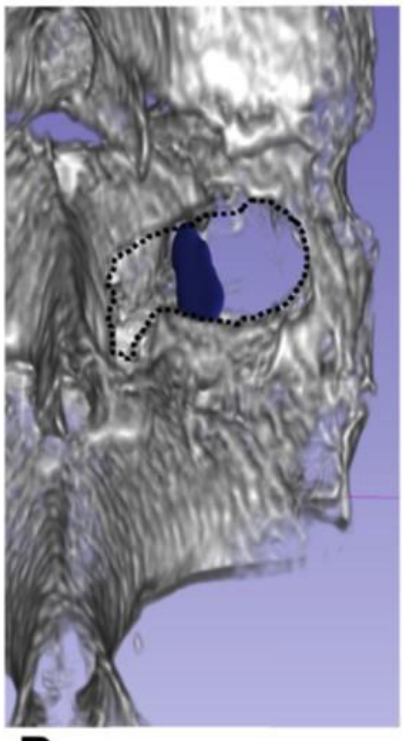



Abb. 2



# P242

## Bilaterale Arcocristektomie über einen unilateralen, minimalinvasiven tubulären Zugang: Operationsergebnisse bei 21 Patienten

***Bilateral Arcocristectomy via an unilateral, minimally invasive tubular approach: Surgical outcome in 21 Patients***

M. Bissolo[1], J. Beck[1], M. Hohenhaus[1], C. Scholz[1], U. Hubbe[1]

[1]Universitätsklinikum Freiburg, Neurochirurgie, Freiburg i. Br., Deutschland

### Objective

Open posterior osteoligamentous decompression, while effective for degenerative cervical myelopathy, poses drawbacks like neck pain and potential spinal instability. Bilateral arcocristectomy emerges as an alternative in predominantly posterior cervical spinal stenosis, leading to widening of the spinal canal and mitigating the risk of instability. This study showcases the application of this technique in 21 patients, indicating its potential as a viable therapeutic approach.

### Methods

Included were patients who underwent arcocristectomy for cervical myelopathy at our department between September 2016 and December 2022. Operation time, blood loss, and adverse events were recorded. Modified Japanese Orthopaedic Association (mJOA) score, was collected before surgery and 1 year postoperative. Evaluating decompression efficacy involved volumetric analysis comparing pre and immediate postoperative MRI scans.

### Results

21 patients underwent arcocristectomy for cervical myelopathy at our department. On average, surgeries lasted 102 minutes (ranging from 53 to 181 minutes), with an average blood loss of 50 ml (ranging from 0 to 120 ml). Volumetric analysis revealed a statistically significant 66% increase in cervical spinal canal volume from 2.19 cm3 to 3.2 cm3 ($p = .045$). Notably, none of the patients exhibited signs of clinical or radiographic instability and no patient required revision surgery. The average mJOA score displayed an improvement, rising from 12±2 at admission to 15±2 one year postoperatively ($p = .078$). No complications were recorded.

### Conclusion

Minimally invasive arcocristectomy may be a feasible and safe technique for effective decompression of predominantly posterior cervical spinal canal stenosis. The postoperative clinical neurologic outcome may be comparable to open posterior osteoligamentous decompression while reducing the risk of revision surgery due to instability. Prospective studies are warranted.

# P243

## Das chirurgische Management des ´spinal arachnoid web´ bei Patienten mit Syringomyelie: Strategien und Outcome

***Surgical management of spinal arachnoid web in case of syringomyelia: Strategies and outcomes***

S. D. Adib[1], J. Schittenhelm[2], P. Kurucz[3], T. K. Hauser[4], M. Tatagiba[1]

[1]University of Tübingen, Department of Neurosurgery, Tübingen, Deutschland
[2]University of Tübingen, Department of Neuropathology, Tübingen, Deutschland
[3]Klinikum Stuttgart, Department of Neurosurgery, Stuttgart, Deutschland
[4]University of Tübingen, Department of Neuroradiology, Tübingen, Deutschland

### Objective

Spinal arachnoid web (SAW) is a rare disease entity characterized as band-like arachnoid tissue that can cause spinal cord compression and syringomyelia. This study aimed to analyze the surgical management of spinal arachnoid web in patients with syringomyelia, focusing on surgical strategies and outcomes.

### Methods

A total of 135 patients with syringomyelia underwent surgery at our department between November 2003 and December 2022. All patients underwent magnetic resonance imaging (MRI), with a special syringomyelia protocol (including TrueFISP and cine), and electrophysiology. Among these patients, we searched for patients with SAW with syringomyelia following careful analysis of neuroradiological data and surgical reports. The criteria for SAW were as follows: displacement of the spinal cord, disturbed but preserved CSF flow, and intraoperative arachnoid web. Patients were evaluated for initial symptoms, surgical strategies, and complications by reviewing surgical reports, patient documents, neuroradiological data, and follow-up data.

### Results

Of the 135 patients, 3 (2.22%) fulfilled the SAW criteria. The mean patient age was 51.67 ± 8.33 years. Two patients were male, and one was female. The affected levels were TH2/3, TH6, and TH8. Excision of arachnoid web was performed in all cases. No significant change in intraoperative monitoring was noted. Postoperatively, none of the patients presented new neurological symptoms. The MRI 3 months after surgery revealed that the syringomyelia improved in all cases, and caliber variation of the spinal cord could not be detected anymore. All clinical symptoms improved.

### Conclusion

In summary SAW can be safely treated by surgery. Even syringomyelia usually improves in MRI and symptoms also improves, residual symptoms might be observed.

# P244

## Odontogener Fokus bei pyogener Spondylodiszitis: Eine häufig übersehene Entität
*Odontogenic focus in pyogenic spondylodiscitis: A frequently overlooked entity*

A. K. Jörger[1], M. Zahn[1], C. Albrecht[1], M. Nieberler[1], H. Deppe[1], M. Wostrack[1], B. Meyer[1]

[1]Klinikum rechts der Isar, Technical University of Munich, München, Deutschland

### Objective

Primary spondylodiscitis occurs through the hematogenous spread of a pathogen entering the body via a point of entry. The infection's origin often remains unclear. The oral cavity, depending on hygiene status offers opportunities for bacterial colonization. During dental procedures or through minor traumas microorganisms can enter the bloodstream and disseminate throughout the body. An association with cariogenic and periodontal bacteria has been established for infective endocarditis. This study investigates spondylodiscitis patients, with a focus on potential odontogenic origins.

### Methods

In a cohort of 430 consecutive patients treated at our Level I Spine Center from 01/01/2018 to 12/31/2022, those with primary spondylodiscitis and available orthopantomograms (OPG) were retrospectively re-evaluated, emphasizing odontogenic focus aspects. Radiological features indicating a potential odontogenic focus included apical radiolucency, impacted teeth, residual roots, and vertical or cup-shaped bone loss. Patients with secondary spondylodiscitis from a previous operation (< 3 months) in the same segment were excluded.

### Results

80 patients, with a mean age of 66 (+/- 13) years, were included. Initial assessment documented an odontogenic focus in 20% (16/79) of patients. However, re-evaluation of OPGs based on specified criteria identified a potential odontogenic focus in 75%. Apical radiolucency was present in 59%, pathological bone loss in 48% , residual roots in 11% and retained teeth in 8%. Among these cases, an oral bacterium was identified in 16%, either in blood cultures or intervertebral disc samples. Among patients with a potential odontogenic focus 46% (27/59) had a concurrent infectious focus: 8 had joint infection, 6 had prior spinal infiltration, 4 had catheter-associated bloodstream infection, 3 had a urological focus, 3 had an ENT focus, 2 had a leg ulcer and 1 had endocarditis. In 46% no focus was initially found.

### Conclusion

A potential odontogenic focus is more prevalent than initially presumed, particularly in patients where no focus is identified at first sight. We recommend a thorough diagnostic dental work-up as a standard procedure for patients with primary spondylodiscitis.

# P245

## In Vitro Biofilmbildung von *Staphylococcus aureus* auf Implantaten zur Operativen Therapie der Destruktiven Spondylodiszitis

## *In vitro biofilm formation of Staphylococcus aureus on implants used in surgical treatment of destructive spondylodiscitis*

A. T. Zacher[1], K. Mirza[2,3], L. Thieme[2,3], S. Nietzsche[4], C. Senft[1], F. Schwarz[1]

[1]Universitätsklinikum Jena, Institut für Neurochirurgie, Jena, Deutschland
[2]Universitätsklinikum Jena, Institut für Infektionsmedizin und Krankenhaushygiene, Jena, Deutschland
[3]Universitätsklinikum Jena, Leibniz-Zentrum für Photonik in der Infektionsforschung, Jena, Deutschland
[4]Universitätsklinikum Jena, Elektronenmikroskopisches Zentrum, Jena, Deutschland

### Objective

Cases of spondylodiscitis are increasing. This surge of incidence is due to a higher frequency of spinal surgery and rising numbers of elderly patients. Treatment consists of antimicrobial therapy. In case of bone destruction, the infected tissue is removed surgically. To ensure spinal stability, reconstruction can be performed by inserting an implant. Despite appropriate treatment relapses are common. Biofilm formation has been shown to serve as a major factor leading to relapses. There is no consensus regarding the material of choice to minimize formation of biofilm. The objective of this study was to assess whether differences in susceptibility to bacterial attachment exist between certain surgical implants.

### Methods

Eight cages of each Polyetheretherketone (PEEK), PEEK with Titan coating (PEEK-Ti), Titanium, Polyetherketoneketone (PEKK), Tantalum and bone cement were incubated with 20% human plasma for 24h. Three cages of each material were incubated with *S. aureus* for 24h or 48h. Two implants per material served as negative controls. The biofilm was then removed by sonication. The attained fluid was used to prepare a 1:10 serial dilution which was plated on Mueller-Hinton agar plates. The mean CFU count was calculated per implant and per mm² surface area. Scanning electron microscopy of one PEEK cage was performed to confirm bacterial attachment.

### Results

The surface area of the implants differed between PEEK 557mm², PEEK-Ti 472mm², Titanium 985mm², PEKK 594mm², Tantalum 706mm² and bone cement 123mm². The mean CFU count after 24h and after 48h was calculated both per implant and per mm². Bone cement was found to bear significantly more CFUs per mm2 surface area after both 24h and 48h than all other materials tested ($p<0.05$ each). When comparing the CFU count per implant, bone cement was forming significantly more CFUs than PEEK after 48h ($p<0.05$). No statistically significant differences were observed between the other materials when comparing both CFU count per surface area mm² or CFU count per implant ($p>0.05$ each). Electron microscopy showed the attachment of bacteria and production of extracellular polymeric substances (EPS), presenting early stages of biofilm formation.

### Conclusion

Bone cement showed statistically significantly more bacterial attachment than all other examined materials. No differences were found between the other materials regarding bacterial attachment after 24h or 48h. Next, we aim to expand our investigations on additional bacterial pathogens.

Abb. 1

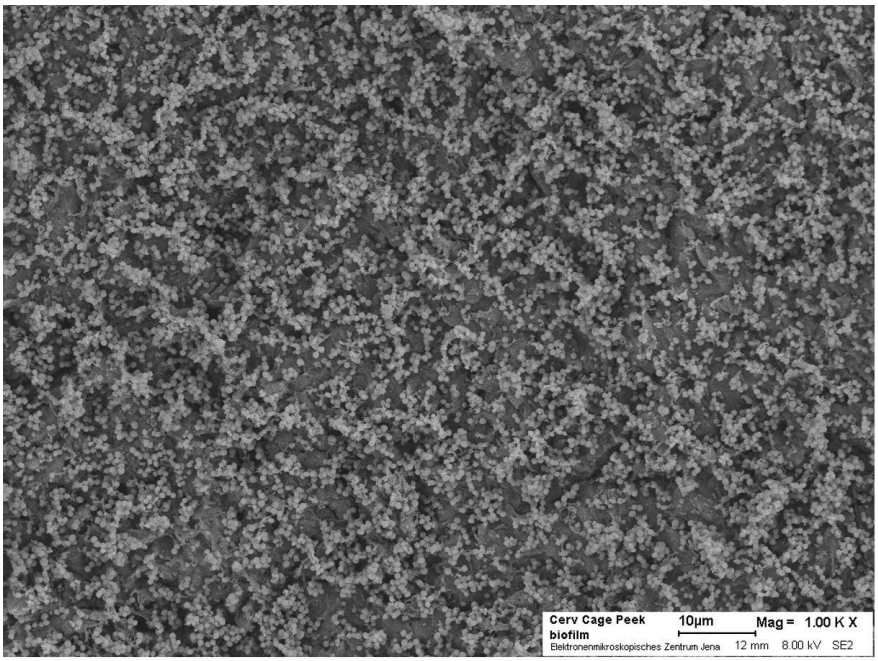



Figure 1 – Scanning electron microscopic image of the surface of a PEEK spinal cage after initial coating with human plasma and 48 h incubation with *S. aureus* suspension before sonication.

Abb. 2

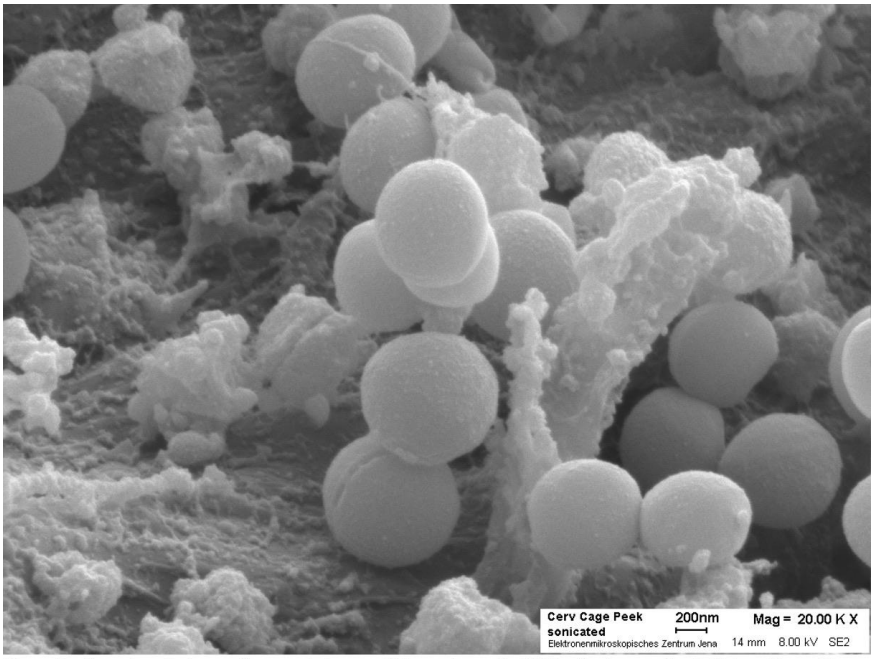



Figure 2 – Scanning electron microscopic image of the surface of a PEEK spinal cage after initial coating with human plasma and 48 h incubation with *S. aureus* suspension after sonication. Some remaining bacteria can be seen on the surface, together with EPS indicating that biofilm formation has begun.

# P246

## Clinical outcome following spondylodiscitis and its predictors of surgical and conservative therapy
*Klinisches Outcome nach Spondylodiszitis und deren Prädiktoren nach operativer sowie konservativer Therapie*

A. Knoll[1], V. Dostal[1], C. Grimm[1], M. Hlavac[1], C. R. Wirtz[2], A. Pala[1]

[1]Universität Ulm, Standort Günzburg, Abteilung für Neurochirurgie, Günzburg, Deutschland
[2]Universitätsklinik Ulm, Neurochirurgie, Ulm, Deutschland

### Objective

Spondylodiscitis remains a rare but severe infection of the spine caused by hematogenous or lymphatic bacterial spreading potential resulting in vital threat. Antibiotic therapy and surgical treatment to relief empyema or stabilization of vertebral segments, if needed, constitute essential treatment concept. Aim of this study was to figure out potential risk factors for severe clinical course of the disease in our patient cohort.

### Methods

All patients with the diagnosis of spondylodiscitis with or without intraspinal empyema treated at our institute either conservative or surgically by decompression, fixation or in combination between 2005 and 2018 were retrospectively analyzed. Patients were subdivided into conservative treatment group (antibiotic medication), surgical treatment group (decompressino and/or stabilisation) and those who changed from conservative to surgical group due to pain that could not improve by analgesic medication or complication for the purpose of neurological worsening or instability due to bony destruction. Among other things, age, risk factors, sex, location of the spondylodiscitis and clinical outcome at point of discharge and follow up at 6 months (46% of patients) were examined.

### Results

A total number of 225 patients (142 male / 83 female) were include in our retrospective investigation, of whom 109 (48%) patients underwent initial medical and 116 (52%) surgical + medical therapy. Total mortality rate was 4,4%. Median Age of medical patient cohort was 68,5 years and of surgical patient cohort 70,0 years. 35 patients (15%) out of 109 switched medical to surgical treatment. Overal clinical improvement could be registered in 76,34% of patients. The surgical group with stabilisation showed significant better results in clinical outcome and less revision rate compared to medical group or solely decompression. Ability to walk could be obtained in 85% of patients, if there was a restriction at admission, improvement could be achieved in 47%.

### Conclusion

Our analysis could figure out, that proceeded spine surgery or fracture within 2 years, as well as proceeded radio/chemotherapy represented risk factors in association of spondylodiscitis. Further, spondylodiscitis in the cervical or upper thoracic spine was associated with higher rates of death, whereas overall clinical improvement was satisfactorily reported, whereas surgical procedure with stabilization seemed to be beneficially related to clinical outcome an revision rate.

# P247

## Die proteomische Signatur von Glioblastomen erlaubt das Verlaufs-Monitoring von Patienten
*A proteomic signature of glioblastoma enables disease monitoring of patients*

J. Bartsch[1], T. Werner[2], M. D. M. Mirza Dr. med. Pojskic[1], A. Grote[1], M. Bopp[1], O. Schilling[3], C. Nimsky[1]

[1]Philipps-Universität Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Universität Freiburg, Institut für klinische Pathologie, Freiburg i. Br., Deutschland
[3]Albert-Ludwigs-Universität Freiburg, Klinische Pathologie, Freiburg i. Br., Deutschland

### Objective

There is an urgent need to understand better the mechanisms associated with the development, progression, and onset of recurrence after initial surgery in glioblastoma (GB). The use of integrative phenotype-focused-omics technologies such as proteomics and lipidomics provides an unbiased approach to exploring the molecular evolution of the tumor and its associated environment.

### Methods

We assembled a cohort of patient-matched initial (iGB) and recurrent (rGB) specimens of resected GB. Proteome and metabolome composition were determined by mass spectrometry-based techniques. We performed neutrophil-GB cell coculture experiments to evaluate the behavior of rGB-enriched proteins in the tumor microenvironment. ELISA-based quantitation of candidate proteins was performed to test the association of their plasma concentrations in iGB with the onset of recurrence.

### Results

Proteomic profiles reflect increased immune cell infiltration and extracellular matrix reorganization in rGB. ASAH1 (average 5.1-fold, p=8x10-4), SYMN (3.9-fold, p=0.01), and GPNMB (12-fold, p=7.8x10-3) were highly enriched proteins in rGB. In accordance with the upregulation of ASAH1, lipidomic analyses indicate the downregulation of ceramides in rGB. Cellular analyses using primary GB cells in co-culture with neutrophils demonstrated a role for ASAH1 in neutrophils and its localization in extracellular traps. Plasma concentrations of ASAH1 and SYNM show an association with time to recurrence.

### Conclusion

We describe the potential importance of ASAH1 in tumor progression and development of rGB via metabolic rearrangement and showcase the feedback from the tumor microenvironment to plasma proteome profiles. We report the potential of ASAH1 and SYNM as plasma markers of rGB progression. The published datasets can be considered as a resource for further functional and biomarker studies involving additional -omics technologies including miRNAs and radiomics.

# P248

## Evaluation der 5-ALA induzierten Fluoreszenz in neuen Exoskopen und deren Applikabilität in der Gliomchirurgie.
## *Assessment of 5-ALA induced fluorescence in novel exoscopes and their feasibility in glioma surgery*

Z. Özdemir[1], A. Walke[1], M. Müther[1], M. Schwake[1], N. Warneke[1], E. Suero[1], W. Stummer[1]

[1]Universitätsklinikum Münster, Neurochirurgie, Münster, Deutschland

### Objective

Fluorescence-guided surgery (FGS) using 5-aminolevulinic acid (5-ALA) has increased the extent of resection in high-grade glioma (HGG) and, hence, is associated with longer progression-free survival. Therefore, it has become an indispensable part of the neurosurgical armamentarium. Filter specifications for visualizing 5-ALA-induced fluorescence with high specificity and sensitivity were published in 1998 and are now commonly incorporated into standard wide-field microscopes. With ongoing technological advances, exoscopes have been introduced to neurosurgery. Although exoscopes are also equipped with a 5-ALA visualization system, validation studies regarding their fluorescence visualization are lacking. Inferior tumor discrimination could result in either excessive or insufficient resection. The purpose of the current study is to analyze fluorescence visualization of the Aeos and ORBEYE as well as their photobleaching effects.

### Methods

A total number of 17 patients who underwent FGS were included in this study. 5-ALA (20 mg/kg bw) was administered four hours prior to surgery. 73 tissue samples with heterogeneous fluorescence signals from the resection cavity margins were assessed ex vivo. The fluorescing area was determined by six senior surgeons and was then calculated using ImageJ software. Unpaired t-test was performed to compare novel technologies with the gold standard. Shapiro-Wilk test was used for normality testing. If the values were not normally distributed, the Mann-Whitney U test was performed as a non-parametric test. Statistical significance was set at $p < 0.05$. Intraclass correlation coefficient (ICC) was calculated to assess reliability and reproducibility of the results.

### Results

The Aeos revealed significantly greater extent of fluorescence compared with the established gold standard, i.e. Kinevo. Although not statistically significant, the ORBEYE showed 13% more fluorescing area than the Kinevo. ICC values showed good to excellent agreement among raters, supporting the reliability of the fluorescence assessment method. With a three times faster PpIX decay rate, the Aeos has the fastest photobleaching effect compared with the Kinevo.

### Conclusion

Significant differences regarding the extent of 5-ALA fluorescence visualization between exoscopes and the Kinevo as well as faster PpIX decay rates in novel technologies might have major implications regarding the extent of resection in HGG.

# P249

## Eine Spektralbibliothek und Methode für die spärliche Unmixing von hyperspektralen Bildern bei der fluoreszenzgeführten Resektion von Hirntumoren.

***A spectral library and method for sparse unmixing of hyperspectral images in fluorescence guided resection of brain tumors***

D. Black[1], S. Kaneko[2,3], W. Stummer[2], E. Suero Molina[4,2]

[1]University of British Columbia, Vancouver, Kanada
[2]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[3]Hokkaido University Graduate School of Medicine, Department of Neurosurgery, Sapporo, Japan
[4]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien

### Objective

Hyperspectral imaging (HSI) in fluorescence-guided tumor surgery can detect and classify tumor regions invisible to the human eye. To achieve this, HSI captures the full light emission spectrum at every image pixel. Through a priori knowledge of the fluorescing substances present in the image (endmembers) and their emission spectra, the measured spectra can be unmixed to determine their relative abundance. These abundances can be used to distinguish solid tumor from infiltrating margins and healthy tissue. Prior work has determined a minimal set of viable endmember spectra, which (1) are known to be in the brain, (2) effectively fit human data, and (3) do not overfit. With these endmembers, non-negative least squares regression (NNLS) was commonly used to compute the abundances. However, one small set of basis spectra may not fit all pixels well, as HSI images are heterogeneous. Additionally, NNLS is the maximum likelihood estimator only if the measurement is normally distributed and it does not enforce sparsity, which leads to overfitting.

### Methods

We propose a library of 9 endmember spectra, including PpIX (620 nm and 634 nm photostates), NADH, FAD, flavins, lipofuscin, melanin, elastin, and collagen. With these endmembers, we introduce a sparse, non-negative Poisson regression algorithm to perform the unmixing in a physics-informed manner that does not overfit.

### Results

We analyzed 555,666 HSI fluorescence spectra from 891 ex vivo measurements of biopsies of 184 patients with various brain tumors to show that a Poisson distribution models the measured data 82% better than a Gaussian in terms of the Kullback-Leibler divergence. This measurement model generated highly realistic simulated spectra with known endmember abundances. The new unmixing method was then tested on the human and simulated data and compared to four other methods. It outperforms them with 25% lower error in the computed abundances on the simulated data versus NNLS, lower reconstruction error on human data, better sparsity, and 31 times faster runtime than state of the art Poisson regression.

### Conclusion

Our sparse, non-negative Poisson regression algorithm, utilizing 9 endmember spectra, is superior in spectral unmixing compared to existing methods, offering enhanced accuracy, reduced error rates, improved sparsity, and significantly faster runtime. This advancement holds great potential to provide more precise resection guidance, leveraging hyperspectral imaging for improved surgical outcomes.

# P250

## Klinische Anwendung eines Kombinationsinstrumentes aus Thulium-Laser und Ultraschallaspirator zur Hirntumorresektion

***Clinical application of a combination instrument consisting of a thulium laser and an ultrasonic aspirator for brain tumor resection***

J. Kren[1], D. Theisen-Kunde[2], S. Buschschlüter[3], M. M. Bonsanto[1]

[1]UKSH Lübeck, Neurochirurgie, Lübeck, Deutschland
[2]Medizinisches Laserzentrum Lübeck GmbH, Lübeck, Deutschland
[3]Söring GmbH, Quickborn, Deutschland

### Objective

Coagulation is an essential component of brain tumor resection. Permanent coagulation of smaller and larger hemorrhages keeps blood loss low, reduces the risk of secondary bleeding, and keeps the surgical field clear. Coagulation can also be used for tumor shrinkage. For resection, the ultrasonic aspirator is usually suitable, especially for debulking large tumors, but bleeding that occurs, requires frequent changes of instruments. This instrument change is time consuming and interrupts the workflow. Our preliminary investigation revealed that during tumor resection with the ultrasonic aspirator, the surgeon must change the instrument every 60 seconds on average to stop occurring bleeding. Typically, bipolar forceps are employed for this purpose. To address these circumstances, a 1940 nm thulium laser was integrated into an ultrasonic aspirator for contactless coagulation.

### Methods

The 1940 nm thulium laser is suitable for CNS tissues due to its wavelength-specific water absorption. The laser fiber used has a diameter of 400µm and is additionally cooled by a CO2 flow of 2 l/min. The laser fiber was integrated into the ultrasonic instrument [DB1] using a special adapter. Both instruments could be triggered via a double foot switch. Between February 2022 and November 2023, 12 patients with diagnosed brain tumors were enrolled in a clinical pilot trial. We evaluated the use of a laser-ultrasonic aspirator combination instrument during standard tumor resections regarding efficiency and safety. The surgeons had four different settings available for different levels of bleeding. From 15 watts, 100ms pulse duration at 5Hz to 15 watts 400ms pulse duration at 1Hz, 15 watts cw (continuous wave) and 30 watts cw.

### Results

We found that laser integration offers advantages in the workflow, especially for diffuse venous bleeding. Bleeding could be stopped precisely and with sufficient efficiency. The operating concept was perceived as simple. However, most users preferred the bipolar forceps for stopping more severe arterial bleeding.

### Conclusion

Nevertheless, there are great advantages in the workflow, especially when debulking large tumors. The combination instrument of ultrasonic aspirator and laser offers a considerable advantage in the case of diffuse venous bleeding in smaller vessels. There were disadvantages when stopping arterial bleeding in larger vessels. Here, the use of bipolar forceps is advantageous, also due to the mechanical effect on the vessel during coagulation.

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P251

### Analyse des Sheddings von PD-L1: mögliche Ursache für ineffiziente Immuntherapie?
***Analysis of PD-L1 shedding in glioblastoma: Links to inefficient immunotherapy?***

K. Zhao[1], A. P. Candiota[2], C. Nimsky[1], J. Bartsch[1]

[1]Philipps-Universität Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Universitat Autònoma de Barcelona, Departament de Bioquímica i Biologia Molecular, Facultat de Biociències, Unitat de Bioquímica de Biociències, Cerdanyola del Vallès, Spanien

#### Objective

Glioblastomas (GB) have a dismal prognosis. Metalloproteases (MPs) have been described for early GB diagnosis as essential for macrophage reprogramming whereas the PD-1/PD-L1 axis reflects immunosuppressive mechanisms in GB. Previous work demonstrated that the preclinical GL261 GB mouse model responding to Temozolomide (TMZ) treatment increased its PD-L1 expression strongly correlated with A disintegrin and metalloprotease 8 (ADAM8) but not ADAM10 and 17. Proteolytic processing of PD-L1 was described to be associated with MP expression, such as ADAM10/17, but not ADAM8. Here we investigated if ADAM8 could also be involved in PD-L1 proteolytic processing.

#### Methods

GL261 cells with a knockout for the *Adam8* gene were generated using the CRISPR/Cas9 methodology and confirmed by western blot. GL261 cells were incubated with a medium containing either mTNFα or mIFNγ to induce PD-L1 expression over 24 and 48 hours. In addition, primary macrophages from wt and ADAM8 KO mice were also investigated for PD-L1 release. From all cells, conditioned media were analyzed to detect levels of soluble PD-L1 by ELISA.

#### Results

The mRNA levels of ADAM8 increased significantly after mIFNγ stimulation in GL261 wt cells by 2.5-fold, $p<0.001$). Concomitantly, extracellular levels of soluble released PD-L1 were strongly increased after mIFNγ stimulation in GL261 wt cells (2.6-fold after 24 and 15-fold after 48 hours), while PD-L1 release from GL261 knockout cells was reduced by 90% compared to GL261 wt cells. This differential release of PD-L1 was also seen in macrophages *+/- Adam8*, although to a lesser extent (250 ± 32 pg/ml for GL261 wt vs. 150 ± 8 pg/ml), predominantly in M1-like macrophages. Soluble PD-L1 can suppress T cells in the tumor microenvironment.

#### Conclusion

Abrogation/Inhibition of ADAM8 prevented/decreased proteolytic release of PD-L1 causing immunosuppression, suggesting that a new potential therapeutic strategy could emerge from such findings to enable/improve immunotherapy in glioblastoma.

# P252

## UNet-verstärkte, Deep Learning-basierte Vorhersage der intraoperativen 5-ALA-Fluoreszenz mittels präoperativer multimodaler MRT bei niedriggradigen Gliomen.

***UNet-Enhanced deep learning-based prediction of intraoperative 5-ALA-Fluorescence via preoperative multimodal MRI in lower-grade gliomas***

Z. Özdemir[1], G. Azemi[2], A. Valls Chavarria[1], C. Thomas[3], C. Russo[2], S. Liu[2], A. Di Ieva[4], W. Stummer[1], E. Suero Molina[1]

[1]Universitätsklinikum Münster, Klinik für Neurochirurgie, Münster, Deutschland
[2]Macquarie University Hospital, Computational NeuroSurgery (CNS) Lab, Macquarie Medical School, Sydney, Australien
[3]Universitätsklinikum Münster, Neuropathologie, Münster, Deutschland
[4]Macquarie University Hospital, Department of Neurosurgery, Sydney, Australien

### Objective

Only 20-30% of lower-grade gliomas typically have fluorescence after 5-aminolevulinic acid (5-ALA) administration. This can be increased by doubling the administered dose of 5-ALA. We aimed to analyze if a deep learning model can predict intraoperative fluorescence based on preoperative multimodal magnetic resonance imaging (MRI). Accurately identifying tumor regions during surgery is crucial for identifying regions of anaplastic foci, as they tend to fluoresce, allowing surgeons to precisely deliver malignant tissue for histopathological evaluation and avoid undergrading.

### Methods

The MRI images consisted of T1, T1-post gadolinium, and FLAIR. The images were standardized through a preprocessing pipeline involving isotropic transformation, bias field correction, registration to T1-post gadolinium space, alignment to a brain atlas, and skull stripping using ANTs and FSL software packages. The preprocessed MRIs were fed into the UNet, which was initially developed for tumor segmentation for each subject. We used the outputs of the bottom layer of the UNet in the Variational Autoencoder as features for classification. Using the partial least square discriminant analysis algorithm, we identified and utilized the most effective features in a Random Forest classifier. We allocated ~80% of the data for training purposes.

### Results

We included a cohort of 170 patients categorized as positive (n=89) or negative (n=81). The performance of our proposed approach is evaluated using key metrics. The optimal results were obtained by employing 18 top-performing features, resulting in an accuracy of 79% with the following associated confusion matrix:

[14 3

4 13]

### Conclusion

Our findings highlight the potential of a UNet model, coupled with a random forest classifier, for intraoperative fluorescence prediction. We achieved a good accuracy by using advanced techniques such as DL-based tumor segmentation and Variational Autoencoder for radiomics feature extraction. While the model can still be improved, it has the potential for evaluating when to administer 5-ALA to tumors lacking typical imaging features of high-grade gliomas.

# P253

## Die kombinierte Überexpression von EP2 und EP4 in Glioblastomen ist mit einem kürzeren Gesamtüberleben assoziiert

***Combined overexpression of EP2 and EP4 in glioblastoma is associated with shorter survival***

H. Gött[1], E. Sevgi[1], F. P. Schwarm[1], E. Uhl[1], M. A. Kolodziej[1]

[1]Universitätskliniken Gießen und Marburg, Klinik für Neurochirurgie, Gießen, Deutschland

### Objective

Targeted therapy and personalized medicine are one of the central interests in neurooncology research. Nevertheless, therapy for glioblastoma still mainly relies on surgery followed by chemoirradiation and the search of new markers with prognostic or predictive value and in the best case targetable molecules. The prostaglandin receptors EP2 and EP4 are involved in pro tumorigenic signaling in various cancer types and there are studies suggesting a proliferative effect in glioblastoma cells. Therefore, we determined the expression of EP2 and EP4 in glioblastoma and investigated, whether their expression is associated with worse prognosis.

### Methods

EP2 and EP4 expression was determined via quantitative Real-Time PCR (qPCR) and semiquantitative immunohistochemistry (IHC) in 42 glioblastoma patients, who had undergone surgery in our department between 2013 and 2020. Data on MGMT-promotor status and TERT mutation status as well as progression free survival (PFS) and overall survival (OS) were collected from patient records. Patient with ΔCT-values for EP2 or EP4 in qPCR below the median were defined as high expression group (HEG) and above the median as low expression group (LEG). For IHC expression values above the median were defined as HEG and below the median as LEG. Group comparison was done via Log-rank test and survival analyses were performed with the Kaplan-Meier method; correlation was calculated as Pearson Index in SPSS.

### Results

On mRNA level mean EP2 expression was 9.25 ± 2.56 and mean EP4 expression was 7.62 ± 2.37. In IHC mean EP2 expression value was 7.00 ± 4.12 and mean EP4 expression was 9.14 ± 5.09. No correlation with MGMT promotor status or TERT mutation was observed. Median OS and PFS showed no statistically significant difference in LEG and HEG of the single receptors, although we observed a trend towards an association of high EP4 expression in IHC with shorter OS ($r = -0.278$; $p = 0.075$) and PFS ($r = -0.196$; $p = 0.213$).Combined expression of EP2 and EP4 correlated significantly with shorter OS ($r = -0.313$; $p=0.044$) and there was a non-significant trend toward a shorter PFS ($r= -0.243$; $p=0.121$).

### Conclusion

Combined expression of the prostaglandin receptors EP2 and EP4 is moderately associated with shorter OS in glioblastoma patients. The expression of EP4 seems to have a higher prognostic impact than expression of EP2. The detailed role of the receptors and the possibility of a therapeutic use should be further investigated.

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P254

### Erniedrigte Expression der TRAF Proteine mit steigendem Malignitätsgrad mit der niedrigsten Expression in IDH-Wildtyp Glioblastomen

***Decreasing expression of TRAF proteins with increasing malignancy with lowest expression in IDH-wildtyp glioblastoma***

S. Kuhl[1], L. Sagcob[1], R. Goldbrunner[1], M. Timmer[1]

[1]Universitätsklinikum Köln, Neurochirurgie, Köln, Deutschland

#### Objective

The tumor necrosis factor receptor-associated factors (TRAF) are cytoplasmatic adapter proteins that can interact directly with the intracellular domains of cell surface receptors, such as the TNF receptor superfamily. TRAFs are thus involved in cellular processes like proliferation or apoptosis. Seven members are known; all expressed in the cytosol of various cell and tissue types. Increased levels of TRAF4 in GBM tissue are related to cell proliferation and migration. About 25 % of grade I meningioma show mutations in TRAF7, which are associated with a lower risk of malignant transformation. Therefore expression patterns of all seven TRAF members are evaluated in different glioma grades.

#### Methods

Following tumor samples were obtained during neurosurgery and shock frozen in liquid nitrogen: peritumoral tissue, astrocytoma and oligodendroglioma (G2, G3) and glioblastoma (primary and recurrent). Transcription rate of TRAF1-7 was measured via qPCR. Correlation of TRAF expression level and patient overall survival was evaluated using TCGA datasets of the TCGA-LGG and TCGA-GBM projects.

#### Results

With the exception of TRAF5, a decreased mRNA level with increasing malignancy could be found for all TRAFs (TRAF1 p=n.s.; TRAF2 p=0.0026; TRAF3 p<0.0001; TRAF4 p=0.0021; TRAF6 p<0.0001; TRAF7 p<0.0001). IDHwt glioblastoma showed significant lower expression level compared to IDHmut glioblstoma in all TRAFs except for TRAF1 (TRAF2 p<0.0001; TRAF3 p=0.0346; TRAF4 p<0.0001; TRAF6 p=0.0447; TRAF7 p=0.0081). TRAF5 again showed a reverse effect (p=0.0065). Correlation of TRAF expression level in low grade glioma and patient survival revealed longer overall survival with low TRAF1,2,4 and TRAF5 expression (p<0.0001, p= 0.0178, p=0.0307, p<0.0001). No difference in survival rate in high grade glioma could be found.

#### Conclusion

We found an inverse relationship between WHO garde an TRAF expression in glioma. TRAF5 was the only isoform with a distinct behavior.

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P255

### Juglone als ein die DNA-Methylierung beeinflussendes Medikament bei der Behandlung von Glioblastoma
***Juglone as a DNA methylation-affecting drug in glioblastoma treatment***

A. M. Barciszewska[1], A. Belter[2], I. Gawronska[2], M. Giel-Pietraszuk[2], M. Naskręt-Barciszewska[3]

[1]Karol Marcinkowski University of Medical Sciences, Neurosurgery and Neurotraumatology, Posen, Polen
[2]Polish Academy of Sciences, Institute of Bioorganic Chemistry, Posen, Polen
[3]Polish Academy of Sciences, Institute of Bioorganic Chemistry, Posen, Polen

#### Objective

Glioblastoma (GBM) is the most aggressive primary brain tumor with high mortality. Standard approaches, including gross total resection, radiotherapy, and chemotherapy with temozolomide (TMZ), are not curative. Therefore there is a need for new treatment agents acting on various molecular levels.

Epigenetics provides a potent area for explaining cellular pathological processes. It offers a link between genetic and environmental factors that influence disease development and plays a key role in the pathophysiology of various diseases, from neurological disorders to cancer, thus leading to the adaptation of conventional therapies and, ultimately, to better outcomes.

Juglone (5-hydroxy-1,4-naphthoquinone, J) is a bicyclic small natural origin compound. It inhibits various enzymes and affects many cellular processes. Juglone shows anticancer, antibacterial, antifungal, and antiviral properties. Juglone reduces tumor growth through various mechanisms, such as cytotoxicity, apoptosis, and angiogenesis, as a result of increasing ROS levels.

The aim of our study was to evaluate the epigenetic effect of Juglone alone and in combination with TMZ on GBM cell lines.

#### Methods

The analysis was performed on different glioblastoma cell lines (T98G, U138, U118), and HaCaT.

For total DNA methylation analysis we used the radiolabelling method with TLC separation of nucleotides and content estimation with phosphoimager. The amounts of 5-methylcytosine (m5C) was calculated as a ratio (R) of spot intensities of m5C to m5C+C+T.

#### Results

We noticed concentration and time-dependent changes in total DNA methylation. The highest increase was observed for the T98G cell line at the incubation time of 24hrs. Normal cell line (HaCaT) did not present significant changes. TMZ alone induced a lowering of DNA methylation, but juglone diminished that effect. J induces minute oxidative stress in low concentrations, but is quite high and rapid at concentrations over 50uM, concomitantly with none/slight decrease in DNA methylation. However, the combination of J/TMZ in increasing concentrations diminished the oxidative stress effect.

#### Conclusion

Juglone affects the levels of m5C, the epigenetic marker, and 8-oxo-dG, oxidative damage marker. The combination of J with TMZ modulates the level of m5C and 8-oxo-dG. Therefore, Juglone can be used for glioblastoma treatment alone or in combination with TMZ.

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P256

### Der Stellenwert der Salvage-Therapie bei rezidivierendem Glioblastom
*The value of salvage therapy in recurrent glioblastoma*

A. Dauth[1], H. Krenzlin[1], F. Lange[1], D. Jankovic[1], L. Schmidt[1], F. Ringel[1], N. Keric[1]

[1]Universitätsmedizin Mainz, Klinik mit Poliklinik für Neurochirurgie, Mainz, Deutschland

#### Objective

Virtually all glioblastoma relapse. Progression free (PFS) and overall survival (OS) after recurrence is poor. Evidence for efficacy of salvage therapies is scarce. The aim of this study is to investigate the impact of salvage therapy on OS in recurrent glioblastoma.

#### Methods

From August 1st, 2005, to December 31th, 2022 patients presenting with recurrent IDH-wildtype glioblastoma (CNS WHO grade 4) to our department were included in this retrospective analysis. Inclusion criteria were histologically diagnosis, prior first-line therapy according to STUPP or CeTeG and ECOG performance status score ≤2 at the time of recurrence and no re-radiotherapy. Salvage therapies included lomustine (CCNU), dose intensified temozolomide (TMZ+),temozolomide rechallenge (TMZ) and nimustine (ACNU)/teniposide (VM26) as second-line and regorafenib and CCNU as third-line therapy. Primary outcome parameter was overall survival (OS).

#### Results

A total of 90 patients from all patients with recurrent glioblastoma met the inclusion criteria. The median age was 62 years (21-81) with 38 being female (42%). MGMT promotor methylation was found in 27 (30%) and was not analysed in 23 (25,6%) patients. 47 patients (52.2%) underwent re-surgery prior to second-line, 8 (4,4%) patients prior to third-line therapy. In the second-line group,47 (53,2%) patients received CCNU, while 14 (15,56%) received TMZ+,13 (14,4%) TMZ and 10 (16,2%) ACNU/VM26 as second-line therapy.19 (21,1%) patients received regorafenib and 10 (11,1%) patients CCNU as third-line therapy. However, median OS was not significantly different between different second-line treatment modalities (CCNU 8.3 m, TMZ+ 7 m (95% CI 0.45-4.0), TMZ 11.4 m (95% CI 0.34-2.16), ACNU/VM26 7.2 m (95% CI 0.52-2.5) (p=0.07). Median OS after third-line therapy was 10.4 m in those receiving regorafenib and 5.8 in those receiving CCNU (95% CI 0.78-4.1) (p=0.009). No difference was found in OS between patients undergoing re-surgery prior to salvage chemotherapy and chemotherapy alone. OS after third-line treatment was superior compared to best supportive care (p

#### Conclusion

Second- and third-line salvage therapies significantly prolonged OS in patients with relapsed glioblastoma independent from deployed therapy regimens. Re-resection and salvage chemotherapy were significant and independent predictors of OS after tumor recurrence. This data emphasizes the high value of salvage therapies as second- and third-line treatment in recurrent glioblastoma.

# P257

## Epigenetische Charakteristiken in Primär- und Rezidivglioblastomen - Einfluss auf den klinischen Verlauf
*Epigenetic characteristics in primary and recurrent Glioblastoma – Influence on the clinical course*

A. Quiring[1], F. Teping[2], M. L. Schürgers[2], H. Spielmann[2], W. Schulz-Schaeffer[3], N. Monfroy[2], R. Ketter[2], S. Urbschat[2], J. Oertel[2], S. Linsler[4], C. Sippl[4]

[1]Klinikum rechts der Isar, Technische Universität München, Klinik für Neurochirurgie, München, Deutschland
[2]Universität des Saarlandes, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[3]Universität des Saarlandes, Institut für Neuropathologie, Homburg a. d. Saar, Deutschland
[4]Medizincampus Oberfranken, Klinik für Neurochirurgie, Bayreuth, Deutschland

### Objective

Epigenetic tumor characteristics are in focus for glioblastoma prognosis. This raises the question if these characteristics present with stable expression during the progression of the disease, and if potential temporal instability might influence their prognostic value.

### Methods

A total of 44 patients suffering from glioblastoma who were treated for their primary and relapse tumors were included in the study. Tumor specimens from the initial and recurrent tumor resection were subjected to evaluation of *MGMT*, *p15,* and *p16* methylation statuses. MiRNA-21, -24, -26a, and -181d expression was evaluated as well. The stability of these epigenetic markers during the progression of the disease was correlated with further clinical data. A Cancer Genome Atlas (TCGA) dataset of 224 glioblastoma patients was used as an independent cohort to validate the results.

### Results

Instability was observed in all examined epigenetic markers. *MGMT* methylation changed in 29.5% of patients, *p15* methylation changed in 31.8%, and *p16* methylation changed in 34.1% of cases. MiRNA expression in corresponding initial and relapse tumor specimens varied considerably in general, individual cases presented with a stable expression. Patients with a decreased expression of miRNA-21 in their recurrence tumor showed significantly longer overall survival. These results are supported by the data from TCGA indicating similar results.

### Conclusion

Epigenetic characteristics may change during the course of glioblastoma disease. This may influence the prognostic value of derived molecular markers.

# P258

## Einführung eines Simulators für die Resektion von Insel-Gliomen mit Fluoreszenzbildgebung (SIGMA)

***Overcoming barriers in neurosurgical education: Introducing a simulator for insular glioma resection with fluorescence imaging (SIGMA)***

S. Al-Hamid[1], A. Amini[1], V. M. Swiatek[1], F. Taskaya[1], J. Reiser[1], K. P. Stein[1], A. Rashidi[1], I. E. Sandalcioglu[1], B. Neyazi[1]

[1]Otto-von-Guericke-Universität Magdeburg, Universitätsklinik für Neurochirurgie, Magdeburg, Deutschland

### Objective

Addressing the challenges in neurosurgical education, particularly in teaching transsylvian insular glioma resection, we developed an anatomically accurate, patient-specific simulation model. This model not only tackles the complex anatomical and strategic aspects of this neurosurgical procedure but also integrates fluorescence imaging for glioma visualization, enhancing realism and comprehensive training.

### Methods

The simulator, created using open-source 3D software, features a digitally reconstructed skull, brain, and cerebral vessels, including a fluorescent insular glioma. Produced through additive manufacturing and rheological analyses with neurosurgeon input, it realistically and reusably represents the Sylvian fissure and bone structures. Its educational effectiveness and usability were assessed by 12 varied-experience neurosurgeons using actual microsurgical tools and microscopes, based on both subjective and objective criteria.

### Results

Subjective evaluations, using a 5-point Likert scale, showed high face and content validity, averaging 4.7/5. Objectively, the simulator accurately reflected participants' skills, proving significant construct validity. Novices displayed rapid skill acquisition and confidence growth, evidencing high predictive validity and practical skill transfer.

### Conclusion

This simulator meets the advanced training needs in neurosurgery, especially for microneurosurgical resection of insular gliomas. Its realism, cost-effectiveness, and skill-enhancement potential make it a valuable educational tool. The positive results suggest potential for broader adoption in neurosurgical curricula, warranting further studies and integration into training programs.

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P259

### Tenascin-C tragende EVs ermöglichen tumorspezifische Mutationsanalyse bei Glioblastom-Patienten
*EVs carrying Tenascin-C enable tumor-specific mutation analysis in glioblastoma patients*

F. Ricklefs[1], A. Salviano da Silva[2], C. Maire[3], K. Wollmann[3], R. Reimer[4], J. Neuman[5], M. Dottermusch[5], U. Schüller[6], J. Gempt[3], D. H. Heiland[7], M. Westphal[3], K. Lamszus[3]

[1]Universitätsklinikum Hamburg-Eppendorf, Neurchirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[3]Universitätsklinikum Hamburg-Eppendorf, Neurochirurgie, Hamburg, Deutschland
[4]Leibnitz Institute, Hamburg, Deutschland
[5]University Medical Center Hamburg-Eppendorf, Neuropathology, Hamburg, Deutschland
[6]Universitätsklinikum Hamburg-Eppendorf, Institut für Neuropathologie, Hamburg, Deutschland
[7]University Medical Center Freiburg, Department of Neurosurgery, Freiburg i. Br., Deutschland

#### Objective

Extracellular vesicles (EVs) transport biological and specific information from tumors into the bloodstream, enabling non-invasive detection of tumor material and disease monitoring.

#### Methods

We performed immunophenotyping of eight glioma-related antigens (tenascin-C (TNC), integrin-beta 1 (ITGB1), profilin-1 (PFN1), CD44, CD133, GPNMB, HLA-II, SPARC) and tetraspanins (CD9, CD63 and CD81) in plasma EVs from GBM patients (before and after surgery (n=38)), from matched GBM relapse patients (n=11), and from healthy donors (HD, n=12) using imaging flow cytometry. EVs were further analysed by electron microscopy and nanotracking analysis. Tissue samples were analyzed by IHC, methylation analysis and spatial transcriptomics.

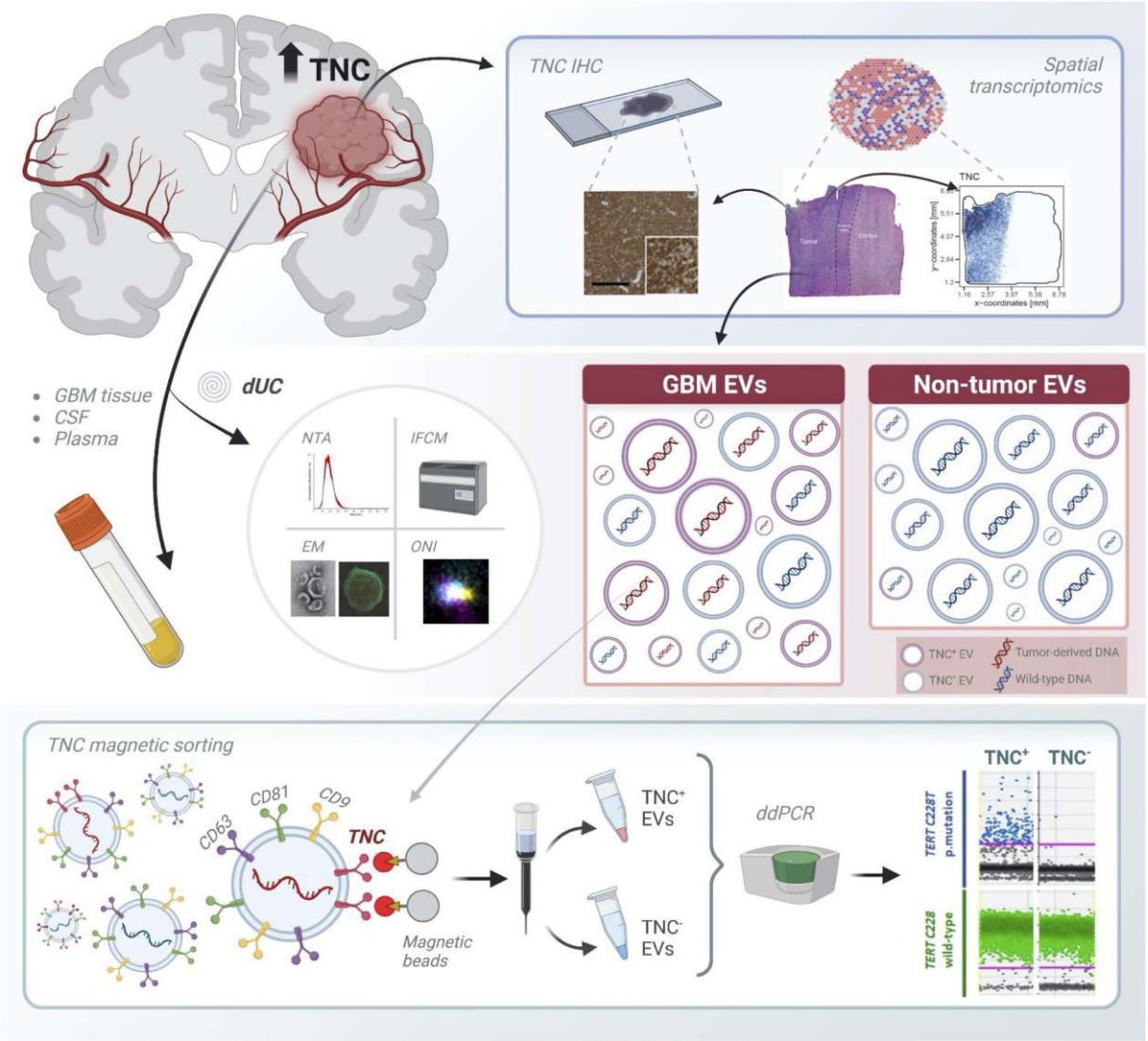
#### Results

Double-positive $TNC^+/CD9^+$ EVs showed the strongest differences per mL of plasma in primary (FC = 7.6, p<.0001, ROC analysis AUC = 81%) and relapsed GBM (FC = 16.5, p<.0001; AUC = 90%) compared to HD subjects. High TNC signals were also observed in GBM-EVs by immunogold electron microscopy compared to HD-EVs. In paired analysis, $TNC^+/CD9^+$ EVs showed a 3.9-fold decrease after tumor removal (p<.001) and re-increased at GBM recurrence in these patients (FC = 8.4, p<.05; AUC = 84%). In tissue samples, TNC levels were 5.4-fold higher in GBM patients than in non-neoplastic cortex controls (p<.01) measured by immunohistochemistry and correlated positively with plasma $TNC^+/CD9^+$ EV levels in RTK-I/II GBM patients (r = 0.42, p<.05). Accordingly, spatial transcriptomics of GBM tissue sections revealed that TNC is specifically overexpressed in GBM cells. Furthermore, magnetic sorting of TNC in plasma EVs allowed detection of GBM-specific TERT*C228T mutations by digital droplet PCR. Mutated TERT DNA was enriched in $TNC^+$ EVs (n=13) compared to TNC- EVs (FC = 110, p<0.0001), total EV DNA (FC = 36.7, p<0.01), and cfDNA (FC = 7.2, p <0.05).

#### Conclusion

In conclusion, we identified TNC as a biomarker in circulating EVs from GBM patients that can be isolated and used for tumor-specific mutation analysis.

Abb. 1


TNC
TNC IHC
Spatial transcriptomics
GBM tissue
CSF
Plasma
dUC
NTA
IFCM
EM
ONI
GBM EVs
Non-tumor EVs
TNC+ EV
TNC- EV
Tumor-derived DNA
Wild-type DNA
TNC magnetic sorting
CD63
CD81
CD9
TNC
Magnetic beads
TNC+ EVs
TNC- EVs
ddPCR
TNC+
TNC-
TERT C228T p.mutation
TERT C228 wild-type

# Tumor – Verschiedenes 3 | Tumour – Various 3

## P153

### Schwangerschaft in jugendlichen und jungen erwachsenen Gliom-Patienten - eine systematische Literaturrecherche und Daten des deutschen Entgeltsystems

***Pregnancy and fertility in adolescent and young adult glioma patients – A systematic literature review and national reimbursement data for Germany***

M. T. Forster[1], M. A. Kamp[1]

[1]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Klinik mit Poliklinik für Neurochirurgie, Frankfurt a. M., Deutschland

#### Objective

Glioma diagnosis, particularly for younger individuals planning families, profoundly disrupts life. Despite this, the prospect of pregnancy and fertility preservation is no longer excluded for glioma patients and additionally patients might be diagnosed during pregnancy. Our study aimed to quantify the number of pregnant glioma patients in Germany and address the associated challenges during pregnancy in the context of glioma disease.

#### Methods

We utilized data from the Institute for the Hospital Remuneration System (InEK GmbH, Siegburg, Germany) for the years 2019 to 2022 to determine the incidence of pregnant patients with malignant glioma (ICD-10 code: C71) in Germany. A subsequent literature review covered studies published between 1993 and 2023.

#### Results

From 2019 to 2022, 121,761 hospital cases included patients suffering from malignant glioma, with 51,711 being female inpatients (42.5%). Notably, 38 hospital cases (0.07%) were treated for malignant glioma during pregnancy in German hospitals. Twelve fetuses were at 20 or more weeks of gestational age. MRI with contrast-enhanced sequences was performed in 26 pregnant glioma patients, and tumor resection was conducted in 22 cases. Birth events (vaginal birth, cesarean section, hospital stay before birth) were coded for 13 hospital cases. However, no further data on patient and offspring outcomes were available.

Studies and articles from the last 30 years reported on 160 patients with newly diagnosed glioma during pregnancy and 204 female glioma patients becoming pregnant after glioma diagnosis and treatment. Pregnancy interruption was described in the first cohort, while the rate of uneventful births in the latter group was comparable to the normal population.

The influence of pregnancy on glioma progression remains debated, with observations suggesting a correlation between the prior extent of tumor resection and tumor progression during pregnancy.

#### Conclusion

Data on pregnancy in glioma patients remain limited. Recognizing children as a positive resource for both healthy individuals and glioma patients emphasizes the need for further research to better counsel glioma patients considering childbearing.

# P261

## RB1-Promotormethylierung bei Glioblastomen: Ein seltenes Ereignis beim Glioblastom
*RB1-Promoter methylation in glioblastoma: A rare event in Glioblastoma*

M. Henia[1], G. Breitfelder[1], C. Sippl[2], W. Schulz-Schaeffer[3], R. Ketter[1], J. Oertel[1], S. Urbschat[1]

[1]Uniklinikum Homburg/Saar, Klinik für Neurochirurgie, Homburg a. d. Saar, Deutschland
[2]Medizin Campus Oberfranken, Klinik für Neurochirurgie, Bayreuth, Deutschland
[3]Uniklinikum Homburg/Saar, Institut für Neuropathologie, Homburg a. d. Saar, Deutschland

### Objective

The development of glioblastoma is often the result of an accumulation of genetic changes and dysregulation of signaling cascades leading to uncontrolled proliferation of tumor cells. Methylation is consider one of the most important epigenetic mechanisms. The RB1 gene plays an important role in a whole range of tumor diseases. Actually, the role of methylation of the RB1 promoter in glioblastoma has been controversial so far. Our intention was to examine a large number of glioblastoma patients to make a general statement on the relevance of RB1 methylation in glioblastoma and to evaluate the impact of methylation on clinical parameters.

### Methods

This study analyzed the methylation status of the RB1 promotor of 85 glioblastomas according to the recent WHO classification. Methodically, a methylation-specific PCR with subsequent evaluation of results of the PCR products via gel electrophoresis using ethidium bromide to visualize the bands in the gel was use.

### Results

The average overall survival of the patient population was 15.7 months; the average progression free survival was 9 months. In 6.1% of the patients, an IDH1 mutation was detect. Additionally, in 48.2% of the patients, a methylation of the MGMT-promotor was present. With an average age of patients of 60 years, there was a significant decrease of overall survival and progression free survival with higher age at initial diagnosis. Furthermore, we found out that patients with a high Karnofsky-Score at initial diagnosis had a significantly longer overall survival and progression free survival. Overall, methylation of the RB1 promotor was found in one of the 85 analyzed tumor samples (1.2%). Therefore, a correlation of the RB1 methylation status with other analyzed items is obsolete.

### Conclusion

In our study with so far the highest number of cases corresponding to the recent WHO classification, we could make a clear statement that RB1 promotor methylation is not a relevant event in the development and progression of glioblastoma

# Funktionelle Neurochirurgie – DBS | Functional Neurosurgery – DBS

## P262

### *Effekte multimodaler Bilddaten auf die Segmentierung des Nucleus Subthalamicus*
### *Variability of segmentation of the subthalamic nucleus based on multimodal image data*

M. Bopp[1,2], A. Grote[1], M. Gerwing[1], M. Gjorgjevski[1], C. Nimsky[1,2]

[1]Universitätsklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland
[2]Center for Mind, Brain and Behavior (CMBB), Marburg, Deutschland

### Objective

Improved magnetic resonance imaging (MRI) techniques, higher field strength, quality enhancing postprocessing and automatic segmentation approaches, the visualization of relevant target structures such as the subthalamic nucleus (STN) in deep brain stimulation (DBS), has become a valuable tool during preoperative planning to optimize lead positioning on an individual level, or to enhance postoperative programming by visualizing target structures in relation to leads and volume of activated tissue (VTA). Traditionally performed monomodal, multimodal automatic segmentation approaches allow for the integration of multiple MRI submodalities that are considered for atlas mapping and refinement. However, its effect on the visualization of the target structure needs to be investigated.

### Methods

Ten patients diagnosed with Parkinson"s Disease (PD) who underwent STN-DBS were included. Preoperative MRI data acquired at a 3T MRI (Trio, Siemens, Erlangen, Germany) included a T1-weighted (T1w), T2-weighted (T2w), fluid-attenuated inversion recovery (FLAIR) and a susceptibility weighted (SWI) data set. In addition, intraoperatively, CT data sets were acquired after microelectrode placement (tip at target level) in clinical routine. For analysis regarding the effect of multimodality, for each patient eight MRI subsets were created (only T1w, T1w in combination with one further, two further or all three other data sets). For all eighty data subsets, rigid Image Fusion (Brainlab, Munich, Germany) was performed with the T1w as root data set, followed by automatic segmentation using the Anatomical Mapping Element (Brainlab, Munich, Germany). Within the CT data the microelectrodes were localized manually using the Trajectory Element (Brainlab, Munich, Germany) and entry and exit along the segmented STN was evaluated.

### Results

In total, 160 STN segmentations (80 left, 80 right) in relation to 25 detected trajectories were analyzed. In case of six STN outlines, the trajectory did not intersect with the segmentation. Overall the variability regarding the STN entry along the trajectory was 1.40 ± 0.74 mm, regarding the STN exit 1.43 ± 0.63 mm.

### Conclusion

The spatial location of automatically generated STN segmentations varies depending on the included imaging data, and thereof can affect preoperative planning of optimal DBS leads location, intraoperative visualization in relation to electrophysiological measurements and postoperative image guided programming.

# P263

## Exaktheit bei der Elektrodenpositionierung im Rahmen der Tiefen Hirnstimulation (THS): Eine Vergleichsstudie zwischen bilateraler und vier-Elektroden Implantationen

***Accuracy of Deep Brain Stimulation (DBS) lead placement: A comparative study of bilateral and four-lead implantation techniques***

R. Nickl[1], C. Matthies[1], V. Nickl[1], M. Reich[2], P. Fricke[1]

[1]Universitätsklinikum Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Universitätsklinikum Würzburg, Neurologische Klinik und Poliklinik, Würzburg, Deutschland

### Objective

Deep Brain Stimulation (DBS) is an established treatment modality for various movement disorders and psychiatric conditions. The effectiveness of DBS largely hinges on the precise placement of electrode leads. However, inaccuracies in electrode positioning can lead to reduced treatment efficacy and adverse side effects. This study aims to compare the accuracy of electrode placement in bilateral DBS versus a four-lead DBS session, correlating the outcomes with clinical effectiveness.

### Methods

52 patients with 128 leads, (40 patients in the bilateral group with 80 leads & 12 four-lead group with 48 leads) who received DBS at the University Hospital of Wuerzburg between 2013 and 2019 were reviewed. Preoperative planning and postoperative imaging (MRI and CT scans) were reviewed to assess lead placement accuracy for centrally implanted trajectories. Clinical outcomes, surgical sequelae, and stimulation parameters were evaluated through patient records.

### Results

The bilateral group exhibited a mean radial deviation of 1.40 mm from the planned trajectory, with a significant difference in accuracy between the first and second implanted leads. In the four-lead group, while there was an increasing trend in deviation from the first to the fourth electrode, it was not statistically significant. Brain shift, particularly due to cerebro-spinal fluid (CSF) leakage, was identified as a primary factor affecting lead placement accuracy. No significant correlations were found between lead displacement and clinical outcomes, including motor function and stimulation parameters.

### Conclusion

This study contributes novel insights into the complexities of implanting multiple leads in a single DBS session. It highlights the importance of minimizing brain shifts during surgery to improve lead placement accuracy. The findings recommend prioritizing the implantation of the most clinically significant lead first, given the observed decrease in placement accuracy for subsequent leads.

# Funktionelle Neurochirurgie – DBS | Functional Neurosurgery – DBS

## P264

### Augmented Reality geführte Punktionsverfahren
*Applications of augmented reality for intraoperative targeting*

P. C. Reinacher[1,2], R. Roelz[3], A. Stanicki[1], N. Schallner[4], V. Coenen[1], J. Beck[3], T. Demerath[5]

[1]Universitätsklinikum Freiburg, Abteilung Stereotaktische und Funktionelle Neurochirurgie, Freiburg i. Br., Deutschland
[2]Fraunhofer Institut für Lasertechnik (ILT), Aachen, Deutschland
[3]Universitätsklinikum Freiburg, Klinik für Neurochirurgie, Freiburg i. Br., Deutschland
[4]Universitätsklinikum Freiburg, Klinik für Anästhesiologie und Intensivmedizin, Freiburg i. Br., Deutschland
[5]Universitätsklinikum Freiburg, Neuroradiologische Klinik, Freiburg i. Br., Deutschland

#### Objective

Augmented reality (AR) is a technological megatrend that is increasingly being applied in many areas. The availability of this technology increasingly prompts the question of meaningful applications in clinical practice. We have investigated various use-cases.

#### Methods

Four AR devices (Magic Leap 1, Plantation, FA, USA) were used in combination with neurosurgical planning software (Elements, Brainlab, Munich) for various applications. Overall, 204 procedures in three intraoperative use-cases were investigated on phantoms regarding feasibility and accuracy in order to compare AR guided procedures to the respective standard methods. On a phantom with intracranial hemorrhage, a total of 60 operations for placement of hemorrhage drains (compared with freehand and sterotactic frame-based placement) were performed by 5 surgeons. Percutaneous placements of a cannula into the foramen ovale for ablation of the gasserian ganglion in trigeminal neuralgia were performed a total of 64 times by 4 subjects (compared with the landmark-based method). 80 placements of a cannula into a defined peridural target point in the lumbar spine were performed by 4 physicians. Placement accuracy was measured using computed tomography and the planning software.

#### Results

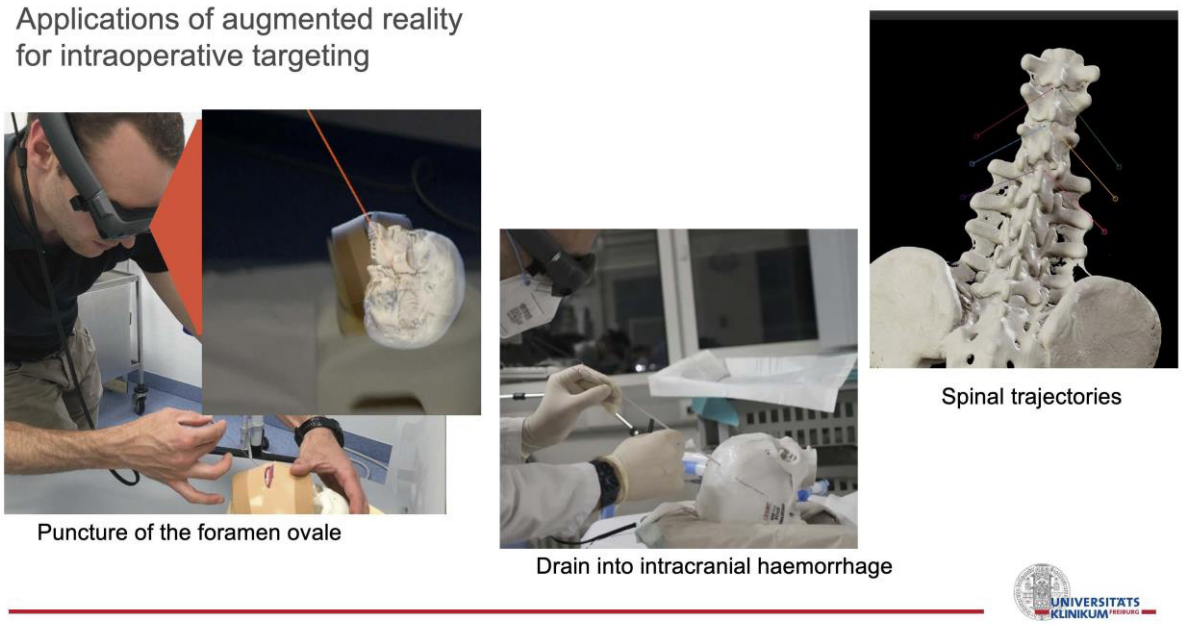
In the phantom experiments, compared to freehand applications, AR was significantly more accurate in all cases studied ($p<0.001$ in hemorrhage drains, $p<0.01$ in ganglion gasseri and $p<0.0001$ spinal).

Nonetheless, when compared to a stereotactic approach based on frames in the phantom experiment regarding bleeding drains, the Euclidean distance achieved using AR (median 3 mm) was lower, but it was comparable to that achieved using STX (median 1.95 mm; $P=0.023$). In an emergency situation, this could be offset by the better time efficiency of bedside procedures using AR compared to a stereotactic operation.

#### Conclusion

AR is an interesting technical development that allows intraoperative applications for cases that are performed landmark-based (e.g. puncture of the foramen ovale or spinal punctures) or where bed-side procedures are performed due to urgency (e.g. hemorrhage drainage).

Abb. 1


Applications of augmented reality
for intraoperative targeting
Puncture of the foramen ovale
Drain into intracranial haemorrhage
Spinal trajectories
UNIVERSITÄTS
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# Funktionelle Neurochirurgie – DBS | Functional Neurosurgery – DBS

## P265

### *Vergleich von CT und MRT basierter Lokalisation nach THS-Operationen: Eine Analyse der klinischen Ergebnisse*
### *Comparing CT and MRI-Based localization in DBS surgery: An analysis of clinical outcomes*

A. Paul[1], T. Juratli[1], B. Falkenburger[2], N. Schnalke[2], I. Prilop[1], S. B. Sobottka[1], I. Y. Eyüpoglu[1], W. H. Polanski[1]

[1]Klinik und Poliklinik für Neurologie, Universitätsklinikum Carl Gustav Carus Dresden, Dresden, Deutschland
[2]Klinik und Poliklinik für Neurologie, Universitätsklinikum Carl Gustav Carus Dresden, Dresden, Deutschland

#### Objective

Deep Brain Stimulation (DBS) is an established therapy for advanced Parkinson's disease, particularly when fluctuations or tremor impair patients` quality of life. This study investigated the deviation of placed DBS leads in the subthalamic nucleus (STN) depending on preoperative CT- or MRI-based localization, as well as the impact of this deviation on the clinical outcome, measured by the Unified Parkinson's Disease Rating Scale (UPDRS III) and medical reduction in Levodopa Equivalent Dose (LED).

#### Methods

In this retrospective study we examined 80 directional DBS leads with CT-based localization and 7 directional DBS leads with MRI-based localization into the STN to assess the deviation from the final electrode position using coordinates in stereotactic imaging. The deviation was calculated as a 3D vector, representing the distance from the planned contact position of the electrode to the position of the contact of the final electrode as controlled in the CT using Elements (Brainlab GmbH). Clinical outcomes were evaluated using the UPDRS III and the LED from preoperative assessment to 15 months postoperatively.

#### Results

CT-based localization showed a significant (p=0.002) smaller median deviation of 1.72mm between the planned trajectory and the placed lead, compared to MRI-based localization with a deviation of 2.86mm. Significant differences in stereotactic imaging accuracy were observed between CT and MRI, as analyzed using Elements software. CT demonstrated a lower mean deviation of 0.17mm compared to MRI's 0.33mm ($p<0.001$) and a smaller maximum deviation (CT: 0.48mm, MRI: 1.09mm; $p<0.001$). Irrespective of the initial localization modality, there was a significant improvement in UPDRS III (n=30, p=0.0003, median reduction=36.4%) and LED (n=30, $p<0.0001$, median reduction=57.3%) after DBS surgery 7.4 to 15.1 months postoperatively. For CT localized electrodes, no correlation was found between the mean of both target point deviations and clinical outcomes in UPDRS III and LED.

#### Conclusion

CT-based localization of DBS leads offers significantly greater precision than MRI-based methods. Interestingly, the deviation from the target point does not appear to directly influence clinical outcomes. This observation could be attributed to the potential of directional stimulation to counterbalance minor localization inaccuracies, highlighting the importance of the interplay between technological precision and clinical programming in DBS.

# P266

## Inzidenz und klinische Relevanz des Peri-Elektroden-Ödems bei DBS-Patienten
*Incidence and clinical relevance of peri-lead edema in DBS Patients*

M. Gjorgjevski[1], M. Bopp[1], A. C. Benescu[1], C. Nimsky[1]

[1]Uniklinikum Marburg, Klinik für Neurochirurgie, Marburg, Deutschland

### Objective

Determining the incidence and clinical relevance of early post-surgery peri-lead edema (PLE) as well as the long-term persistence in DBS-patients.

### Methods

We conducted a retrospective analysis of all patients implanted with a deep brain stimulation (DBS) system since 2021 (n = 46). Indications for DBS-implantation were Parkinsons disease (36 patients), cervical dystonia (three patients) and essential tremor (seven patients). A total of 46 patients and 92 leads were included in the analysis. The occurrence of PLE was analyzed in an early postoperative computer tomography (CT), done 1-12 days after surgery, as well as a secondary CT, performed in an interval of 3 – 13.7 months after the implantation.

### Results

Early postoperative CT-scans were conducted in 15 patients, totaling to 30 leads being analyed. PLE at this stage was detected at 15 (50%) of those leads. Seven of the patients had bilateral edema, and only one unilateral. 13 leads (86%) were implanted in the subthalamic nucleus. The other two were implanted in globus pallidus internus. No leads in the ventral intermediate nucleus of the thalamus were assessed with the early postoperative CT. All of the PLEs diagnosed in the initial CT scan had completely disappeared by the time of the secondary CT scan.

There was no overlaying clinical correspondence to the appearance of the edema. One patient preoperatively treated with oral anticoagulation developed a left frontal subcortical peri-lead bleed which led to a slight motoric aphasia. This improved completely and spontaneously. Another patient described a light postoperative headache, which is not an uncommon occurrence. None of the patients which developed PLE needed surgical treatment.

The secondary CT scan showed PLE in a total of four patients, in each case unilaterally. None of these patients exhibited any surgical complications and all described a clinical benefit following the dbs implantation.

### Conclusion

Although common in the early postoperative period, the analysis shows that PLE is a reversible occurrence and should not be viewed as a postoperative complication or an indicator of an intracerebral infection.

# P267

## Monitoring von Herzfrequenz und Aktivität zur Beurteilung der Belastung im unilateralen und bilateralen 6-OHDA-Parkinson-Modell der Ratte

***Monitoring of heart rate and activity for severity assessment in the unilateral and bilateral 6-OHDA rat Parkinson model***

M. R. Oelerich[1], A. K. Riedesel[1], M. Alam[1], J. K. Krauss[1], K. Schwabe[1]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland

### Objective

In animal experimentation, welfare and severity assessments are necessary to meet legal and ethical requirements, as well as public interests. Injection of 6-hydroxydopamine (6-OHDA) into the nigrostriatal system of rats is used as a model for Parkinson's disease (PD) to investigate the pathophysiological background and treatment. The classical method of unilateral intranigral infusion of 6-OHDA leads to a massive destruction of nigrostriatal dopaminergic neurons and concomitant motor disturbances. After daily injection of Levodopa (L-Dopa), these rats develop dyskinesias, a devastating side effect after long-term treatment in PD patients. In the bilateral model, 6-OHDA infused into the striatum leads to slow and incomplete retrograde degeneration of dopaminergic neurons. This model can be used to study the development of PD or cognitive function. For severity assessment, we here quantitatively measured weight, heart rate and activity in the unilateral and bilateral 6-OHDA model, as well as during 21 days of L-Dopa injection.

### Methods

In male Sprague Dawley (SD) rats (n=16) a telemetric device was subcutaneously implanted under general anesthesia and perioperative pain management. After recovery, rats received either unilateral stereotaxic injection of 6-OHDA into the substantia nigra (n=8) or bilateral injection into the striatum (n=8). Four weeks after unilateral 6-OHDA injection, rats were subcutaneously injected with L-Dopa (10 mg/kg) for 21 days. Perioperatively and during the L-Dopa injection we measured weight, heart rate and activity during the first two hours after light on and light off, as well as directly before and after L-Dopa injection.

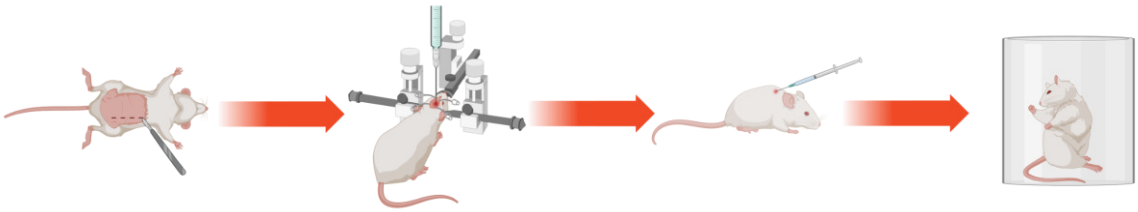
### Results

Bilateral injection of 6-OHDA led to weight loss for the first four postoperative days (two rats nearly 20% of their preoperative weight; $p<0.05$), while unilateral 6-OHDA injection had no effect. Heart rate was enhanced for the first postoperative three days in both models, while activity measures were not affected after surgery. L-Dopa injection had no effect on weight and heart rate, but enhanced activity.

### Conclusion

The results indicate that perioperatively rats` wellbeing is more affected by bilateral injection of 6-OHDA with incomplete loss of nigral dopamine, although heart rate measures also indicate disturbed wellbeing after unilateral injection of 6-OHDA. The development of dyskinesias, however, has only mild and transient effects on rat`s wellbeing.

Abb. 1



# P268

## Prospektives, multizentrisches, internationales Register zur Tiefe Hirnstimulation bei Dystonie: Eine Sub-Analyse von Patienten mit zervikaler Dystonie

***Prospective, multicenter, international registry of Deep Brain Stimulation for dystonia: A sub-analysis of cervical dystonia patients***

J. K. Krauss[1], G. Edward[2]

[1]Medizinische Hochschule Hannover, Neurosurgery, Hannover, Deutschland
[2]Boston Scientific Neuromodulation, Clinical Research, Valencia, MA, Vereinigte Staaten

### Objective

The objective of this clinical evaluation is to assess and report real-world outcomes of Dystonia patients implanted with Multiple Independent Current Control (MICC)-based directional Deep Brain Stimulation (DBS) systems.

### Methods

This is a sub-analysis of patients with focal (cervical) dystonia only or cervical dystonia in the frame of segmental or generalized dystonia assessed within a prospective, multicenter, international dystonia registry (NCT02686125). All patients receive an MICC-based, directional DBS system (Vercise, Boston Scientific). Patients are followed up to 3-years (post-implant). Several study assessments are being collected to evaluate their dystonia symptoms (e.g., TWSTRS), quality of life and overall satisfaction. Adverse Events are also collected.

### Results

A total of 43-patients (mean age 56.9-years, 58% females) with focal (cervical) dystonia only and 83 patients (mean 41.95-years, 61% females) with cervical dystonia in the frame of segmental or generalized dystonia have been evaluated. Both groups reported significant improvement in overall TWSTRS scores – however the extent varied. In the cervical only cohort, a 19.9-point improvement was noted at 6-months (n=25) and sustained up to 1-year (23.2-point improvement, n=20). In those with cervical dystonia in the frame of segmental or generalized dystonia, a 9.7-point and 7.3-point improvement in overall TWSTRS scores was noted at 6- (n = 50) and 12-months (n = 38), respectively.

### Conclusion

This registry represents the first comprehensive, large-scale collection of real-world outcomes associated with dystonia patients implanted with a directional DBS system capable of MICC. Preliminary results demonstrate significant improvement in patients with cervical dystonia (alone or in frame of segmental or generalized dystonia) following DBS.

# P269

## Rettung infizierter tiefer Hirnstimulation-Therapien bei schwer betroffenen Patienten
*Rescuing infected Deep Brain Stimulation therapies in severely affected patients*

T. Fortmann[1,2], S. Zawy Alsofy[1,2], M. Lewitz[1,2], E. Wilbers[1,2], M. Nakamura[2,3], R. Lehrke[1]

[1]St. Barbara-Klinik Hamm-Hessen, Hamm, Deutschland
[2]Universität Witten/Herdecke, Witten, Deutschland
[3]Kliniken Köln, Köln, Deutschland

### Objective

Infections in deep brain stimulation (DBS) hardware, while an undesired complication of DBS surgeries, can be effectively addressed. Minor infections are typically treated with wound revision and IV antibiotics. However, when a visible hardware infection occurs, most centers opt for complete removal, leaving the patient in a preoperative state and necessitating post-removal care. To avoid the need for such care, a novel technique was developed using a stereotatic x-ray set-up.

### Methods

The novel technique involves placing new electrodes within a stereotactic x-ray set-up, leading them to the contralateral side, and placing new extensions and a new generator contralateral to the infection as well. Subsequently, the infected system is removed. This case series includes six patients.

### Results

The average duration of DBS system implantation before the second surgery was 272 days. Only one system had to be removed after 18 months due to reoccurring infection; the others remained unaffected - the longest for 89 months so far. Laboratory alterations and pathogens were identified in only half of the patients.

### Conclusion

The described surgical technique proves to be safe, well tolerated, and serves as a viable alternative to complete system removal. Importantly, it effectively prevents the need of post-removal care for patients and saves cost for patients and the health-care system as well.

Abb. 1

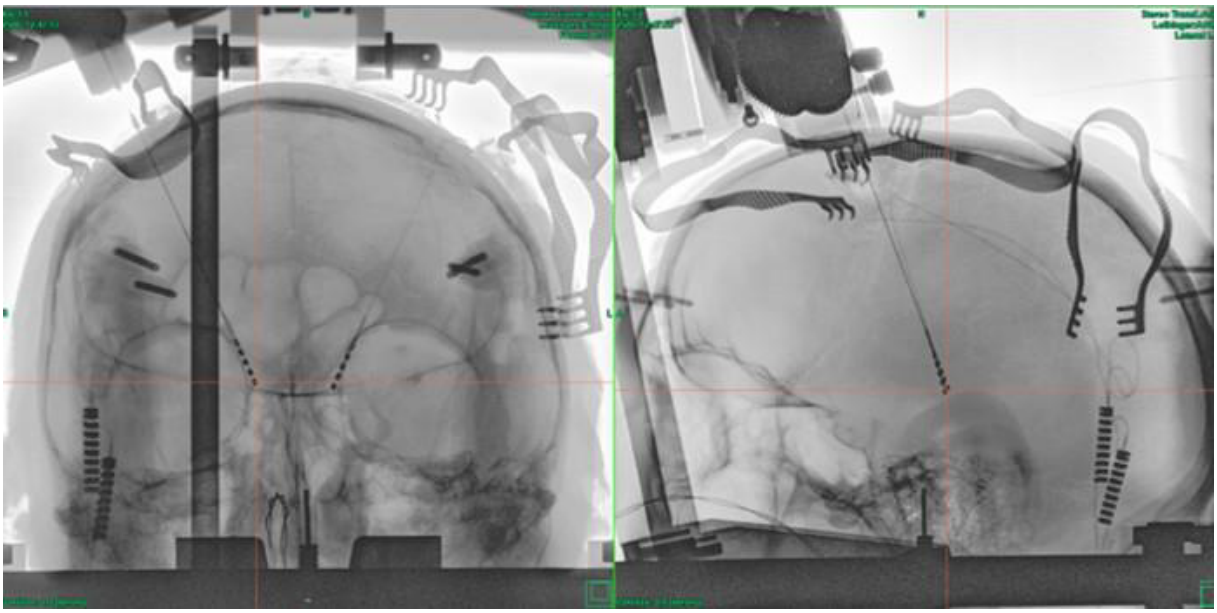
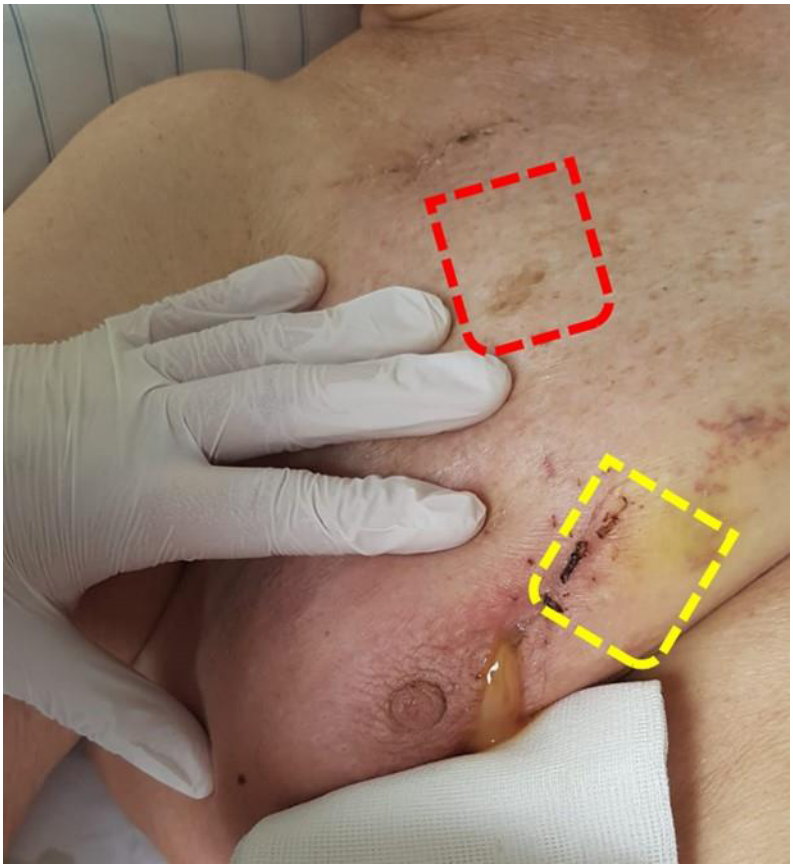


Abb. 2



# Funktionelle Neurochirurgie – DBS | Functional Neurosurgery – DBS

## P270

### Risikofaktoren für perioperative Faktoren bei THS für Bewegungsstörungen
*Risk factors for perioperative complications in movement disorder DBS patients*

J. Vesper[1], L. Lobkowicz[1], P. McPhillips[2], A. Dreyer[2], P. J. Slotty[1], Z. Krause Molle[1]

[1]Heinrich-Heine-Universität Düsseldorf, Sektion Stereotaktische und Funktionelle Neurochirurgie, Düsseldorf, Deutschland
[2]University Medical Center, Heinrich Heine University, Funktionelle Neurochirurgie und Stereotaxie, Düsseldorf, Deutschland

#### Objective

Deep brain stimulation (DBS) is an established and safe treatment option for selected movement disorders, such as idiopathic Parkinson's syndrome (IPS), essential tremor (ET) and dystonia. Although very rare, there are specific complications in DBS surgery. This study retrospectively investigates possible pre- and intraoperative conditions for their predictive value anticipating these complications. The investigated factors are disease duration, H/Y stage, UPDRS III score and non-disease-specific factors (age, diagnosis, secondary diseases, and duration of surgery).

#### Methods

Between January 2016 and October 2020, a total of 181 patients DBS were treated in our center with primary DBS implantation. Out of them, 160 were operated under general anesthesia and 21 patients underwent an awake procedure. We retrospectively reviewed patients" charts for surgical complications, such as intracranial hemorrhage, hematoma at the IPG site and infections. Neurological complications, such as postoperative delirium and mild cognitive impairment, were also included.

#### Results

In the postoperative cCT, a hemorrhage was seen in 5 patients (3.1%, four SAH, one ICH), all asymptomatic not requiring additional treatment. Hematoma at the IPG side occurred in 8 patients (5%), none of them requiring surgical revision.

Infection and prolonged wound healing at the IPG site was found in 9 patients (5.6%) and electrode infections occurred in three patients (one intracerebral, two extracerebral (1.9%)). Neurological complications independent from stimulation were rare. Confusion was noted in 8 patients (5%), all of them following an awake procedure. Mild cognitive impairment was also seen following awake surgery only (two patients, 9.5%)

#### Conclusion

ICH was rare, all affected patients were asymptomatic and the hemorrhage was found in the routinely performed postoperative CT(3.1% vs. 0.2- 5.6% in the literature). Confusion and de novo mild cognitive impairment were only seen in awake DBS patients, casting doubt on the usefulness of awake DBS procedures.In this retrospective review in a large cohort of patients, we failed to identify specific predictors for complications in DBS de novo surgery. Larger prospective real-world data registers are required as effect sizes are small.

# P271

## Rahmen-basierte stereotaktische Biopsien infratentorieller Raumforderungen über den subokzipitalen, transzerebellären Zugang mit dem Zamorano-Duchovny System - eine retrospektive Analyse von 79 Fällen

***Stereotactic frame-based biopsy of infratentorial lesions via the suboccipital-transcerebellar approach with the Zamorano-Duchovny stereotactic system– a retrospective analysis of 79 consecutive cases***

M. Kaes[1], C. Beynon[1], K. Kiening[1], J. O. Neumann[1], M. Jakobs[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Lesions of the posterior fossa (brainstem and cerebellum) are challenging in diagnosis and treatment due to the fact that they are often located eloquently and total resection is rarely possible. Therefore, frame-based stereotactic biopsies are commonly used to asservate tissue for neuropathological diagnosis and further treatment determination. The aim of our study was to assess the safety and diagnostic success rate of frame-based stereotactic biopsies for lesions in the posterior fossa via the suboccipital-transcerebellar approach.

### Methods

We performed a retrospective database analysis of all frame-based stereotactic biopsy cases at our institution since 2007. The aim was to identify all surgical cases for infratentorial lesion biopsies via the suboccipital-transcerebellar approach. We collected clinical data regarding outcome, complications, diagnostic success, radiological appearances and stereotactic trajectories.

### Results

A total of n=79 cases of stereotactic biopsies for posterior fossa lesions via the suboccipital-transcerebellar approach utilizing the Zamorano-Duchovny stereotactic system were identified. Mean age at the time of surgery was 42.5 years (+/-23.3, range: 1-87 years). All patients were operated with intraoperative stereotactic imaging (n=62 MRI, n=17 CT). The absolute diagnostic success rate was 87.3%. Most common diagnoses were glioma, lymphoma and inflammatory disease. The overall complication rate was 8.7% (7 cases). All patients with complications showed new neurological deficits, of those 3 were permanent. Hemorrhage was detected in 5 of the cases having complications. The 30-day mortality rate was 7.6%, 1-year survival rate was 70%.

### Conclusion

Our data suggests that frame-based stereotactic biopsies with the Zamorano-Duchovny stereotactic system via the suboccipital-transcerebellar approach are safe and reliable for infratentorial lesions bearing a high diagnostic yield and an acceptable complication rate. Further research should focus on the planning of safe trajectories and a careful case selection with the goal of minimizing complications and maximizing diagnostic success.

# P272

## Okzipitalnervenstimulation als alternative Behandlung für Hemicrania continua: ein systematisches Review

***Occipital nerve stimulation as an alternative treatment for hemicrania continua: A systematic review***

F. Wolff Fernandes[1], G. L. Duarte[2]

[1]Medizinische Hochschule Hannover, Klinik für Neurochirurgie, Hannover, Deutschland
[2]Universitätsspital Zürich, Klinik für Neurologie, Zürich, Schweiz

### Objective

Hemicrania continua (HC) is a disabling primary headache disorder characterized by its marked sensitivity to indomethacin. However, some patients are unable to take indomethacin due to contraindications or significant side effects. Occipital nerve stimulation (ONS) has been shown as an effective treatment option for refractory primary headache disorders. This study aims to examine the efficacy and safety described in the present literature regarding ONS in HC.

### Methods

Two independent authors conducted a systematic literature review focused on ONS as a treatment option for patients with HC unable to tolerate indomethacin. A comprehensive search was conducted in June 2023, employing relevant keywords associated with ONS and HC. Each article was assessed for study type, number of treated patients, additional type of headache, average pain intensity, frequency at both baseline and follow-up, and adverse effects reported.

### Results

Eighty studies were identified, from which 6 full-text articles met the eligibility criteria. In a total of 29 patients, with a mean age of 50.6 years at the time of surgery, 16 (55.2%) had a favorable response. The average improvement of the outcome was 55.0%, documented in 24 out of 29 patients. The visual analog scale improved by 3.1 out of 10.0 points (mean reduction of 47.8%) during an average follow-up of 31.1 months. The frequency of headaches decreased from 30 to an average of 19.9 headache days per month (33.7%).

### Conclusion

These results offer preliminary evidence in favor of considering ONS as a safe and effective alternative to reduce both the intensity and frequency of headaches in patients with HC unable to tolerate indomethacin. Further studies should prioritize prospective trials and establish standardized methods for reporting outcomes in this set of patients.

# P273

## Rahmen-basierte stereotaktische Biopsien von Hirnstamm Raumforderungen - Monozentrischer Vergleich des transfrontalen und des subokzipitalen Zugangs über einen 16-Jahres-Zeitraum

***Frame-based stereotactic biopsies of brainstem lesions – Monocentric comparison of the transfrontal and the suboccipital-transcerebellar approach over a 16-year period***

M. Kaes[1], C. Beynon[1], K. Kiening[1], S. Krieg[1], J. O. Neumann[1], M. Jakobs[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

Both the transfrontal and the suboccipital-transcerebellar approaches are commonly used trajectories for frame-based stereotactic biopsies of brainstem lesions. Nevertheless, it remains unclear which approach is more favorable in terms of complications, diagnostic success and outcome, especially considering the location of the lesion within the brainstem. This study compared the safety and diagnostic yield of these two approaches and a brainstem zone model was created to answer the question, whether there is a favorable approach depending on the location of the lesion in the brainstem.

### Methods

A retrospective analysis of 84 consecutive cases, which underwent frame-based stereotactic biopsy for brainstem lesions via either the transfrontal or the suboccipital-transcerebellar approach, over a 16-year period was performed. Clinical and surgical data regarding trajectories, histopathology, complications and outcome was collected. Subsequently, the brainstem was divided in anatomical zones to compare the frequency of use and the efficacy of the two approaches depending on the location of the lesions.

### Results

A total of n=84 stereotactic biopsies for brainstem lesions were performed. In 36 cases the suboccipital-transcerebellar approach was used, whereas in 48 cases surgery was performed via the transfrontal approach. Patients demographic data were comparable. Overall diagnostic yield was 90.5% (93.8% transfrontal vs. 86.1% suboccipital, p=0.21). Complications occurred in 11 cases, which adds up to a total complication rate of 13.1% (12.5% transfrontal vs. 13.9% suboccipital, p=0.55). The brainstem model showed a more frequent use of the suboccipital approach in lesions of the dorsal pons. The transfrontal approach was used more frequently for mesencephalic targets. No significant differences in terms of complications and diagnostic yield were observed, even though complications in medullary lesions appeared to be higher using the transfrontal approach.

### Conclusion

This study showed, that if the approaches are used for their intended target locations there are no significant differences between the transfrontal and the suboccipital-transcerebellar approach for frame-based stereotactic biopsies of brainstem lesions in terms of diagnostic yield and safety. Therefore, our data suggests that both approaches should be considered for stereotactic biopsy of brainstem lesions.

# P274

## IMAGINER 2 – Verbesserung der Genauigkeit mit dem Augmented Reality Navigationssystem bei der Platzierung externer ventrikulärer Ableitungsschläuche über Kaufmans, Keens, Kochers und Fraziers Punkt.

***IMAGINER 2 – Improving accuracy with augmented reality navigation system during placement of external ventricular drains over Kaufman's, Keen's, Kocher's and Frazier's point***

M. Vychopen[1], F. Kropla[1], J. Wach[1], D. Winkler[1], E. Güresir[1], R. Grunert[1,2]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland
[2]Fraunhofer-Institute for Machine Tolls and Forming Technology, Department of Medical Engineering, Dresden, Deutschland

### Objective

External ventricular drain (EVD) placement is a routinely performed neurosurgical procedure that plays a crucial role in a treatment of acute hydrocephalus and provides intracranial pressure monitoring. Kocher´s point is the most commonly used anatomical landmark for the procedure. In several cases, other anatomical landmarks must be used in order to perform the procedure safely and successfully. In such cases, augmented reality (AR) might be the decisive factor for a successfully and safely performed procedure. The previous study (IMAGINER I) presented an improved accuracy by ventriculostomy performed by medical students without previous neurosurgical experience. In this study, we evaluate the impact of augmented reality on the accuracy of EVD placement performed by experienced neurosurgeons.

### Methods

In our study, neurosurgeons perform ventriculostomies over Kaufman´s, Keen´s, Kocher´s and Fraizer´s point on a Styrofoam head. We compared ventriculostomies according to anatomical landmarks with ventriculostomies performed with the aid of the Microsoft Hololens Augmented Reality system according to a pre-planned trajectory. Subsequently, CT-Scans are performed to assess the data.

### Results

The mean target-point deviation in all ventriculostomies was 16.93 ± 9.3 mm in AR group 21.71 ± 9.5 mm in Free-hand group compared to 21.71 ± 9.5 mm in Free-hand group, with mean difference of 4.78mm (p=0.0027, CI 95% 1.68 – 7.78). After comparing separately every pre-defined ventriculostomy entry-point separately, we saw reduction in mean target point deviation in all groups with statistically significant difference in Keen´s point (Kocher´s point 16.33 ± 7.32 mm vs. 20.60 ± 6.88 mm; p=0.08, Keen´s Point 15.29 ± 7.26mm vs. 23,48 ± 11.21mm, p=0.01, Kaufman´s point 19.29 ± 12.11mm vs. 22.72 ± 11.20mm, p=0.38 and Fraizer´s point 16.82 ± 10.27mm vs. 20.03 ± 8.8mm, p=0.32).

### Conclusion

Following the IMAGINER I results, we performed an evaluation of the augmented reality supported placement of a ventricular drain over Kaufman´s, Keen´s, Kocher´s and Fraizer´s point performed by experienced neurosurgeons. Overall, we saw a significant reduction in mean target deviation, if AR was used.

# P275

## Tiefe Hirnstimulation bei Zwangsstörungen: Umbrella-Review und Metaanalyse

***Deep brain stimulation for obsessive-compulsive disorder: Umbrella review and a meta-analysis***

A. Abdulbaki[1], J. El Masri[2], M. Ghazi[2], K. G. Kahl[3], R. Mocking[4], R. Schuurman[5], B. Nuttin[6], J. K. Krauss[1]

[1]Hannover Medical School, Department of Neurosurgery, Hannover, Deutschland
[2]Lebanese University, Faculty of Medical Sciences, Beirut, Libanon
[3]Hannover Medical School, Department of Psychiatry, Hannover, Deutschland
[4]University of Amsterdam, Department of Psychiatry, Amsterdam, Niederlande
[5]University of Amsterdam, Department of Neurosurgery, Amsterdam, Niederlande
[6]University Hospitals Leuven, Department of Neurosurgery, Leuven, Belgien

### Objective

Deep brain stimulation (DBS) for otherwise treatment-refractory obsessive-compulsive disorder (OCD) represents an emerging therapy. This umbrella review and meta-analysis aims to provide a comprehensive summary of studies published in the literature on the outcomes of DBS in the context of OCD.

### Methods

In adherence to PRISMA guidelines, an umbrella review and meta-analysis was conducted in October 2023, systematically searching PubMed, Medline, Embase, and Web of Science for meta-analyses on the treatment of OCD with DBS. Individual studies within the included meta-analyses, along with new studies from 2023, were meticulously reviewed, and duplications were removed. They were further categorised based on stimulation targets. Their results were collected and pooled to generate forest plots. The primary outcome was the relative change in Y-BOCS, HAM-A, HAM-D and Global Assessment of Functioning (GAF) scores at last available follow-up after DBS.

### Results

This umbrella review encompassed seven meta-analyses evaluating the outcomes of DBS in patients with OCD published between 2014 and 2022. The analysis, including 40 studies, revealed a significant overall improvement in OCD symptoms following DBS, as measured by Y-BOCS (mean difference (MD)=1.94, 95%CI=1.70, 2.18, $p<0.00001$, $I^2=43\%$), HAM-A (MD=24.56, 95%CI=23.41, 25.72, $p<0.00001$, $I^2=99\%$), HAM-D (MD=9.36, 95%CI=7.94, 10.77, $p<0.00001$, $I^2=45\%$), and GAF scales (MD=-4.87, 95%CI=-5.58, -4.16, $p<0.00001$, $I^2=99\%$).

### Conclusion

*DBS is safe and effective for OCD. Careful patient selection according to clear definitions of "treatment refractoriness" is recommended.* Further research is essential to better understand and assess the treatment's efficacy, as well as to determine the most optimal brain targets for *OCD.*

# Funktionelle Neurochirurgie – DBS | Functional Neurosurgery – DBS

## P276

### *Aktivierung außerhalb des kanonischen Riechhirns führt zu Geruchsempfindungen*
### *Activation outside the canonical olfactory brain leads to odor sensations*

D. Podlesek[1], C. Mignot[2], S. Menzel[2], S. B. Sobottka[1], G. K. Leonhardt[1], T. Juratli[1], W. H. Polanski[1], M. Bensafi[3], I. Y. Eyüpoglu[1], T. Hummel[2]

[1]Technische Universität Dresden, Klinik mit Poliklinik für Neurochirurgie, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Hals-, Nasen- und Ohrenheilkunde; Interdisziplinäres Zentrum für Riechen und Schmecken, Dresden, Deutschland
[3]University Lyon, Lyon Neuroscience Research Center, Lyon, Deutschland

#### Objective

To stimulate specific brain regions and generate olfactory sensations (phantosmia) to bypass the potential peripheral nerve impairment sufficiently so that it evokes an olfactory sensation.

#### Methods

The study involved 11 patients undergoing stereoencephalography (SEEG, N = 5) and awake brain surgery (ABS, N = 6). Stimulation was applied during SEEG elective procedures and to peritumoral tissue in ABS patients. Interprocedural testing evaluated odor perception, including strength and hedonics. Olfactory performance was assessed preoperatively.

#### Results

Due to intraoperative speech problems, vomiting and seizure during the procedure, 4 patients were excluded from the study. 4 SEEG and 3 ABS patients were enrolled. During ABS, a single patient reported experiencing a lemon-like olfactory sensation following the direct electrical stimulation of the olfactory tract by the bipolar tweezers. None of the electrical stimulations changed the way the odorants of rose and peppermint were rated. Nevertheless, in a different patient, the application of 6mA electrical stimulation to the gyrus rectus modified his impression of a rose, which he subsequently classified as having a vanilla scent.

The application of stimulus resulted in the emergence of an olfactory percept in 2 SEEG individuals. This was in the right amygdala after stimulation of 1.6mA, 5sec duration, and 50Hz frequency for one patient, which led to a spinach odor perception. In the case of the second patient, an unfamiliar malodorous scent was detected after stimulation in the right temporo-parieto-occipital junction using the specified parameters.: 7mA, 5sec duration and 50Hz frequency. There was no significant impact observed on the perceived ratings of the odorants as a result of any of the administered electrical stimulations.

#### Conclusion

Overall, the use of central stimulation to circumvent peripheral neuronal damage has shown effectiveness in many sensory systems. We have successfully elicited olfactory sensations by directly stimulating certain areas of the brain, including the right amygdala, left olfactory tract, left temporo-parieto-occipital junction, and left gyrus rectus, despite the small number of patients involved in the study. The findings should be considered as a "proof of concept" and the anatomical locations that had a role in the development of olfactory perception should be examined as potential areas of focus for future research on olfactory stimulation.

# Trauma und Neurointensiv - Verschiedenes 1 | Trauma

## P277

### Welche Faktoren könnten bei Rezidiven eines chronischen subduralen Hämatoms eine Rolle spielen?
*Which factors could play a role in recurrences of a chronic subdural haematoma?*

S. Zawy Alsofy[1,2], M. Lewitz[1,2], T. Fortmann[1,2], E. Wilbers[1,2], M. Nakamura[2,3], C. Ewelt[1]

[1]St. Barbara-Klinik Hamm-Hessen, Neurochirurgie, Hamm, Deutschland
[2]Witten/Herdecke University, Department of Medicine, Faculty of Health, Witten, Deutschland
[3]Academic Hospital Koeln-Merheim, Neurochirurgie, Köln, Deutschland

### Objective

In this study, epidemiological, clinical, therapeutical, and haemostaseological variables were investigated regarding their correlation with the recurrence of chronic subdural haematomas to be able to assess the risk of recurrence more reliably in everyday clinical practice.

### Methods

The electronic patient records of 90 patients who underwent surgery for chronic subdural haematoma at our institute between 1 January 2017 and 31 May 2021 were analysed regarding previously defined variables.

### Results

In the patient collective, 33.33% of the 90 patients experienced a recurrence requiring treatment. The occurrence of a recurrence was not statistically significantly related to age, gender, known alcohol abuse, a specific location, extension over one or both hemispheres, the surgical method, or anticoagulant medication. However, the recurrence was statistically significantly related to haematoma width (p =0.000007), septation (p =0.005), and the existence of a coagulation disorder not treated with medication (p =0.04).

### Conclusion

In our Study, width of haematoma, septation, and coagulation disorders not treated with medication were documented as risk factors for the occurrence of a chronic subdural haematoma. Identifying of these risk factors could help to adapt individual therapeutic concepts for chronic subdural haematomas.

### Abb. 1

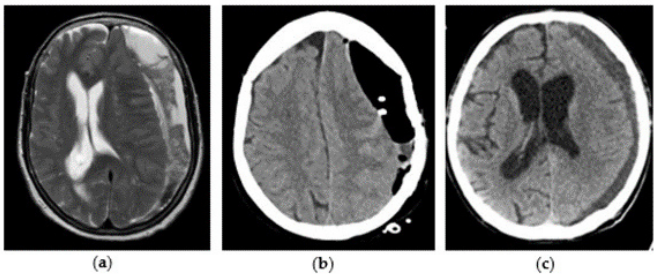



**Figure 1**. Axial presentation chronic subdural haematoma: (a) preoperative septation in axial plane in MRI; (b) postoperative subdural air accumulation in CT; (c) recurrence of chronic subdural haematoma in CT.

Abb. 2

**Table 1.** Analaysed epidemiological, clinical, therapeutical, and haemostaseological variables in patient groups with and without recurrence.

| Characteristis | Group1 recurrence (n=30) | Group 2 no recurrence (n=60) | p-value |
|---|---|---|---|
| age (years), mean ± SD (min-max) | 74.40 ± 2,66 (44 – 93) | 74.15 ± 1.41 (46 – 97) | 0.93 (non-significant) |
| gender: | | | |
| male | 22 | 38 | 0.48 |
| female | 8 | 22 | (non-significant) |
| alcohol abuse | 1 (3.33%) | 1 (1.67%) | 1.00 (non-significant) |
| width (mm) ± SD (min-max) | 22.83 ± 1.31 (14 – 40) | 16.23 ± 0.73 (8 – 30) | 0.000007 (significant) |
| localisation: | | | |
| entire hemisphere | 17 (56.57%) | 24 (40.00%) | |
| fronto-parietal | 10 (33.33%) | 16 (26.67%) | 0.28 |
| frontal | 3 (10.00%) | 12 (20.00%) | (non-significant) |
| septation | 10 (33.33%) | 5 (8.33%) | 0.005 (significant) |
| surgical procedure: | | | |
| membrane opening | 5 (16.67%) | 5 (8.33%) | 0.29 (non-significant) |
| intraoperative irrigation | 23 (76.67%) | 44 (73.33%) | 0.80 (non-significant) |
| subdural drainage | 30 (100%) | 59 (98.33%) | 1.00 (non-significant) |
| haemostaseology: | | | |
| anticoagulant medication | 12 (40.00%) | 21 (35.00%) | 0.929 (non-significant) |
| coagulation disorders | 3 (10.00%) | 1 (01.66%) | 0.04 (significant) |
| laboratory parameters: | | | |
| fibrinogen concentration (mg/dl) ± SD | 344 ± 19 | 381 ± 17 | 0.19 (non-significant) |
| thrombocytes concentration(thrombocyte/nl) ± SD | 213 ± 13 | 236 ± 9 | 0.14 (non-significant) |
| prothrombin time | 85% ± 3 | 90% ± 2 | 0.19 (non-significant) |
| acivated partial thromboplastin time (seconds) | 29.7 ± 0.9 | 29.9 ± 0.6 | 0.851 (non-significant) |

# P278

## Herausforderungen bei der Behandlung des geriatrischen leichten Schädelhirntraumas - eine Analyse von 617 Patienten

***Assessing injury burden in elderly patients with mild traumatic brain injury***

T. Schink[1], S. Bahtijari[1], L. Kromer[1], S. Krieg[1], A. Unterberg[1], A. Younsi[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgische Klinik, Heidelberg, Deutschland

### Objective

With the elderly population (≥80 years) growing from 2% in the 1970s to 7% in 2021, and forming a majority of mild traumatic brain injury (mTBI) cases, this study aims to analyze this demographic's clinical management and outcomes in a neurosurgical emergency setting.

### Methods

A retrospective review (2018-2020) was conducted in the emergency department (ED) of a German neurosurgical tertiary care center. Patients aged ≥80 years with mTBI (Glasgow Coma Scale 13-15) were included. Demographics, symptoms, and treatment modalities were analyzed.

### Results

Within 36 months, 617 mTBI patients aged ≥ 80 years old were identified (median age: 86; 60% female (n=369)). The predominant cause of TBI in this geriatric cohort was falls (87.5%, n=540) – often at home (33%, n=205) or in nursing homes (28%, n=172). Incidental falls (12.5%, n=77) and syncopes (7%, n=44) were common triggers. Notably, 22% (n=137) had a prior TBI history, and 21% (n=131) exhibited neurological deficits. Antithrombotic medication was used by 76% (n=472). In the ED, 47% (n=292) underwent blood analysis, revealing sodium deficiency (22%, n=64) and hemoglobin deficiency (females 46%, n=70; males 66%, n=93) as the most common pathological findings. Cranial CT scans were performed in 98% (n=606), detecting traumatic injuries in 26% (n=167), primarily acute subdural hematomas (53%, n=85), chronic subdural hematomas (39%, n=63) and traumatic subarachnoid bleeding (38%, n=60). Neurosurgery was performed on 38% (n=61) of these patients, accounting for 10% of the geriatric cohort. Overall, 36% (n=223) of all patients were hospitalized (85% general ward, 15% intensive care unit) and 67.5% (n=417) received interventions like superficial wound treatment (33%, n=207), i.v. analgesia (12%, n=76), balancing of coagulation (6%, n=32) or antibiotic treatment (9%, n=57). Mortality in the geriatric mTBI cohort was below 1% (n=6).

### Conclusion

Geriatric mTBI patients represent a complex neurotrauma subgroup, necessitating extensive diagnostic and therapeutic resources. Given the frequency of repeated falls, more proactive preventive strategies should be considered.

# P279

## Frailty als prognostischer Faktor bei älteren Patienten, die eine dekompressive Kraniektomie zur Behandlung eines posttraumatischen akuten subduralen Hämatoms erhalten

***Frailty as a prognostic factor in elderly patients undergoing decompressive craniectomy for posttraumatic acute subdural hematoma***

S. Niedermeyer[1], M. Leiber[1], S. Stöcklein[1], T. Weig[2], N. Terpolilli[3]

[1]LMU Klinikum, Klinik und Poliklinik für Radiologie, München, Deutschland
[2]LMU Klinikum, Klinik für Anästhesiologie, München, Deutschland
[3]LMU Klinikum, Neurochirurgische Klinik und Poliklinik, München, Deutschland

### Objective

Acute subdural hematoma (ASDH) is a significant contributor to adverse and fatal outcomes following traumatic brain injury (TBI) in elderly patients. In this study, we aimed to investigate the role of frailty as a prognostic factor in elderly patients undergoing decompressive craniectomy for posttraumatic ASDH.

### Methods

We conducted a retrospective review of clinical notes of patients aged > 60 years, who underwent decompressive craniectomy (DC) for ASDH between January 2010 until December 2021. Temporalis muscle area (TMA) was quantified from head CT-scans upon admission. Frailty was assessed using the Clinical Frailty Scale (CFS) and the 11-items modified Frailty Index (mFI-11). Univariate and multivariate regression analysis were employed to determine the predictive role of preoperative TMA and frailty in terms of postsurgical 30 day-mortality and Glasgow Outcome Scale (GOS).

### Results

We identified 55 patients with a median age of 72 years (IQR 67-77; range 60-93 years). The 30-day mortality rate was 14.6%. 32.7% of patients achieved a good recovery (GOS 4-5), while 67.3% had an unfavorable outcome (GOS1-3). TMA was significantly larger in male patients compared to females (p=0.047) and showed an inverse correlation with age (Spearman`s rho=-0.2), but it was not associated with short-term mortality (p=0.375) or GOS (p=0.773). After controlling for age and Glasgow Coma Scale (GCS), multivariate regression analysis demonstrated that CFS and mFI-11 were significantly associated to GOS (p=0.013 and 0.028 respectively). As previously reported, we observed high procedure-related morbidity after cranioplasty (26.3%) without any fatal outcome. The timing of cranioplasty did not influence complication rate (p=0.566)

### Conclusion

Frailty, rather than chronological age, appears to be a crucial predictor of short-term mortality and GOS following decompressive craniectomy for posttraumatic ASDH in elderly patients. Incorporation of frailty assessment by CFS and mFI-11 into the decision-making process may help to identify elderly patients with a more favorable outcome after decompressive craniectomy, thereby facilitating treatment decisions.

# P280

## *Klinische Bedeutung der Drainagelokalisation bei der chirurgischen Behandlung subduraler Hämatome*
## *Clinical relevance of drain location in the surgical treatment of subdural hematomas*

D. Januzi[1], J. Hoffmann[1], N. Dinc[1], M. A. Kamp[1], C. Senft[1], P. Baumgarten[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

### Objective

The primary objective of this study was to compare the outcomes associated with the placement of a drainage in either the subdural or the subgaleal space among patients diagnosed with subdural hematomas and treated with burrhole evacuation. Furthermore, the study aimed to evaluate potential risk factors contributing to postoperative complications and mortality.

### Methods

This retrospective analysis was performed on data collected from 88 patients with chronic subdural hematomas (cSDH) treated through a burrhole evacuation and receiving a drain at the Neurosurgery Department of University Hospital Jena between October 2020 and January 2023. Patient information encompassing medication usage, comorbidities, trauma history, symptomatology, hematoma size and density, treatment modalities, complications, and outcome variables including re-operation, recurrence, and overall survival, were obtained through an SAP-data query. Statistical analyses were conducted using JMP 14.0 software.

### Results

The total cohort consisted of 64 male (72.72%) and 24 female (27.27%) patients, with a mean age of 78.5 years. All patients underwent a burrhole evacuation of the hematoma, with 57 individuals (64.8%) receiving subdural drainage and 31 (35.2%) a subgaleal one. In the subdural group, subsequent surgery was necessary for 12 patients (21.1%), while in the subgaleal group, it was required for 10 patients (32.3%). Analyzing the drainage location did not reveal any statistically significant correlation or difference (Pearson's Chi-squared test: $p = 0.2462$). Survival analysis indicated no noteworthy extension in survival for patients with subgaleal drainage (Log-Rank Test: $p = 0.3953$). Moreover, the choice of drainage location did not lead to a statistically significant impact on epileptic seizures (Pearson's Chi-squared test: $p = 0.8336$). Nevertheless, the occurrence of an epileptic seizure was significantly associated with the need for a repeat operation during the same hospital stay (Pearson's Chi-squared test: $p = 0.0008$).

### Conclusion

In conclusion, drainage location post burrhole trepanation for subdural hematoma did not significantly affect complications, recurrence, or outcomes, emphasizing the role of patient-specific factors. Despite study limitations, our findings contribute insights to the growing body of literature on drainage placement.

# Trauma und Neurointensiv - Verschiedenes 1 | Trauma

## P281

### Kranioplastie in Deutschland - Ergebnisse einer landesweiten Umfrage zur Kranioplastie
***Current practices in cranioplasty in Germany: Insights from a german cranioplasty survey***

P. Naser[1,2,3], F. Zacharias[1,2], H. Giese[1,4], S. Krieg[1,2], A. Unterberg[1,2], A. Younsi[1,2]

[1]Heidelberg University, Department of Neurosurgery, Heidelberg, Deutschland
[2]Heidelberg University, Medical Faculty, Heidelberg, Deutschland
[3]German Cancer Research Center (DKFZ), AI Health Innovation Cluster, Heidelberg, Deutschland
[4]Klinikum Braunschweig, Neurochirurgie, Braunschweig, Deutschland

#### Objective

Cranioplasty (CP) post-decompressive craniectomy (DHC) commonly employs the patient's own bone flap (BF), stored intraabdominally or in a freezer. Recent legal concerns have brought the storage practices of explanted BFs into question. Moreover, new materials might offer superior outcomes, mitigating the risk of osteolysis. This study aimed to evaluate the prevailing CP methodologies in German medical centers.

#### Methods

From May to September 2023, a 24-item online survey was circulated via the German Society of Neurosurgery (DGNC), inquiring about the practices and frequencies of DHC and CP, along with the reasons for these practices.

#### Results

Of the 76 respondents from German centers, the majority (41%) reported performing 25-50 DHCs annually. Only two centers conducted over 100 DHCs yearly, while nine centers performed fewer than 10. CP numbers post-DHC paralleled DHC figures: 41% conducted 25-50 CPs yearly, 38% 10-25, and a minority (five centers) exceeded 50. Regarding CP timing post-DHC, 57% waited 8-12 weeks, 11% opted for an earlier timeframe (<8 weeks), and 29% delayed CP beyond 12 weeks. Autologous bone, preferred by 47 centers, was favored for its biocompatibility (83%), cost-effectiveness (62%), and fit (32%). Deep-freezers were the primary BF storage method in 80% of centers, with only seven centers opting for intraabdominal storage. The discard policy for stored BFs varied, with 31% discarding within 12 months and 29% within 6 months. Ten centers kept BFs indefinitely. In centers using autologous bone, informed consent was sought for BF storage in only 49%. Alloplastic materials were the primary choice in 34% of centers, chosen for their fit (69%), biocompatibility (58%), and longevity (42%). Shifts away from autologous CP were driven mainly by organizational and legal challenges, along with concerns about osteolysis.

#### Conclusion

The survey unveils significant variability in CP approaches across Germany. Despite the gradual transition to alloplastic materials, autologous CP remains widely used. The practice of storing BFs in deep-freezers poses notable medicolegal risks, particularly without patient consent. The insights from our survey underscore the need for establishing community-wide guidelines.

# P282

## Gebrechlichkeit ist mit einem schlechteren neurologischen Outcome nach chirurgischer Therapie des chronischen Subduralhämatoms assoziiert

***Frailty is associated with a worsened neurological outcome following surgical treatment for chronic subdural hematoma (cSDH)***

T. P. Schmidt[1], C. Jacquemain[1], J. Rupprecht[1], K. Jütten[1], A. Höllig[1], M. Veldeman[1], H. R. Clusmann[1], G. A. Schubert[1,2], C. Conzen[3]

[1]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland
[2]Kantonsspital Aarau, Klinik für Neurochirurgie, Aarau, Deutschland
[3]Universitätsklinikum RWTH Aachen, Klinik für Neurochirurgie, Aachen, Deutschland

### Objective

Increased frailty, defined as a state of decreased physiologic reserve in older patients, is a recognized risk factor for unfavorable treatment outcomes in various surgical specialties. In neurosurgical literature, most studies are retrospective and focus on spine and brain tumor surgery. Despite the prevalence of chronic subdural hematoma (cSDH) in the elderly population, there is a lack of prospective studies addressing frailty and postoperative outcomes. Therefore, this prospective study aims to assess the predictive value of the Clinical Frailty Scale (CFS) for neurological outcomes after surgical treatment of cSDH.

### Methods

An ongoing single-center prospective cohort study examines consecutive patients aged over 60 years with the indication to haematoma evacuation via burrhole craniotomy. Each patient is assessed for CFS and categorizing as having mild, moderate, or severe frailty. The primary endpoint is neurological outcome measured by the modified Rankin Scale after six months and one year. Secondary endpoints included mortality, length of stay, adverse events, recurrent surgery, and nonhome discharge.

### Results

Our preliminary results (n = 45) show no significant association between age and CFS ($p = .108$). There is a significant correlation of outcome with both age (mRS: $p = .001$, GOSe: $p < .001$) and CFS (mRS: $p < .001$, GOSe: $p < .001$) assessed after 3 months using mRS and GOSe. However, after 6 months and Bonferroni correction for multiple comparisons (adjusted p = .004), the significant correlation remains with CFS only (mRS: $p = .003$, GOSe: $p < .001$), not with age (all p >.008). The mean neurological outcome after 6 months is mRS 2 ± 2 and GOSe 6 ± 2.

### Conclusion

Despite the frequency of chronic subdural hematoma in the elderly, there are only few studies exploring the relationship between frailty and postoperative outcomes. Our preliminary prospective data analysis emphasizes the importance of the frailty concept concerning clinical outcomes in patients with cSDH.

# P283

## Epileptische Anfälle als maßgebender Prädiktor für das schlechte Outcome bei Patienten mit subduralem Hämatom: Metaanalyse

***Epileptic seizures as outcome worsening complications by patients with subdural hematoma: Meta-analysis***

K. Isoyan[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

### Objective

Subdural hematoma (SDH) is a frequent consequence of head traumata and among the most commonly addressed conditions in the field of neurosurgery. According to recent epidemiological studies, the incidence of both acute and chronic SDH is expected to rise. Beside recurrence of the hematoma, epileptic seizures (ES) are feared complication, contributing to increased mortality and potentially worsening both short- and long-term outcome. In this meta-analysis, we aim to investigate the correlation between ES and outcome in patients with both acute and chronic SDH.

### Methods

We conducted a literature search in PubMed, Embase, Medline, and Cochrane databases and found 12 eligible studies published between 2010 and 2023. Furthermore, we screened the published meta-analyses to identify any studies that might have been overlooked. The studies were subsequently divided into three separate groups: 1) acute SDH (n=6), 2) chronic SDH (n=4), 3) epidemiological studies on acute SDH (n=2). Subsequently, meta-analysis was conducted to analyze the correlation of ES with outcome in all 3 groups.

### Results

The results of the study revealed a significant correlation between ES and poor outcomes in both aSDH ($p<0.001$, 95%CI 0.327-1.723; Egger´s test for bias: $p=0.402$) and cSDH ($p<0.001$, 95%CI 0.905-1.752; Egger´s test for bias: $p<0.254$). Furthermore, the analysis of epidemiological studies showed that ES potentially increase mortality in patients with aSDH ($p<0.001$, 95%CI 0.585-0.938).

### Conclusion

Our results suggest that epileptic seizures present severe and potential fatal risk factor for patients with both acute and chronic SDH. According to presented clinical studies, ES significantly increase mortality and is associated with higher incidence of poor outcome. Therefore, the preventative application of antiepileptic drugs could be beneficial, particularly if considering patients at risk of seizure development.

# P284

## Einfluss der kathetergestützen Embolisation der A. meningea media auf die postoperative Rezidivrate bei Patienten mit einem chronischen Subduralhämatom.

***Effect of catheter-based embolization of the middle meningeal artery on the postoperative recurrence rate in patients with chronic subdural hematoma***

A. Strauss[1], F. Schanz[2], M. Scheer[1], K. Spindler[1], A. Spröggel[2], E. Elolf[2], S. Rampp[1], S. Schob[2], C. Strauss[1], J. Prell[1]

[1]Universitätsmedizin Halle (Saale), Universitätsklinik und Poliklinik für Neurochirurgie, Halle, Deutschland
[2]Universitätsmedizin Halle (Saale), Universitätsklinik und Poliklinik für Radiologie, Halle, Deutschland

### Objective

Chronic subdural hematoma is a common neurosurgical condition that is usually treated surgically, but is associated with a high recurrence rate. To date, there have been few therapeutic approaches to tackle this problem. In recent years, there have been increasing reports in the literature on the successful use of catheter-based embolization of the middle meningeal artery (MMA) for the treatment of chronic subdural hematomas. We evaluated the recurrence rate in surgically treated patients (group A) compared with those complementary treated with MMA embolization (group B).

### Methods

In our monocentric study, the recurrence rate in group B (treated in 2022 and 2023) was compared with the recurrence rate in group A (treated 2005 to 2023). Patients with acute bleeding complications, hygroma and underage patients were excluded from the study. In addition, patients who were in the group of the "learning curve" defined in advance in consensus with colleagues from the Department of Neuroradiology were excluded (a total of 14 patients treated September 2021 to August 2022). Patients in group B received interventional treatment within one week of hematoma evacuation; apart from this, there were no differences in management between groups A and B. The rate of recurrence was evaluated as the primary endpoint. In addition, we evaluated CT-volumetry and radio density data on admission, before discharge and 14 days after. For this purpose, a matched-cohort was created from the patients in group A.

### Results

A total of 405 patients were included, 376 patients in group A and 29 patients in group B. There were no significant differences between the groups in demographic data (age p=0.838, gender p=0.544), laterality of hematoma (p=0.558), laterality of surgery (p=0.974), or presence of subdural drainage (p=0.268). The recurrence rate (requiring surgery) in group B was 30% (114/376), in group A 33% (10/29) (p = 0.68). There were also no significant differences with regard to the volumetric and radio density data.

### Conclusion

The results suggest that the complementary postoperative embolization treatment does not appear to provide superior results, at least in the short term. However, evaluation of the long-term recurrence rate is still pending.

# P285

## Einfluss klinischer Merkmale auf das Outcome nach chirurgischer Behandlung von chronischen Subduralhämatomen: Eine retrospektive Analyse

***Impact of clinical characteristics on outcome after surgical management of chronic subdural hematomas: A retrospective analysis***

F. Meinert[1], M. Broischer[1], S. Helgers[1], P. Dömer[1], J. Woitzik[1]

[1]Evangelisches Krankenhaus Oldenburg, Universitätsklinik für Neurochirurgie, Oldenburg, Deutschland

### Objective

Chronic subdural haematoma (cSDH) is a common neurosurgical condition in elderly patients, with an incidence of 7.4 cases per 100,000 individuals. Despite common surgical evacuation, there remains a significant risk of mortality and recurrence, lacking reliable predictors for postoperative recurrence requiring further intervention.

### Methods

In this retrospective cohort study, we analysed 60 patients with cSDH who underwent surgical haematoma evacuation between 02/2022 and 01/2023, focusing on the impact of clinical characteristics on recurrence. Postoperatively, imaging control via CT or MRI was conducted to detect potential rebleeding. The degree of disability was assessed using the modified Ranking Scale (mRS) and Glasgow Outcome Scale (GOS) at 4 and 8 weeks after the operation, along with overall survival (OS).

### Results

During the observation period (6 months), 16 patients (26.7%) experienced cSDH recurrence. The mean hematoma width for patients with or without recurrence showed no significant statistical difference ($p = 0.95$). The age of patients with recurrence (75.4 years; ± 9.4) did not significantly differ from those without recurrence (75.7 years; ± 10.2). Females exhibited a lower recurrence rate compared to males (1 vs 15; $p = 0.01$). Additionally, patients receiving antiplatelet medication at the initial diagnosis had a higher odds ratio for recurrence (OR 4.5, 95% CI 1.07-18.92, $p = 0.04$). A GCS of 12-14 at diagnosis showed a significantly increased odds ratio for recurrence (OR 5.4, 95% CI 1.27-22.93, $p = 0.02$) compared to a GCS of 15. Recurrence-free survival time did not significantly differ among age groups or hematoma widths. Moreover, 63.7% of patients without recurrence exhibited a favourable mRS of 0 or 1 after 4 weeks compared to 58.3% with recurrence, though without statistical significance ($p = 0.76$). GOS categorization revealed slightly higher adverse outcomes in the recurrence group but lacked statistical significance ($p = 0.65$). Eighth-week measurements hinted at a trend for a favourable outcome post-recurrence.

### Conclusion

Our findings suggest that male gender, the use of antiplatelet agents, and a Glasgow Coma Scale (GCS) score below 15 at the initial diagnosis may potentially predict recurrence development, indicating a complicated course following surgical treatment of cSDH.

# P286

## Ein postoperativer Pneumocephalus erhöht das Risiko für ein Rezidiv nach Entlastung eines chronischen Subduralhämatoms

***Postoperative pneumocephalus is a predictor for recurrence after chronic subdural hematoma***

M. Tahir[1], T. Lampmann[1], H. Asoglu[1], H. Alenezi[1], M. Jaber[1], I. Maiseyeu[1], M. Schneider[1], M. Banat[1], H. Vatter[1], M. Hamed[1]

[1]University Hospital Bonn, Department of Neurosurgery, Bonn, Deutschland

### Objective

Pneumocephalus is defined as the presence of air in the intracranial cavity. This finding is frequently seen following trauma and neurosurgical procedures. Prior studies have shown that there is an association with postoperative pneumocephalus after surgical evacuation of chronic subdural hematoma and recurrence rate, but the volume of air itself was not defined precisely. The aim of this retrospective study was to analyze the effect of the volume of postoperative pneumocephalus on the recurrence of chronic subdural hematoma following surgical evacuation.

### Methods

338 patients underwent surgical evacuation of chronic subdural hematoma at the authors" institution, which were from January 2015 to June 2020. Patient characteristics, postoperative pneumocephalus (air volume in postoperative CT scans) and recurrence rate (defined as necessity for reoperation) were analyzed and collected retrospectively. Data were shown as means ± standard deviation. Unpaired t-test was performed and a statistical significance was assumed when $p<0.05$.

### Results

The analysis included a total of 229 patients. 47 patients (20.5%) suffered from a symptomatic recurrent subdural hematoma that required reoperation. Notably, patients with recurrent subdural hematoma exhibited a significantly greater air volume in postoperative CT scans (25.2 ±26.6 mL vs. 17.6 ±19.8 mL; $p=0.031$) compared to patients without recurrence.

### Conclusion

Postoperative pneumocephalus is a predictive factor for recurrence following surgical evacuation of chronic subdural hematoma. The amount of air correlates with a higher risk of recurrence.

# P287

## *Prognostische Auswirkungen des kognitiven Reserve Index bei Patienten mit subduralen Hämatomen*
## *Prognostic implications of cognitive reserve index in subdural hematoma patients*

D. Januzi[1], J. Hoffmann[1], N. Dinc[1], C. Senft[1], P. Baumgarten[1], M. A. Kamp[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

### Objective

This ongoing study investigates the Cognitive Reserve Index Questionnaire (CRIq) in patients diagnosed with subdural hematomas. The primary objective is to assess whether CRIq scores correlate with postoperative complications, recurrence rates, neurological outcomes, and mortality in individuals undergoing various treatment methods. Additionally, the study explores the impact of demographic and clinical factors, including age, gender, hematoma etiology and volume, on the prognostic value of CRIq.

### Methods

Data is being collected from an ongoing study involving patients treated for subdural hematomas at the Neurosurgery Department of University Hospital Jena between October 2020 and January 2023. Patient information, encompassing demographics, comorbidities, trauma history, symptoms, hematoma characteristics, treatment modalities, complications, and outcomes, is systematically gathered through an SAP-data query. An interview to assess the Cognitive Reserve Index utilizing the CRI questionnaire already validated by Nucci et al. follows with patients who agree to participate in the study. Statistical analyses will be conducted using Prism for Windows 10 (Version 8.4.2, GraphPad Prism).

### Results

Preliminary observations from the ongoing study are anticipated to reveal correlations between CRIq scores and postoperative outcomes in subdural hematoma patients. Additionally, insights into the interplay between demographic and clinical variables and the prognostic value of CRIq will be explored, contributing to a comprehensive understanding of cognitive reserve's role in predicting outcomes in this patient population.

### Conclusion

Our ongoing study aims to uncover the pattern of Cognitive Reserve Index questionnaire in subdural hematoma patients. Similar studies in the neuro-oncological and neuro-vascular patients have previously indicated a potential prognostic value of the CRIq. This investigation aims to shed light on the potential prognostic significance of cognitive reserve in determining complications, recurrence rates, and above all, neurological recovery.

*Both last authors contributed equally to this work.

*Literature:*

Nucci M, Mapelli D, Mondini S. Cognitive Reserve Index questionnaire (CRIq): a new instrument for measuring cognitive reserve. Aging Clin Exp Res. 2012 Jun;24(3):218-26. doi: 10.3275/7800. Epub 2011 Jun 20. PMID: 21691143.

# P288

## Risikofaktoren für eine Vigilanzminderung bei Patienten mit einem unilateralen chronischen Subduralhämatom
*Risk factors for disturbance of consciousness in patients with unilateral chronic subdural hematoma*

A. Liebert[1], L. Ritter[1], T. Eibl[1], T. Bertsch[2], H. H. Steiner[1], K. M. Schebesch[1]

[1]Klinikum Nürnberg, Paracelsus Medizinische Universität, Klink für Neurochirurgie, Nürnberg, Deutschland
[2]Klinikum Nürnberg, Paracelsus Medizinische Universität, Institut für klinische Chemie, Labormedizin und Transfusionsmedizin, Nürnberg, Deutschland

### Objective

Most patients with chronic subdural hematoma (CSH) have mild symptoms, however a significant subset of patients present with disturbance of consciousness (DOC) before surgery. Our study aimed to identify risk factors for DOC in CSH patients.

### Methods

We retrospectively evaluated laboratory (leukocyte and platelet counts, C-reactive protein (CRP), international normalized ratio (INR), partial thromboplastin time (PTT) and hemoglobin value), clinical and radiological parameters of consecutive CSH patients undergoing unilateral burr hole trephination. Co-morbidities and medications, including antiplatelet and anticoagulants, were documented. Maximal hematoma size, midline shift more than 10 mm, radiological type (modified Nakaguchi Classification), presence of fresh blood ("acute on chronic", "acute to chronic"), localization (frontal, parietal, temporal, occipital) were assessed in the preoperative cranial CT scans.

The assessed data were statistically compared between the DOC group and the control group of awake, but symptomatic CSH patients.

### Results

31 patients of 222 patients presented with DOC (n=27 somnolent, n=2 soporous, n=2 comatose). In bivariate analysis, INR and CRP were significantly higher in patients with DOC (p=0.028, p<0.001, resp.), preoperatively. The homogenous hypodense type (p=0.006), "acute on chronic" type (p=0.025), as well as "acute to chronic" type (p=0.002), occipital (p<0.0001) and temporal localization (p=0.002), midline shift > 10 mm (p=0.024) were more common in the DOC group. The trabecular type was less common in the DOC group (p=0.027). In multivariate analysis, the "acute on chronic" (p=0.036) and the "acute to chronic" type (p=0.009), and presence of additional occipital CSH (p=0.001) remained significant.

### Conclusion

According to our study, multiple radiological and laboratory parameters correlated with DOC. Patients with "acute on chronic", "acute to chronic" types, and with additional occipital CSH had the highest rate for DOC, preoperatively.

# P289

## Occipitale Condylenfrakturen - Eine retrospektive Kohortenstudie: Epidemiologie und Outcome

***Traumatic occipital condyle fractures – A retrospective, level one trauma center cohort study: Epidemiology and concomitant injuries***

L. Felger[1], C. M. Jesse[1], R. Schär[1], A. Raabe[1], E. Piechowiak[2], C. Albers[3], M. Deml[3]

[1]Inselspital – Universitätsspital Bern, Universitätsklinik für Neurochirurgie, Bern, Schweiz
[2]Inselspital – Universitätsspital Bern, Universitätsinstitut für Diagnostische und Interventionelle Neuroradiologie, Bern, Schweiz
[3]Inselspital – Universitätsspital Bern, Universitätsklinik für orthopädische Chirurgie und Traumatologie, Bern, Schweiz

### Objective

Traumatic occipital condyle fractures (OCF) are infrequent injuries associated with severely injured trauma patients. The aim of our study was to examine the relevance of OCF in polytraumatic patients and discuss the role of concomitant injuries in these patients.

### Methods

Clinical and radiological data at admission and follow-up was documented by medical chart review after patient selection through query of our radiological database. Descriptive statistics were used to present epidemiological data of 152 patients.

### Results

Female to male ratio was roughly 1:2 and mean age at presentation was 58 years. Mean hospitalization time was 9.8 days. Trauma mechanism was a fall <2 meters in 29% of cases, a fall >2 meters in 25%, a motor vehicle accident (MVA) as a passenger in 9%, a MVA as a pedestrian in 5%, a bicycle accident (<40 km/h) in 18% and a scooter, ski or motorbike accident (>40km/h) in 14% of cases.

14% of OCF were classified as Anderson and Montesano type 1, 37% as type 2 and 49% as type 3.

60% of patients were diagnosed with concomitant intracranial injuries, 14% of patients had associated fractures of the upper cervical spine and 34% had concomitant fractures of the remaining spine. Spinal cord injury or compression was observed in 8% of patients, however never at the level of the OCF. 28% of patients had concomitant injuries of the thorax, abdomen, extremities and/or pelvis

9.2% of patients showed focal neurological deficits and 65% presented with a reduced mental state.

### Conclusion

Epidemiology of OCF in our study was comparable to smaller published cohorts. OCF may be seen as markers for severe trauma; however, their stand-alone role and influence on initial neurological impairment is not clear in view of more severe concomitant injuries and must be further investigated.

# Trauma und Neurointensiv - Verschiedenes 1 | Trauma

## P290

### Occipitale Condylenfrakturen – Eine retrospektive Kohortenstudie: Therapie und Follow-Up

***Traumatic occipital condyle fractures – A retrospective, level-one trauma center cohort study: Treatment and outcome***

L. Felger[1], C. M. Jesse[1], R. Schär[1], A. Raabe[1], E. Piechowiak[2], M. Deml[3], C. Albers[3]

[1]Inselspital – Universitätsspital Bern, Universitätsklinik für Neurochirurgie, Bern, Schweiz
[2]Inselspital – Universitätsspital Bern, Universitätsinstitut für Diagnostische und Interventionelle Neuroradiologie, Bern, Schweiz
[3]Inselspital – Universitätsspital Bern, Universitätsklinik für orthopädische Chirurgie und Traumatologie, Bern, Schweiz

#### Objective

Traumatic occipital condyle fractures (OCF) are infrequent injuries associated with severely injured trauma patients. High-level evidence for treatment is lacking. The aim of our study was to examine treatment modalities and outcome within a large cohort.

#### Methods

After retrospective patient selection from our radiological database within a 10-year period, fracture type, treatment modality as well as clinical features at admission and follow-up were documented by medical chart review. Descriptive and bivariate statistics were used to define cohort variables and check for associations. Data of 152 patients were included in our analysis. Mean follow-up was 6 weeks.

#### Results

43% of patients were treated using a semi rigid collar with lower jaw inclusion, 3.3% received surgical treatment (1.5% Halo fixation and 1.8% internal fixation.) 12% of cases received a soft collar and 40.8% did not receive documented treatment. All patients treated surgically had associated upper cervical spine fractures. We observed no spinal cord injury at the occipitocervical junction.

Anderson and Montesano Type II fractures were left untreated significantly more often than other fracture types. No Type II fracture was treated surgically.

At follow-up 41% of patients with initial focal neurological deficits had no neurological deficits and 55.7% of patients with neck pain at admission were pain free.

Follow-up imaging was conventional radiography in 63% of cases whereby OCF could not be clearly delineated in 76% of cases. Secondary dislocation was observed in 0.8% of cases.

#### Conclusion

A clear statement on OCF treatment and neurological outcome cannot be made, as neurological impairment was more likely due to concomitant injuries rather than C0 injury.

Our study shows that not all fracture types are treated equally despite clear recommendations. Further investigation into fracture stability must therefor be made if one fracture type is disadvantaged therapeutically. Plain radiography as a follow up imaging must be reevaluated as fractures are seldom identified in this imaging technique.

# P291

## *Das Volumen von traumatischen intraventrikulären Blutungen korreliert nicht mit der Entwicklung eines posttraumatischen Hydrozephalus*
## *The volume of traumatic intraventricular hematoma does not correlate with the development of post-traumatic hydrocephalus*

S. M. Fernandes Romualdo[1], M. Dengl[1], M. G. Prem[1], I. Y. Eyüpoglu[1], G. Schackert[1], T. Juratli[1], K. H. Sitoci-Ficici[1]

[1]Universitätsklinikum Carl Gustav Carus Dresden, Neurochirurgie, Dresden, Deutschland

### Objective

Severe traumatic brain injury (TBI) is a devastating condition, and a post-traumatic hydrocephalus (PTH) worsens the outcome further. Previous studies have explored the impact of intraventricular hemorrhage (IVH) on the development of PTH. Our group previously investigated whether the prevalence of IVH in TBI patients has any effect on development of a PTH but found no statistical significance. In this study, we hypothesized that the volume of IVH might indeed influence the likelihood of developing PTH.

### Methods

We utilized the existing patient database of our department, which includes all patients who underwent decompressive craniectomy (DC) for traumatic brain injury (TBI) from 2008 to 2019 and had complete data sets. We focused on the subgroup with IVH, evident in either initial or follow-up cranial CT scans. IVH volumes were calculated via manual segmentation using BrainLab® software, with the highest recorded values analysed. Patients were categorized into two groups: those who did not develop PTH requiring shunt implantation (Non-Shunt group) and those who did (Shunt group).

### Results

The study comprised 126 patients (93 males, 33 females) with a median age of 53 years (range: 18-84 years). The Shunt group included 34 patients (27%). Of all patients, 28 (22.2%) exhibited IVH. The Non-Shunt group had a median IVH volume of 1.65 $cm^3$, an average of 5.05 $cm^3$, and an interquartile range (IQR) of 2.54 $cm^3$. In the Shunt group, these values were a median of 1.46 $cm^3$, an average of 9.05 $cm^3$, and an IQR of 13.62 $cm^3$. The Mann-Whitney U test yielded a non-significant p-value of 0.817. Further analysis using a 6 $cm^3$ volume cut-off and the Fisher exact test also showed a non-significant p-value of 0.269.

### Conclusion

Our study found no significant correlation between IVH volume and the development of PTH in patients undergoing DC following TBI. These findings suggest that the presence, independent of its volume, alone may not be a reliable predictor for the development of PTH in this patient population.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P292

### Vitamin-D-Plasma-Spiegel von kritisch kranken Patienten mit subarachnoidaler- oder anderweitiger intrakranieller Blutung
*Vitamin-D-plasma-levels in patients with subarachnoid and intracranial hemorrhage*

C. Stephani[1]

[1]Universitätsmedizin Göttingen, Anästhesiologie, Göttingen, Deutschland

### Objective

Vitamin-D-deficiency is a common finding in critically ill patients and often is associated with poorer outcomes. Few data are available regarding the Vitamin-D-plasma-levels of patients with acute-onset hemorrhagic intracranial pathology.

### Methods

We prospectively measured vitamin-D-plasma-levels in patients who had been admitted due to a subarachnoid hemorrhage or an intracranial bleeding to the operative intensive care unit of the University Medical Center Göttingen. Blood samples were taken within 48 hours after admission and twice a week thereafter. Informed consent was obtained from the patients' legal representatives.

### Results

Between May 2020 and November 2021, we collected blood samples from 28 patients (12 male, average age 58.4 ± 15.2). The median Vitamin-D-levels on day one, four, seven, ten, and fourteen were 11, 14, 16, 16, and 17 µg/l, respectively (Figure 1). At day one, 71.5% of all patients had a subnormal Vitamin-D-plasma-level (with a lower limit of the normal range of 20 µg/l). Applying the non-parametric Median-test ($p = 0.11$, $p = 0.24$; $p = 0.41$; $p = 0.37$; $p = 1$ for the first 5 measurements, respectively) there were no significant differences between the Vitamin-D-plasma-levels between the 9 patients with intracranial bleedings and the 19 patients with subarachnoid hemorrhage.

### Conclusion

The prevalence of vitamin-D-deficiency in this cohort of neurosurgical patients resembled that of more general populations of critically ill patients (Zajic and Amrein 2014). Furthermore, no significant differences were found between the cohort of patients with subarachnoid and the one with other intracranial hemorrhage. Despite these and similar results of others (Alvarado Reyes et al. 2016) it may be wothwhile to evaluate if Vitamin-D, which largely regulates Calcium-homeostasis and sensitivity, is of any relevance for the course of subarachnoid hemorrhage in a larger cohort.

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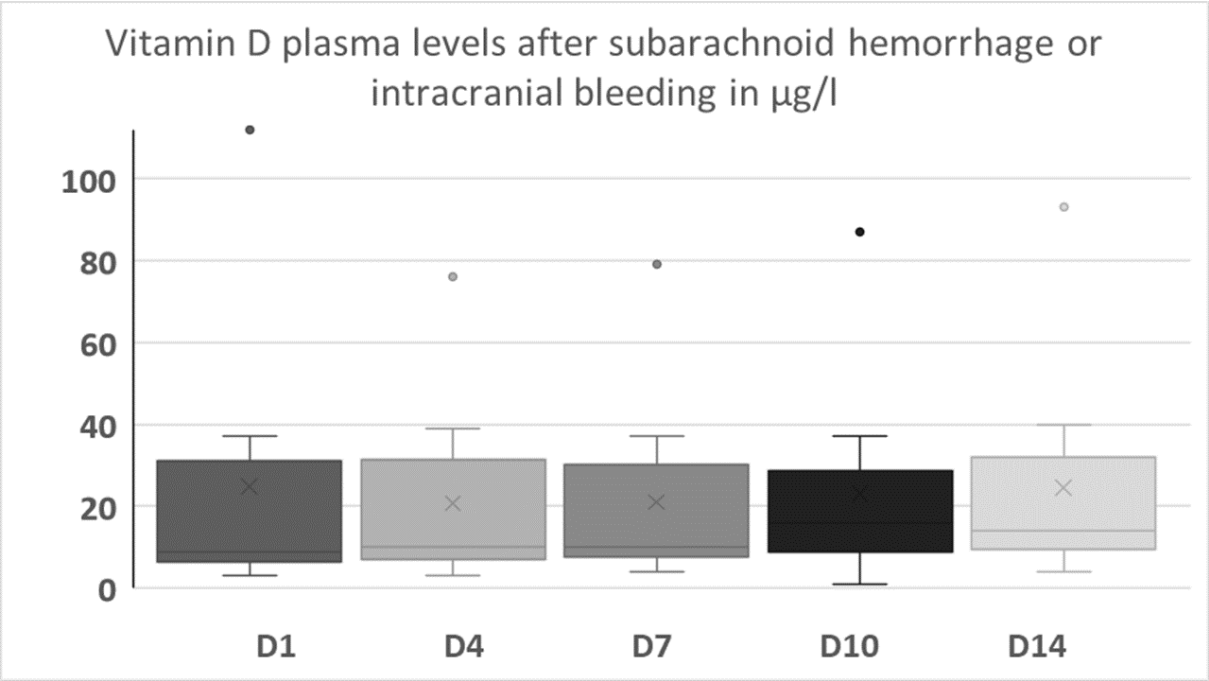
Abb. 1


Vitamin D plasma levels after subarachnoid hemorrhage or intracranial bleeding in µg/l
100
80
60
40
20
0
D1
D4
D7
D10
D14

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P293

### Vitamin-D-Mangel bei Patienten mit aneurysmatischer Subarachnoidalblutung und Schädel-Hirn-Trauma in deutschen Krankenhäusern

***Vitamin D deficiency in German hospital patients with aneurysmal subarachnoid hemorrhage and traumatic brain injury***

A. Mirbagheri[1], N. Etminan[1], G. Rinkel[1,2]

[1]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland
[2]UMC Utrecht, Neurology, Utrecht, Niederlande

#### Objective

Inflammatory processes lead to the development and rupture of intracranial aneurysms. Vitamin D has shown to attenuate neuroinflammation. The aim of this study was to assess the prevalence of vitamin D deficiency in hospitalized German patients with aneurysmal subarachnoid hemorrhage (aSAH) vs. a control group consisting of patients with traumatic brain injury (TBI).

#### Methods

We included patients diagnosed with aSAH (ICD-10 I60) and TBI (ICD-10 S06). Data about vitamin D deficiency (ICD-10 E55) in both disease groups were collected. In a subgroup analysis, we distinguished between children and adolescents (<20 years), adults and elderly (>65 years). Data were obtained from the German Federal Statistical Office (DeStatis) and covered all hospitalized and discharged patients with the respective diagnoses in Germany during the time period between January 1st and December 31st, 2022.

#### Results

16,835 aSAH patients and 309,598 TBI patients were admitted in the one-year study period. The prevalence of Vitamin D deficiency was 2.07 % in aSAH patients vs. 1.23 % in TBI patients (OR=1.70, confidence intervals(CI)=1.52-1.90). There was a female preponderance in aSAH (1:1.2 = M:W) vs. TBI (1.1:1 = M:W). More aSAH cases occurred in adults (p=0.04) and elderly (p=0.0004) than in children; more TBI cases were seen in children (p=0.03) and elderly (p=0.0006) than in adults. The prevalence of Vitamin D deficiency in children was 0% in aSAH vs. 0.04 % in TBI (Haldane-corrected OR≈11.97, CI≈0.73-197.03), in adults 1.3 % in aSAH vs. 0.29% in TBI (OR=4.47, CI=3.43-5.81) and in elderly 2.4% in aSAH vs. 2.19% in TBI (OR=1.10, CI=0.97-1.25), respectively.

#### Conclusion

The prevalence of Vitamin D deficiency was distinctly higher in aSAH than TBI patients, especially in adult and elderly subgroups. Future studies with adjusted analysis for known vascular risk factors such as smoking and arterial hypertension are necessary to further investigate this effect and assess potential benefits of nutritional supplementation.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P294

### Der Nutzen von Troponin I zur Prädiktion des Auftretens von Vasospasmen in der transkraniellen Dopplersonographie bei Patienten mit nicht-traumatischer Subarachnoidalblutung

***Troponin I as a predictor of transcranial doppler sonography defined vasospasm in intensive care unit patients after non-traumatic subarachnoid hemorrhage***

S. Tajmiri-Gondai[1], M. Bender[1], M. Stein[1], K. Haferkorn[1], H. Voigtmann[1], E. Uhl[1]

[1]Universitätskliniken Gießen und Marburg, Neurochirurgie, Gießen, Deutschland

#### Objective

Elevation of Troponin I (TnI) in non-traumatic subarachnoid hemorrhage (ntSAH) patients is a well-known phenomenon and associated with cardiopulmonary complications and poor outcome. However, the use of TnI upon admission to predict the occurrence of cerebral vasospasm is discussed controversially. The current study was conducted to investigate the impact of the initial TnI value at admission on the occurrence of cerebral vasospam in ntSAH patients.

#### Methods

A total of 142 ntSAH-patients, who were admitted to the neurosurgical intensive care unit (ICU) between December 2014 and January 2021 were retrospectively evaluated. Blood samples were drawn at admission to determine TnI value. Each patient's demographic, radiological, medical data, and continuous measurements of transcranial Doppler sonography were analyzed. A maximum mean flow velocity (MMFV) >120 cm/sec was defined as any vasospasm. These were stratified into severe vasospasms, which were defined as at least two measurements of MMFVs >200 cm/sec or an increase of MMFV >50 cm/sec/24 hours over two consecutive days or a new neurological deterioration and mild vasospasm defined as MMFVs >120 cm/sec in absence of severe vasospasm criteria. The total study population was dichotomized into patients with an initial elevated TnI and without elevated TnI upon admission.

#### Results

Elevated TnI level upon admission was found in 52 patients (36.6%), which was significantly associated with lower GCS score ($p<0.001$), higher WFNS score ($p<0.001$) and higher Fisher grade ($p=0.01$) at admission as well as a higher rate of ischemic brain lesions ($p=0.02$), higher modified Rankin Scale score ($p>0.001$) and increased mortality ($p=0.02$) at discharge. In addition, TnI was identified as an independent predictor for the occurrence of any vasospasm OR:5.55, CI:1.77-17.41, $p=0.003$) and severe vasospasm (OR:3.3, CI: 1.1-9.95, $p=0.034$) in a binary logistic analysis.

#### Conclusion

An initially elevated TnI level is an independent predictor for the occurrence of any and severe vasospasm in ICU-admitted ntSAH patients, so that TnI seems to be a helpful serum biomarker to improve ICU treatment.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P295

### Die Rolle von Vitamin D für die Inzidenz und Mortalität nach aneurysmatischer Subarachnoidalblutung
*The role of Vitamin D for incidence of and mortality after aneurysmal subarachnoid hemorrhage*

A. Mirbagheri[1], S. Hetjens[2], J. Kanning[3], K. Rannikmäe[4], N. Etminan[1], Y. Ruigrok[3], G. Rinkel[1,3]

[1]Universitätsmedizin Mannheim, Neurochirurgie, Mannheim, Deutschland
[2]Universitätsmedizin Mannheim, Medizinische Statistik, Biomathematik und Informationsverarbeitung, Mannheim, Deutschland
[3]UMC Utrecht, Neurology, Utrecht, Niederlande
[4]University of Edinburgh, Centre for Medical Informatics, Usher Institute of Population Health Sciences and Informatics, Edinburgh, Vereinigtes Königreich

### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) has been described as an inflammatory disease. Vitamin D has systemic anti-inflammatory properties and may therefore reduce the risk of development and rupture of intracranial aneurysms (IA). We aimed to investigate the association between vitamin D and the incidence and mortality after aneurysmal subarachnoid hemorrhage (aSAH) using the UK Biobank.

### Methods

We retrieved data from the UK Biobank, a prospective population-based cohort study of 502,411 participants, initiated in 2006. Serum 25-hydroxyvitamin D [25(OH)D] levels were analyzed between participants with ruptured IA and the general population. 25(OH)D levels were classified as sufficient (> 50nmol/L), deficient (<50nmol/L) and severely deficient (<30nmol/L). Multivariate logistic regression analysis and Cox regression were performed and adjusted for demographic characteristics and vascular risk factors.

### Results

During the 16-year follow-up period (April 2006 - May 2022), 1,447 aSAH were reported. Compared to the general population, aSAH patients had a female preponderance (60.23% vs. 51.71%, p<0.0001) with a higher prevalence of smoking (67.09% vs 60.40%, p<0.0001) and higher systolic blood pressure (142.7 mmHg vs. 140mmHg, p<0.0001). Participants with vitamin D deficiency (<50nmol/L), had a higher incidence of SAH than participants with sufficient 25(OH)D levels (> 50nmol/L; odds ratio (OR) 1.448, confidence intervals (CI) 1.036 – 2.2026, p=0.0303). This association was more pronounced in patients with severe vitamin D deficiency vs. sufficient 25(OH)D levels (OR = 2.052, CI = 1.278 – 3.294, p=0.0029). Vitamin D insufficiency (hazard ratio (HR) 0.940, CI 0.638 – 1.386, p=0.7534) or severe vitamin D insufficiency (HR 0.982, CI 0.565 – 1.815, p=0.9517) were not predictive for mortality after aSAH.

### Conclusion

Individuals with vitamin D deficiency and severe vitamin D deficiency have a higher risk of aSAH than those with sufficient vitamin D levels, but vitamin D deficiency did not influence mortality outcome after aSAH. Future studies might investigate potential benefits of Vitamin D supplementation in preventing rupture in IA.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P296

### Die alkalische Phosphatase als prädiktiver Faktor des Vasospasmus in der aneurysmatischen Subarachnoidalblutung.
*Alkaline phosphatase as a predictive factor for vasospasm in aneurysmal subarachnoid hemorrhage*

M. Bauer[1], K. Penn[1], A. Krigers[1], C. Thomé[1], C. Freyschlag[1]

[1]Medizinische Universität Innsbruck, Klinik für Neurochirurgie, Innsbruck, Österreich

#### Objective

The consequences of aneurysmal subarachnoid hemorrhage (aSAH) are severe, with one of the main complications being cerebral vasospasm (VS), leading to reduced blood supply. Timely recognition or even preventive interventions are crucial, as prompt treatment of these issues might potentially improve outcomes.

#### Methods

A retrospective data collection was conducted on patients in the neurosurgical intensive care unit. Included were all patients with aSAH and an intubation duration of at least 3 days.

#### Results

A total of 140 patients were included in the data analysis. 87 (62.1%) were female. The mean age was 55 years (CI95 52.7 – 56.7), and the mean intubation duration was 20.5 days (CI95 17.2 – 23.7). Vasospasm was detected in 68% of patients, with 43% of them requiring intervention.

An increase in alkaline phosphatase (ALP) on day 6 after the event compared to the previous day was associated with an increased likelihood of vasospasm ($p = 0.016$). In the ROC analysis, the ALP increase of 16 IU/L was confirmed as the cutoff (AUC = 0.649, sensitivity 0.426, specificity 0.879, $p = 0.01$).

#### Conclusion

ALP has previously been identified as a potential marker for inflammation and oxidative stress in critically ill patients. Our analysis demonstrated the association between ALP and vasospasm and can be used as a predictive factor for early detection of vasospasm.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P297

### Analyse der inner- und außerklinischen Mortalität nach aneurysmatischer Subarachnoidalblutung: Ein Ansatz zur Optimierung der neuro-intensiven Versorgung?

***Analyzing in- and out-of-hospital mortality following aneurysmal subarachnoid hemorrhage: Means to optimize neuro-intensive care?***

S. Odensass[1], M. Gümüs[1], M. Said[2], J. Rodemerk[1], M. Darkwah Oppong[1], Y. Li[3], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland
[2]Evangelisches Krankenhaus Oldenburg, Unisversitätsklinik für Neurochirurgie, Oldenburg, Deutschland
[3]Universitätsklinikum Essen, Institut für diagnostische und interventionelle Radiologie und Neuroradiologie, Essen, Deutschland

#### Objective

Despite recent advances in neuro-intensive care, there is still considerable mortality in patients with aneurysmal subarachnoid hemorrhage (SAH). In this long-term monocentric observational cohort study, we aimed to analyze the rates, timing, and predictors of mortality after SAH.

#### Methods

All consecutive SAH cases treated between January 2003 and June 2016 were included. Patients' demographic characteristics, previous medical history, SAH-related parameters, as well as available post-treatment follow-up data were collected and evaluated as potential mortality predictors in univariate and multivariate analyses.

#### Results

Of 992 patients, 179 died during the initial treatment and 33 during the follow-up time reaching an overall mortality rate of 21.4%. Of over 119 tested variables, we identified the following independent predictors in the final multivariate Cox regression analysis: age >55 years ($p < 0.0001$); WFNS admission grade IV or V ($p = 0.025$); Hijdra sum score ≥15 points ($p = 0.003$); intracranial pressure (ICP) increase ($p < 0.0001$); and delayed cerebral ischemia (DCI) ($p < 0.0001$). Being exposed to all five risk factors resulted in the case fatality rate of 75% within a median survival of 14 days, compared to 2.5% within a median of 1525 days when none of these features were present.

#### Conclusion

The initial impact of aneurysmal bleeding is amongst the major causes of mortality after SAH. Of potentially preventable adverse events, ICP increase and DCI occurring during initial treatment also present eminent clinical relevance for patients' survival in the long-term follow-up. Further optimization of ICP and DCI management might help to decrease the mortality rate after SAH.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P298

### Häufigkeit von Epilepsie nach aneurysmatischer Subarachnoidalblutung und deren Effekt auf das Outcome

***Characteristics and frequency of epilepsy in patients suffering from aneurysmal subarachnoid hemorrhage and the effect on outcome***

T. Lampmann[1], H. Asoglu[1], H. Alenezi[1], M. Tahir[1], M. Jaber[1], H. Vatter[1], M. Hamed[1]

[1]University Hospital Bonn, Department of Neurosurgery, Bonn, Deutschland

#### Objective

Many patients suffering from aneurysmal subarachnoid hemorrhage (SAH) suffer from seizure. The recent guidelines do not recommend routine administration of antiepileptic drugs (AED). We performed a retrospective single-center study to analyze the effect of AEDs on the outcome in patients suffering from epilepsy after SAH.

#### Methods

790 patients with SAH treated between 01/2006 and 12/2017 were analyzed. Patients were divided into good grade (WFNS grades I-II) versus poor grade (WFNS grades III-V) on admission. Data of patients" history as well as clinical course were collected. Outcome according to the modified Rankin scale (mRS) score was assessed at 6 months after ictus. Outcome was dichotomized into favorable (mRS 0-2) and unfavorable (mRS 3-6). Univariate and multivariate analyses were performed.

#### Results

347 (43.9%) patients suffered from poor grade SAH and 353 (45.2%) patients achieved unfavorable outcome. 78 (9.9%) patients were discharged with AED, but 97 (12.5%) patients had to take AED 3 months after SAH. Seizures and AED intake after 3 months was more often in patients with unfavorable outcome (15.9% vs. 6.2%; $p<0.001$ and 16.7% vs. 9.0%; $p=0.001$, respectively).

In multivariate analysis, poor grade SAH ($p<0.001$, OR 12, 95% CI 8.4–17.1) and seizures after 3 months ($p<0.001$, OR 12.1, 95% CI 3.0–48.0) were predictors for unfavorable outcome, whereas AED intake after 3 months ($p=0.017$, OR 0.21, 95% CI 0.06–0.76) was predictor for favorable outcome.

#### Conclusion

Enduring epilepsy in patients suffering from SAH deteriorates outcome. Prolonged AED intake may be protective in SAH patients.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P299

### Antagonisierung von Antikoagulation und thrombotische Ereignisse bei Patienten mit intrakranieller Blutung und Herzklappenprothesen

***Anticoagulation reversal and thrombotic events in patients with intracranial hemorrhage and prosthetic heart valves***

C. Franke[1], M. Vychopen[1], E. Güresir[1], F. Wilhelmy[1]

[1]Universitätsklinikum Leipzig, Klinik mit Poliklinik für Neurochirurgie, Leipzig, Deutschland

#### Objective

Patients with prosthetic heart valves usually require anticoagulation (AC) and/or antiplatelet therapy to prevent thromboembolic events. After suffering from an intracranial hemorrhage AC reversal and suspension of antithrombotic therapy in these patients must be considered, since a potentially fatal hemorrhage progression is at stake. The safety of AC reversal regarding consecutive thromboembolic events and prosthetic heart valve thrombosis remains unclear due to limited data. This retrospective cohort study aims to contribute to decision-making in this particular patient cohort regarding antithrombotic management and complications of reversal therapy.

#### Methods

An institutional retrospective cohort study was conducted to investigate thrombotic events in patients with prosthetic heart valves after intracranial hemorrhage during acute hospitalisation. We searched for patients treated in our clinic between 2010 and 2023 with the combined diagnoses of prosthetic heart valves and intracranial hemorrhage in general (traumatic or non-traumatic subarachnoid, intraventricular, subdural, and intracerebral hemorrhage). Overall, 28 patients were included. We reviewed the electronic medical records and the correlation between thrombotic events and AC reversal as well as time of pause.

#### Results

22 of the included patients had an aortic valve prothesis (6 mechanical and 16 biological), 5 patients had a mitral valve prothesis (2 mechanical and 3 biological), while 1 patient had both an aortic and a mitral valve bioprothesis. After reversal, therapeutic AC medication was discontinued for 24 days (mean). None of the patients suffered a recorded thromboembolic event or prosthetic heart valve thrombosis. We did not find any correlation between the duration of halting antithrombotic therapy and outcome. Comparing patients receiving prophylactic AC within 24 hours and after 24 hours, we found no significant correlation between duration of pause and outcome.

#### Conclusion

Reversal of AC and suspension of antithrombotic therapy was not associated with higher rates of thrombotic events in patients with prosthetic heart valves and intracranial haemorrhage during acute intensive care treatment in the present cohort. Our data suggests that this patient cohort can be treated according to standards applying to patients without prosthetic heart valves.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P300

### Antikoagulationsumkehr bei LVAD und ICH – Retrospektive Analyse und vergleichende Meta-Analyse

***Anticoagulation reversal in left ventricular devices and ICH – Retrospective analysis and comparative meta-analysis***

M. Vychopen[1], L. Zima[2], W. Tim[1], J. Wach[1], B. Börge[1], D. Lindner[1], E. Güresir[1], F. Wilhelmy[1]

[1]Universitätsklinikum Leipzig, Neurochirurgie, Leipzig, Deutschland
[2]University of Texas Health Science Center, Neurosurgery, Houston, TX, Vereinigte Staaten

#### Objective

Left Ventricular Assist Devices (LVAD) remain a definitive treatment option for patients suffering from terminal heart failure. Due to the necessary antithrombotic medication, these patients are prone to bleeding complications, such as intracranial hemorrhage (ICH). The management of these rare cases remains a challenge. Due to the acute setting and the rarity of cases, prospective data is not to be expected. In this retrospective study we investigated 39 cases of ICH during LVAD-therapy, to contribute to the existing data and add new insights regarding antithrombotic management in our facility.

#### Methods

We searched our electronic archive for patients with the combined diagnoses of implanted support devices and ICH. 39 patients where included. We collected biographic, medical and procedural data as well as course of treatment, medication and selective outcomes. Primary outcomes were death within 30 day, overall survival and neurological state at the time of discharge. Furthermore, we performed comparative meta-analysis of correlation between PCC-substitution, surgery and mortality.

#### Results

The application of 4-factor prothrombin complex concentrate (4F-PCC) at the time of ICH diagnosis showed a significant protective effect regarding overall survival ($p=0.007$, Risk assessment 3.0, CI 95% 1.2 – 7.4). Anticoagulation reversal and suspension of antithrombotic agents neither lead to thrombotic events nor pump failures. Anticoagulation-free interval was also significantly associated with lower mortality without higher risk of thrombotic events ($p = 0.03$, OR 1.23-3.47). We further identified risk factors for poor outcomes, such as bleeding volume ($p=0.012$) or high ICH-grade ($p<0.001$). In multivariate regression analysis of univariate significant factors, only ICH-grade ($p = 0.07$, 95%CI 1.65-25, OR 6.4) and PCC substitution ($p=0.017$, 95%CI 0.01 – 0.47, OR 0.16) showed a significant association with higher resp. lower mortality rates. The meta-analysis conducted on correlation between mortality and PCC substitution and mortality and the need for surgical therapy showed no significant results.

#### Conclusion

In our study, the application of 4F-PCC in said cases highly increased overall survival. Despite the strong correlation between substitution and mortality, the positive effect of 4F-PCC substitution on survival could not be demonstrated in the meta-analysis.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P301

***Kognitive Reserve Index in Patienten mit einer subarachnoidalen Blutung***
***Cognitive reserve index in patients with subarachnoid hemorrhage***

D. Januzi[1], E. Secen[1], P. Baumgarten[1], C. Senft[1], M. A. Kamp[1], N. Dinc[1]

[1]Universitätsklinikum Jena, Klinik für Neurochirurgie, Jena, Deutschland

### Objective

The objective of our study was to assess whether evaluating the cognitive reserve index in combination with cognitive testing and volumetric measurements holds predictive value for their prognosis in patients with subarachnoid hemorrhage.

### Methods

In this ongoing study, we are enrolling individuals with subarachnoid hemorrhage, with or without associated aneurysms. Patients who choose to participate undergo an interview to evaluate the Cognitive Reserve Index (CRI) score (Nucci et al.), cognitive tests administered in the German language ('multiple-choice vocabulary intelligence test' and 'number connection test') to assess pre-morbidity cognitive function, and if the case its declination, and volumetric brain substance measurements.To ensure the validity of our findings, we have excluded patients who do not speak German as their native language, patients with depression (assessed using HADS-D), and those with writing or speech disabilities. Statistical analyses are conducted using Prism for Windows 10 (Version 8.4.2).

### Results

Our participant cohort comprises 32 individuals diagnosed with subarachnoid hemorrhage (SAH) since April 2023. Among them, 5 refused to participate, 10 individuals were omitted, leaving us with our Cohort of 17 patients. Of these, 8 (47.05%) presented with SAH accompanied by associated aneurysms, 6 (35.29%) exhibited incidental aneurysms, and 3 individuals (17.64%) manifested spontaneous subarachnoid hemorrhage. The median age of the participants was 60.25 ± 11,32 years. In terms of gender distribution, 15 participants (8.56%) were female and 2 (30.43%) male. Regarding the treatment modalities employed, 8 individuals (47.05%) underwent clipping, 6 individuals (11.76%) underwent coiling, and 7 individuals (41.17%) received conservative management. We found no statistical significance between different treatment modalities (namely incidental SABs with or without treatment and SABs with or without aneurysms) or gender. We observed an upward tendency in adult and elderly patients, though without statistical significance There was however a statistically significant increase in cognitive reserve in patients with children ($p = 0.0178$).

### Conclusion

The Cognitive Reserve Index (CRI) shows promise in assessing cognitive reserve for neurovascular patients. Ongoing data collection, including cognitive assessments and volumetric analyses, aims to determine its effectiveness in assessing patient prognosis.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P302

### Liquor-Biomarker nach aneurysmatischer Subarachnoidalblutung
*CSF Biomarkerpanel in aneursmal subarachnoid hemorrhage*

A. Pfnür[1], M. Huber-Lang[2], P. Broer[3], H. Tumani[4], L. Dörfer[2], T. Kapapa[1]

[1]Universitätsklinikum Ulm, Klinik für Neurochirurgie, Ulm, Deutschland
[2]Institut für klinische und experimentelle Trauma-Immunologie, Ulm, Deutschland
[3]Krankenhaus Winterthur, Klinik für Intensivmedizin, Winterthur, Deutschland
[4]Universitätsklinikum Ulm, Klinik für Neurologie, Ulm, Deutschland

#### Objective

There are pathophysiological processes of early brain damage with endothelial dysfunction and neuroinflammation, the intermediate injury phase with dysfunction of the blood-brain barrier, and cellular changes in the delayed injury phase after aneurysmal subarachnoid haemorrhage (SAH). There is currently a scientific effort to identify metabolism or cellular markers that enable prediction of the further clinical course and complications. The objective is to identify biomarkers with value for predicting vasospasm or DCI in outcome.

#### Methods

A prospective, two-center, observational clinical study, including consecutively treated Patients for SAH from 2008 to 2015. Five to 10 ml CSF as well as peripheral blood (PB) were collected daily for 11 days. The primary endpoint is the angiographic evidence of vasospasm or delayed cerebral ischemia (DCI). The secondary endpoint is the clinical outcome after 12 months. In this approach a panel of biomarkers was selected: Ig G, Ig M, Claudin-5, TREM-1, and TREM-2 as well as IL-10.

#### Results

12 patients were included (mean age 57 (SD:13) years, 8(67%) women). The majority had an anterior communicating artery aneurysm (N=5, 42%), had WFNS grade V (N=6, 50%), and a modified Fisher grade IV (N=7, 58%). Vasospasm was detected angiographically in 5 (42%) patients and DCI in 6 (50%) patients. TREM-1 and TREM-2 as well as Claudin-5 revealed specific courses after SAH in comparison to IL-10, S-100ß and IgM as well as IgG in CSF. There are different concentrations for TREM-1 and TREM-2 between patients with and without DCI.

#### Conclusion

Due to the small number of patients, it was difficult to calculate significant differences. Nevertheless, the concentration curves in CSF and PB show a certain specificity for claudin-5, TREM-1, and TREM-2 after SAH. The predictive power of these biomarkers should be tested in a larger prospective patient population.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P303

### Dekompressive Hemikraniektomie nach spontaner Subarachnoidalblutung - Erfahrungen aus einem klinischen Zentrum

***Decompressive hemicraniectomy after spontaneous subarachnoid hemorrhage – A single center experience***

D. Scurtu[1], D. Kalasauskas[1], F. Ringel[1], A. Neulen[1]

[1]Universitätsmedizin Mainz, Neurochirurgische Klinik und Poliklinik, Mainz, Deutschland

#### Objective

Decompressive hemicraniectomy can prevent herniation in patients with critically elevated intracranial pressure (ICP), and is thought to have neuroprotective effects by reducing ICP and improving cerebral perfusion. The aim of this study was to analyze outcome in patients with spontaneous subarachnoid hemorrhage (SAH) who underwent hemicraniectomy, and to determine factors associated with outcome.

#### Methods

We performed a retrospective single center study, including all SAH patients admitted to our neurosurgical ICU from 2011 - 2021 who underwent decompressive hemicraniectomy. Outcome was determined at 6 months post-SAH using the mRS score. We performed an explorative analysis of our data. Association of age, sex, location of aneurysm, DCI-associated infarctions, cardiopulmonary resuscitation (CPR), Hunt&Hess (H&H), Fisher and WFNS scores with bad outcome (modified Rankin Scale (mRS) ≥4) at 6 months and mortality were evaluated using Chi-Squared test as well as univariate and multivariate logistic regression analysis. $P<0.05$ was considered as statistically significant.

#### Results

39 patients were included (mean age 53.7 (SD 10.6) years, 69% female). After 6 months, 5 (13%) patients achieved good outcome (mRS 0-3), mortality was 36% (14 patients). Although the study was substantially underpowered, we found that WFNS Score (Odds ratio (OR) 3.25 (95% CI 1.14-9.27)), and H&H Score (OR 3.43 (95% CI 1.46-8.07)) were associated with bad outcome in univariate analysis. There was a trend for association with Fisher score (OR 7.00 (95% CI 0.95-51.45)). Of these 3 factors, only WFNS score (OR 3.25 (95% CI 1.14-9.27)) remained statistically significant in multivariate analysis.

Mortality was associated with out-of-hospital cardiac arrest with ROSC after CPR (OR 6.39 (95% CI 1.04-39.11). There was a trend for association with Hunt&Hess score (OR 2.32 (95% CI 0.97-5.55). None of these factors remained significant in the multivariate analysis.

#### Conclusion

SAH with critically elevated ICP requiring decompressive hemicraniectomy is a serious condition. Rates of mortality and unfavorable outcome remain high. However, 13% of the patients in our cohort achieved good outcome after life-saving hemicraniectomy. More studies are needed to identify risk factors for good and unfavorable outcome, and to improve neuroprotective therapy after SAH.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P304

***Deep Immunophenotyping deckt Depletion von entzündungshemmenden T-Helfer-Typ-2-Zellen (Th2) auf und verbindet den Verlust von alternativ aktivierten Monozyten (M2) mit Vasospasmus und Delayed Cerebral Ischemia nach aneurysmatischer Subarachnoidalblutung***
***Deep immunophenotyping unveils depletion of anti-inflammatory T-helper type-2 cells (Th2) and links loss of alternatively activated monocytes (M2) to vasospasm and delayed cerebral ischemia following aneurysmal subarachnoid hemorrhage***

B. B. Hofmann[1], D. Khan[1], I. Fischer[1], J. F. Cornelius[1], D. Hänggi[2], S. Muhammad[1]

[1]Medical Faculty & University Hospital Düsseldorf, Heinrich Heine University Düsseldorf, Department of Neurosurgery, Düsseldorf, Deutschland
[2]International Neuroscience Institute, Department of Neurosurgery, Hannover, Deutschland

### Objective

A sterile inflammatory response initiated immediately after aneurysmal subarachnoid haemorrhage (aSAH) heavily contributes to post-aSAH complications and clinical outcomes. Circulating immune cells, particularly monocytes and T cells, depending on their polarisation form and activation status, hereby play a decisive role. The exact dynamic of subgroup polarisation and their role after aSAH is unclear. Therefore, this prospective and controlled study investigated monocyte and T-cell polarisation after aSAH to explore dynamic changes over the course of aSAH and their association with post-SAH complications and clinical outcomes.

### Methods

We conducted a prospective observational cohort study involving 75 patients with aSAH. Twenty healthy controls were enrolled for this study. Deep immunophenotyping of T-cells and Monocytes was performed using multi-colour FACS analysis on days 1, 4, 7, and 11 post-aSAH. Clinical events, including macro vasospasm, cerebral infarction, and the outcome (mRS 6 months 0-2 vs 3-5 vs 6) were recorded prospectively and analysed using ANOVA and following post-hoc t-tests.

### Results

Patients with aSAH displayed reduced alternatively activated monocytes (M2) (3.0% vs 6.3% of all monocytes; $p=0.04$) and Th2 T cells (45.5% vs 75.3% of all T cells; $p<0.001$) within 24h after bleeding compared to healthy individuals. Prior to macro vasospasm, patients depict relative reduction in alternatively activated monocytes (M2) (2.0% vs 4.0% of all monocytes; $p=0.019$) and relative increase in proinflammatory Th1 T cells (15.8% vs 9.3% of all t cells; $p=0.0022$). Likewise, prior to cerebral infarction, patients showed a relative reduction in anti-inflammatory alternatively activated monocytes (M2) (2.7% vs 4.1% of all monocytes; $p=0.049$). No significant correlation was observed with patient outcomes (for all $p>0.61$).

### Conclusion

Aneurysmal SAH led to an enhanced pro-inflammatory response, inducing an early shift of monocyte and T-cells towards classical inflammatory phenotypes. Patients confronting CVS or DCI revealed a loss of alternatively activated monocytes (M2) and Th2 T cells shortly after the bleeding prior to macro vasospasm and cerebral infarction. Reconstitution of anti-inflammatory monocytes and T-cells can be exploited to combat vasospasm and confer neuroprotection after aSAH.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P305

### Delayed cerebral ischemia nach aneurysmatischer Subarachnoidalblutung: aktuelle Studien zeigen heterogene Definitionen

***Delayed cerebral ischemia after aneurysmal subarachnoid hemorrhage: Current studies reveal heterogeneous definitions***

J. Schürger[1], N. Kastenholz[1], A. Höllig[1]

[1]Universitätsklinikum RWTH Aachen, Aachen, Deutschland

#### Objective

Delayed cerebral ischemia (DCI) is an important prognostic factor after aneurysmal subarachnoid hemorrhage (aSAH). In 2010, Vergouwen and colleagues published a clinical definition of the DCI. However, the definitions of DCI used in clinical studies seem to differ substantially. Therefore, the resulting heterogeneity may comprise the comparability of the results fundamentally. Here, we analyze current studies on aSAH regarding the specific definitions of DCI and point out differences with respect to the definition by Vergouwen and colleagues.

#### Methods

A systematic Pubmed search (01.2015 - 12.2020) was performed using the following search strategy: (subarachnoid hemorrhage OR SAH) AND (DCI OR DIND OR vasospasm OR delayed cerebral ischemia OR delayed ischemic neurological deficit OR CVS OR cerebral vasospasm). We included clinical studies on aSAH with occurrence of DCI (vasospasm or DIND) as one outcome parameter.

#### Results

Out of 211 articles, 71 studies fulfilled the inclusion criteria. The mean sample size was 323 (SD: 535) patients. Twenty-six articles (37%) used the clinical definition of deterioration caused by DCI related to Vergouwen and colleagues. Deviations from the published definition mainly consisted of additional inclusion of imaging parameters (11 out of 45; 24%) such as demarcation of ischemia or occurrence of hypoperfusion (using perfusion imaging). Thus, 52% (n=37) applied the criteria of Vergouwen and colleagues. Thereof, arterial narrowing was a parameter frequently demanded. The mean observation period (with respect to DCI) was 14 (±2) days (n=20; 28%), but overall varied substantially.

#### Conclusion

Despite its considerable degree of popularity, the definition proposed by Vergouwen and colleagues was applied in only the half of the studies. Heterogeneous definitions of DCI may hamper comparability and interpretation of the results. Further, an update of the proposed definition including neuromonitoring parameters might be considered.

# Vaskuläre Neurochirurgie – Verschiedenes 4 | Vascular Neurosurgery – Various 4

## P306

### Zeitlicher Verlauf und Gender-Aspekte bei Secretoneurin nach Subarachnoidalblutung – ein neuer Biomarker?
*Time course and gender aspects of secretoneurin after subarachnoid hemorrhage – A new biomarker?*

S. A. Treichl[1], J. Kölle[1], W. M. Ho[1], R. Fischer-Colbrie[1], C. Thomé[1], O. Petr[1]

[1]Medizinische Universität Innsbruck, Universitätsklinik für Neurochirurgie, Innsbruck, Österreich

### Objective

Secretoneurin is an aminopeptide with an influence on neuroinflammatory processes and angiogenesis. Secretoneurin is discussed as a prognostic marker in critically ill patients with sepsis. Furthermore, secretoneurin has been shown to be an early biomarker for hypoxic brain damage and neurological outcome after cardiopulmonary resuscitation. The significance of this biomarker after subarachnoid hemorrhage is still unclear and was investigated in this study.

### Methods

A total of 80 patients were prospectively included in this study. Secretoneurin was determined in serum and CSF before treatment, during treatment, 6 and 12 hours after treatment after subarachnoid hemorrhage and daily until day 10. Patients with elective aneurysm treatment were examined as control group. We evaluated the results with regard to treatment modality, severity of subarachnoid hemorrhage, gender aspects and functional outcome.

### Results

The examination shows the time course of secretoneurin levels in serum and cerebrospinal fluid after subarachnoid hemorrhage. There is an initial peak in patients with subarachnoid hemorrhage. Over the time, the values after subarachnoid hemorrhage are lower than those of patients with elective treatment. Female patients show a trend towards lower values than male patients. Secretoneurin level were higher in patients with endovascular treatment and poor functional outcome.

### Conclusion

In this study, the course of secretoneurin in serum and cerebrospinal fluid after aneurysmal subarachnoid hemorrhage is shown. Secretoneurin could be a new biomarker for functional outcome after aSAH.

# P307

## Ethik-Konsile bei neurochirurgischen Patienten. Wert von Patientenverfügungen und Rechtsberatung.

***Bioethics consultation in neurosurgical patients – Are advance directives and legal consultations helpful?***

K. Mursch[1,2]

[1]Zentralklinik Bad Berka, Neurochirurgie, Bad Berka, Deutschland
[2]Zentralklinik, Klinisches Ethikkomitee, Bad Berka, Deutschland

### Objective

End of life decisions are medical, but also ethical and medico-legal issues. Different views on the worth and quality of a human life can cause severe conflicts within medical teams and/or between caregivers and relatives. In these cases, an ethic committee is asked to clarify the patient´s interest. When available, an advance directive is helpful, but may also cause conflicts or confusion. Aim of our study was to describe its value in ethical conflicts about patients suffering from impairment of consciousness. Additionally, the role of legal consultation was analysed.

### Methods

In our institution, bioethics consultations are held by qualified members of the ethic committee, including physicians, nurses, clerics and lawyers. We examined the protocols of bioethical consultations involving neurosurgical patients. The author focused on the influence of an advance directive on the conflict and necessity of a legal consultation.

### Results

12 conflicts involving unconscious or desorientated neurosurgical patients (spontaneous intracranial haemorrhages, traumatic injuries, tumours) were identified. In five cases, a patient´s provision was present. In all these cases, the relatives asked for a termination of life support, what, according to the medical team, was not appropriate at that time.In the conflicts where a directive was missing, there were 4 disputes within the family whether life support should be continued. The last dealt with potential complications of an operation in a patient who was unconscious for seven years. An agreement solving the conflict could be achieved in 5 cases.In half of all cases, the advice of a lawyer was helpful or even necessary

### Conclusion

An advance directive is a valuable expression of the patient´s will and autonomy, the highest priciple of bioethics. In our cases, it´s absence caused conflicts within the family. On the other hand, the directive has to be precise enough to avoid differing interpretations. We recommend early and close attention on advance directives in neurosurgical patients.

# P308

## Chronische Hyponatriämie und ihre Auswirkungen auf das Gehirn bei gesunden Ratten und Ratten mit Östrogenmangel

*Chronic hyponatremia and its effects on the brain in healthy or estrogen deficient rats*

S. Sperling[1], M. Komrakova[1], S. Sehmisch[1], K. O. Böker[1], M. Ninkovic[1], V. Rohde[1]

[1]Universitätsmedizin Göttingen, Göttingen, Göttingen, Deutschland

### Objective

Mild chronic hyponatremia (HypoNa) is the most common clinical electrolyte disturbance. Once thought to be asymptomatic due to brain adaptation, recent evidence suggests that chronic HypoNa is associated with attention deficit, risk of falls and cognitive impairment. Such neurological deficits are associated with reduced quality of life and may be a significant cause of mortality. Here we investigated the effect of chronic HypoNa on the expression level of some genes in the brain of healthy or estrogen deficient rats.

### Methods

7-month-old female rats were either ovariectomised (OVX) or SHAM ovariectomised (SHAM). In both OVX and SHAM groups, HypoNa was induced by desmopressin in the s.c. pump. Saline was used in the vehicle groups. After 6 weeks, the first cohort was sacrificed and the other cohort had the pumps replaced for a further 6 weeks (12-week group). RNA was isolated from rat brains and the expression of the following genes was analyzed by quantitative PCR; PLP, MOG, Slac2a1, Slac2a3, CASP3 and BCL2.

### Results

Examination of the myelin marker genes MOG and PLP showed that the expression of the MOG gene was significantly increased in SHAM-HypoNa for 6 or 12 weeks (p*, P**) compared to SHAM. There were no differences between the OVX and OVX-HypoNa groups. There were also no changes in the expression of glucose transporter genes (Slac2a1-GLUT1, Slac2a3-GLUT3) or in caspase 3 (CASP3). On the other hand, BCL2 was significantly reduced in the OVX HypoNa-12 weeks group (p*) compared to the OVX group.

### Conclusion

Here we show that in the presence of estrogen (SHAM) and under HypoNa conditions, the expression of the myelin gene MOG increased. MOG expression was not significantly different between the OVX groups, confirming the influence (direct or indirect) of estrogen on the expression of this gene in the HypoNa rats. Whether the observed downregulation of BCL2 in OVX-HypoNa promotes cell survival and thus the known adaptive mechanism that counteracts the negative effects of HypoNa on the brain, will be further investigated.

# P309

## Diagnosestellung und Risikofaktoren des Delirs bei neurochirurgischen Patientinnen und Patienten
*Diagnosis and risk factors of delirium in neurosurgical patients*

X. Hautmann[1], K. Rambo[1], N. Kunze-Szikszay[2], V. Rohde[1], C. von der Brelie[3]

[1]Universitätsmedizin Göttingen, Neurochirurgie, Göttingen, Deutschland
[2]Universitätsmedizin Göttingen, Anästhesie, Göttingen, Deutschland
[3]Johanniter Kliniken, Neurochirurgie, Bonn, Deutschland

### Objective

Delirium (DL) has a negative impact on the clinical outcome of patients. The incidence is 37-46% in postoperative patients and particularly high in elderly patients. Studies on patients with cerebral diseases report a lower incidence of 12-26%. We therefore assumed that DL is underappreciated in neurosurgical patients. A previous study, using the CAM-ICU-Score (CIS) showed that oral sedative drugs correlated significantly with DL. As the study was possibly underpowered, we collected more patients and looked for additional risk faktors.

### Methods

We conducted a prospective study. Patients >50 years of age on a normal ward who underwent neurosurgery under anesthesia were included. We divided our patients into two groups. In one group, the CIS was collected daily to determine whether delirium was present. In the other group, no scoring method was used and the interpretation whether delirium was present was made by the medical staff. Differences between the two groups were analyzed using Fishers test. Furthermore, we correlated risk factors with the occurrence of DL using Spearman´s correlation and conducted a multivariate regression.

### Results

213 patients were prospectively included. The overall incidence of DL was 9.4% (20 patients). In the group in which CIS was used, it was higher at 12.7% (14 patients) than without the use of CIS (5.8%, 6 patients). The difference was not statistically significant (p=0.102). Risk factors for the occurrence of DL were: cerebral disease (vs. spine; [p=0.003]), higher age (p=0.008), oncological disease (p=0.001), postoperative ICU stay (p=0.012), elevated leukocytes (p=0.029), neurodegenerative diseases (p=0, 016), alcohol abuse (p=0.006), hypacusis (p= 0.03), liver disease (p=0.012), and the use of sedatives (p=0.010), antiarrhythmics (p= 0.010) and steroids (p=0.008). A multivariate analysis only revealed a significant correlation with the occurrence of DL for age (p=0.047), cerebral disease (vs. spine) (p=0.014) and alcohol abuse (p=0.032).

### Conclusion

The application of CIS seems to lead to a more than two-fold incidence of DL, however, statistical analysis failed to show a significance. The current data indicate that typical risk factors do play an important role. The fact that oncological diseases, cerebral operations, and the use of steroids are significantly associated with the occurrence of delirium, suggests, that patients with malignant brain tumors might be particularly at risk even if this could not be confirmed in the multivariate analysis.

# P310

## Unterschiede zwischen der zerebralen, transurethralen und tympanischen Temperatur in Patienten nach Subarachnoidalblutung

***Differences in cerebral, transurethral and typanic temperature in patients after subarachnoid hemorrhage***

P. A. Mercea[1], I. Bohl[2], J. Brugger[2], J. Herta[2], A. Reinprecht[2], W. Plöchl[2], K. Rössler[2], A. Hosmann[2]

[1]Paracelsus Medizinische Privatuniversität (PMU), Neurochirurgie, Salzburg, Österreich
[2]Medizinische Universität Wien, Neurochirurgie, Wien, Österreich

### Objective

Fever is a common phenonmenon (~72%) in patients suffering from subarachnoid hemorrhage during the first 48h after bleeding or as a result of a nosocomial infection. Strict critical care management of raised core temperature is crucial since it is associated with an increased mortality. The core temperature, which is used as the target parameter can be measured at various measuring points in the body (e.g. bladder or tympanon). The goal of this study was to analyze the temperature differences between the different measuring points and the influence on the cerebral metabolism.

### Methods

We included patients suffering from subarachnoid hemorrhage, who were treated at our instiution between 2016 and 2019, and received multimodal neuromonitoring including temperature measuring in the brain, as well as microdialyses for analyses of the cerebral metabolism. The core temperature was measured via a transurethral and tympanic measurement. We distingushed three phases of temperatures: hyperthermia >37.5°C, normothermia 36,0°C - 37,5°C and hypthermia <36,0°C.

### Results

Alltogether, we were able to include 20 consecutive patients after subarachnoid hemorrhage. The differences between brain and core temperature were 0.38°C [CI:0.27-0.48; $p<0.001$]. The temperature differences between the brain and tympanon were 0,70°C [CI:0.48-0.92; $p<0.001$]. During hyperthermia we observed a decrease of intracerebral glucose concentration, as well as an increase in lactate-pyruvate-ratio and simultaneously a decrease in pyruvate concentration as compared to normo- and hypothermia ($p<0.001$).

### Conclusion

The temperature in the brain was higher than the core temperature and the temperate measured at the tympanon, respectively. Especially during phases of hyperthermia the glucose demand and the lactate-pyruvate-ratio was increased. This might be the result of an disrupted cerebral metabolism which further on can have a major impact on the morbidity of the patients.

# P311

## Evaluation eines neuen Scores, abstammend vom SOFA score, zur Prädiktion des Outcomes nach einer Subarachnoidalblutung

***Evaluation of a score derived from the SOFA score as a tool to predict outcome after subarachnoid hemorrhage***

E. Kurz[1], D. Kalasauskas[1], V. Fassl[1], A. Schulze[2], C. Brockmann[3], F. Ringel[1], A. Neulen[1]

[1]Universitätsmedizin Mainz, Neurochirurgie, Mainz, Deutschland
[2]Institut für Medizinische Biometrie, Epidemiologie und Informatik, Mainz, Deutschland
[3]Universitätsmedizin Mainz, Neuroradiologie, Mainz, Deutschland

### Objective

Estimating the prognosis of patients with spontaneous subarachnoid hemorrhage (SAH) early after SAH remains difficult. Hunt&Hess (H&H) as well as WFNS score were shown to have good discriminatory abilities. However, peripheral organ complications are not reflected in these scores. The sequential organ failure assessment score (SOFA) is used in intensive care units (ICU) to monitor organ dysfunction, and it was shown to predict outcome of SAH patients on ICU with similar predictive values as WFNS and H&H. The aim of our study was to determine the most robust prediction parameters for outcome within the SOFA score and to develop a simplified new score.

### Methods

We retrospectively evaluated all SAH patients admitted to our neurosurgical ICU during a 10-year period. Inclusion criteria were availability of clinical data on HH and WFNS scores, SOFA score day 1 after hospital admission, modified Rankin scale (mRS) after 6 months, and a CT scan 14-28 days post-SAH to evaluate DCI-associated infarctions. Each parameter of the SOFA score (GCS, arterial blood pressure, Horovitz quotient, creatinine and bilirubin levels, and platelet counts) was graded for its predictive value and combinations were tested using ROC analysis and Youden Index (YI).

### Results

253 patients with complete necessary data were included; 71.4% were female; mean age was 57.13±12.5 years. Median SOFA score was 4, median H&H score was 3, median WFNS score was 3. Towards predicting unfavorable outcome (mRS 4-6), AUC for SOFA was 0.77 (CI95%=0.71-0.82), YI of 0.39 at a cut off of ≥7 points. For the HH score AUC was 0.73 (CI95%=0.67-0.8), YI 0.37 with a cut off at ≥ 2, and for WFNS score AUC was 0.71 (CI95%=0.65-0.77), YI of 0.36 with the cut off at ≥ 2. Of the parameters within the SOFA score, GCS, mean arterial blood pressure (MAP) and Horovitz quotient (paO2/fiO2) were most reliable. A score combining exclusively these factors (0-4 points per parameter in analogy to the SOFA score) yielded an AUC of 0.79 (CI95%=0.73-0.84) with a YI of 0.43 at a cut off at ≥5 points (PPV 0.53, NPV 0.99, sensitivity 0.99, specificity 0.45).

### Conclusion

A simplified SOFA score, including GCS, the MAP and the Horovitz quotient – which are regularly documented in intensive care medicine and therefore available for SAH patients treated on the ICU – predicted neurological outcome better than the established H&H and WFNS scores. It could therefore provide additional information to select SAH patients at risk for unfavorable outcome.

# P312

## Auswirkungen des initialen systolischen Blutdrucks auf frühe Komplikationen und klinische Ergebnisse bei Patienten/-innen mit aneurysmatischer Subarachnoidalblutung

***Impact of the initial systolic blood pressure management on early complications and outcome of subarachnoid hemorrhage***

M. Gümüs[1], C. Rieß[1], T. F. Dinger[1], Y. Ahmadipour[1], M. Darkwah Oppong[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Neurochirurgie, Essen, Deutschland

### Objective

Proper management of systolic blood pressure (SBP) after aneurysm rupture is considered important for the prevention of aneurysm rebleeding. However, there is no consensus on the optimal values for SBP in patients with subarachnoid hemorrhage (SAH) prior to aneurysm occlusion. We aimed at analyzing the association between the initial SBP and complications and outcome of SAH patients.

### Methods

All consecutive SAH patients who were admitted to our department between 2003 and 2016 and treated within the first 48 hours after ictus were included in the analysis. SBP values were collected from external (paramedic) and internal (intensive care unit) protocols. Baseline characteristics of patients and SAH as well as data on early complications and functional outcome (in-hospital mortality and unfavorable outcome at 6 months measured as modified Rankin scale>3) were recorded. SBP values were divided into three categories according to the receiver operating characteristic curve analysis: <140 (category 1), 140-180 (category 2) and >180 mmHg (category 3). Associations were adjusted for relevant confounders.

### Results

The mean initial SBP in the final cohort (n=756) was 164 mmHg (±26), with the distribution of the above-mentioned SBP categories as follows: 11.4%, 70.6% and 18%. Higher age, pre-existing arterial hypertension, male sex, and poor admission WFNS grade showed associations with increased initial SBP values. The higher the SBP levels, the more frequent were the cases of aneurysm rebleeding (3.5%, 6.4%, 9.7%) and in-hospital mortality (15.1%, 19.3%, 25.7%). Accordingly, unfavorable outcome after 6 months was more common in the highest SBP category (43.9%, 38.3%, 53.5%). In the final multivariate analysis, SBP increase was independently associated with increased risk of aneurysm rebleeding (aOR=1.77 per-category-increase, p=0.042), in-hospital mortality (aOR=1.52, p=0.01), and unfavorable outcome (aOR=1.44, p=0.034).

### Conclusion

Our findings confirm the role of SBP management for the prevention of aneurysm rebleeding and poor SAH outcome. Aiming for SBP values <140 mmHg until aneurysm occlusion might significantly decrease rebleeding rates and improve patients" outcome. Prospective evaluation of the clinical value of strict SBP management is mandatory to further confirm these findings.

# P313

## Einführung eines postoperativen Step-Down-Care-Protokolls: Optimieren eines sicheren, patientenindividuellen und ökonomischen Patientenmanagements nach elektiver Kraniotomie

***Introducing a postoperative Step-Down-Care protocol: Optimizing safe, patient-specific, and economic patient management after elective craniotomy***

P. Selhausen[1], C. Byhahn[2], M. N. Bergold[3], J. Woitzik[1]

[1]Evangelisches Krankenhaus, Universitätsklinik für Neurochirurgie, Oldenburg, Deutschland
[2]Evangelisches Krankenhaus, Klinik für Anästhesiologie, Notfallmedizin und Schmerztherapie, Oldenburg, Deutschland
[3]Evangelisches Krankenhaus, Klinik für Interdisziplinäre Intensivmedizin, Oldenburg, Deutschland

### Objective

Capacity for postoperative intensive care unit (ICU)- or intermediate care unit (IMC)- monitoring of patients undergoing elective craniotomy (EC) can be a limiting factor for the number of EC performed per day. At the same time, the indication and benefit of standard ICU/IMC-monitoring after EC are being discussed controversially.1 Identifying those patients undergoing EC, that can safely reduce the usage of ICU/IMC-monitoring capacities is crucial for safely reducing ICU/IMC-patient load.

We developed a "Step-Down-Care"-protocol to select those patients undergoing EC that can step down from ICU/IMC to the regular neurosurgical ward 6 hours after the operation. We hypothesize, that with the correct identification of eligible patients, these patients can then be safely managed on the regular ward.

1. Qasem et al. (2022) Implementation of the "No ICU – Unless" approach in postoperative neurosurgical management in times of COVID-19. Neurosurg Rev. 45(5):3437-46.

### Methods

We retrospectively analyzed those patients that were included in the protocol in the first full year of the Step-Down-Care-protocol usage, the year of 2023. Inclusion criteria of the protocol included amongst others duration of EC of no more than 6 hours, and expectation of low perioperative risk (ASA I or II according to ASA PS classification)2. At the end of the 6 hour-ICU/IMC-monitoring period, patients had to meet the following criteria to then in fact step down to the regular ward: regular postoperative imaging, no epileptic seizure, no unexpected neurological deficit and cardiovascular stability.

All patients included in the protocol in 2023 were included in this study and data was retrospectively collected concerning patient demographics, clinical and surgical characteristics, and postoperative complications.

2. Mayhew et al. (2019) A review of ASA physical status – historical perspectives and modern developments. Anesthesia. 74:373-9.

### Results

44 patients (mean age 54 years) followed the Step-Down-Care-protocol. Surgeries included supra- and infratentorial craniotomies. Of these patients, no patients had to step back up to ICU/IMC-monitoring and -therapy. No major clinical or radiological complications occurred.

## Conclusion

Having patients step down from ICU/IMC-monitoring to a regular ward after 6 hours of uneventful postoperative monitoring according to the proposed criteria appears to be a safe procedure. Further evaluation of a larger group sample and a comparison to a control group is required.

# P314

## Systemisches inflammatorisches Response-Syndrom bei aneurysmatischer Subarachnoidalblutung: Wechselwirkung mit der Schwere des frühen Hirnschadens"

***Systemic inflammatory response syndrome in aneurysmal subarachnoid hemorrhage: Interaction with early brain injury severity***

S. Tuzi[1], O. Moerer[1], D. Mielke[1], V. Rohde[1], V. Malinova[1]

[1]Universitätsmedizin Göttingen, Göttingen, Deutschland

### Objective

Aneurysmal subarachnoid hemorrhage (aSAH) induces a systemic reaction, which can be reflected by the Systemic Inflammatory Response Syndrome (SIRS) criteria for critically ill patients. The interaction of early brain injury (EBI) with SIRS after aSAH has not been defined yet. This study was conducted to investigate the correlation of SIRS with EBI, with the duration of mechanical ventilation, and with the duration of the need for a catecholaminergic support.

### Methods

A consecutive cohort of aSAH patients treated between 2010 and 2020 was retrospectively analyzed. The presence of SIRS was determined by the fulfillment of at least two criteria, including abnormal body temperature, tachycardia, tachypnea, or aberrations in white blood cell count. EBI grading was defined considering three parameters: overall intracranial blood amount, the presence of global cerebral edema (GCE), and a persistent loss of consciousness (LOC). Patient outcomes at the 3-month follow-up were evaluated using the modified Rankin scale (mRS).

### Results

A total of 324 aSAH patients with a mean age of 55.9 years were included. The SIRS criteria were met in 51% (166/324) of patients. A positive correlation was found between the presence of SIRS and the EBI grade ($r=0.18$; $p=0.002$). There was a positive correlation between the EBI grade and the intubation duration ($r=0.34$; $p=0.002$). Patients with a longer intubation duration also needed catecholaminergic support for a longer time ($r=0.53$; $p<0.0001$) and a poorer overall outcome according to mRS at follow-up ($r=0.3$; $p=0.01$).

### Conclusion

The SIRS criteria were met in the half of patients in our patient population, which not only was associated with the severity of EBI, but also with the duration of ventilation and of the need for a catecholaminergic support. The fulfillment of the SIRS criteria was also correlated to poor outcomes at 3-months follow up.

# P315

## Präoperative Bereitstellung von Erythrozyten- Konzentraten vor elektiven intrakraniellen Eingriffen: Zeit für eine Neubetrachtung?

*Provision of packed red blood cells before elective intracranial surgery: Time for reconsideration?*

N. Elman[1], T. Palmaers[2], J. K. Krauss[1]

[1]MHH, Neurochirurgie, Hannover, Deutschland
[2]MHH, Anästhesie, Hannover, Deutschland

### Objective

The provision of packed red blood cells (PRBCs) prior to certain planned intracranial surgeries has been common practice in neurosurgery. The question, however, arises how often these blood products are actually being transfused to the patient. In view of the shortage of this important resource and in the context of refining the standard operating procedures (SOP), it is necessary to determine the actual needs.

### Methods

PRBCs were orded preoperatively according to a departmental SOP. For the present study, 612 patients older than 12 years, who underwent elective intracranial surgery (over a period of 3 years) were analyzed retrospectively. Emergencies, burrhole procedures and pediatric interventions were excluded. When processing the data, the type of surgery, duration of surgery, age and gender of the patients, experience of the surgeon and postoperative complications were evaluated.

### Results

In the total cohort of 612 patients, 269 were men and 343 were women. Mean age was 58.2 years (range: 12- 90 years. Gender and age distribution were similar in those patients who had provision of PRCBs preoperatively and patients who did not. According to the SOP preoperative PRCBs, were orded mainly for elective vascular surgery and large tumors, mainly meningiomas. In 31/612 (5.1%) patients an intracranial blood transfusion was necessary (17 patients with preoperative provision of PRBCs (54.8%), 14 without (45.2%)). According to the existing SOP, PRBCs were orded in 33/612 patients. Of those 33 patients, 17 had an intraoperative transfusion (51.5%), while 16 did not receive blood products (48.5%). In the subgroup of 579/612 (94.6%) patients who had no preoperative provision of PRCBs 14 patients had an intraoperative transfusion (2.4%), while 565 did not (97.6%). While unplanned transfusions were necessary only in a minority of those patients who had no preoperative provision of PRBCs, only about half of the patients with preoperative provision of PRBCs needed intraoperative blood transfusions. According to subitem analysis modifications of the current SOP are made to further increase specificity.

### Conclusion

Our current study shows that the need of PRCBs for elective intracranial neurosurgical procedures is low. Preoperative provision of PRCBs is useful for certain entities according to defined SOPs. Such SOPs need to be adjusted concerning quality control algorithms.

# P316

## Selected Correlation Dosage als quantitativer Index für Störungen der zerebralen Autoregulation bei Patienten auf der neurochirurgischen Intensivstation.

***Selected correlation dosage as a quantitative index for autoregulation – Impairment in neurosurgical ICU patients***

R. Faltermeier[1], M. Proescholdt[1], E. Bruendl[1], S. Bele[1], N. O. Schmidt[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland

### Objective

In neurocritical care, impairment of cerebral autoregulation and reduced intracranial compliance due to brain swelling are frequent and potentially life–threatening events. Selected correlation analysis (SCA) is a method to detect impaired autoregulation combined with severe brain swelling by calculating a correlation-based index sc using fixed-length windows of arterial blood pressure (ABP) and intracranial pressure (ICP) signals. If sc is higher than a predefined significance level and the correlation is positive, the windows are labeled scp, indicating the pathophysiology mentioned above. We examined whether the quantitative extent of sc under scp conditions, represented by the area under the curve of sc for scp segments, can serve as a useful continuous parameter, indicating the severity of autoregulation failure.

### Methods

We included 77 patients (46 female and 31 male) with a median age of 50 years, treated for subarachnoid hemorrhage (SAH; n = 58) or traumatic brain injury (TBI; n = 19). The median initial GCS was 8, and the median GOS at the last follow-up was 3. SCA was used to extract all segments of scp (sc > 0.0556), and for these segments, the sc dosage was calculated by area under the curve (AUC) of the sc values. The resulting value for one segment is called scp_dosage of this segment. In the first step we calculated the sum of scp_dosage per patient scaled by the measurement length and analyzed whether there exists, in analogy to the scp values, a significant correlation to the GOS. Additionally, we selected the maximum, minimum, and mean values of scp_dosage per patient and repeated the above-mentioned statistical analysis with these values.

### Results

We could demonstrate that the scp_dosage per patient scaled by the measurement length strongly correlates to patient outcome after the last follow-up with a correlation coefficient of -0.4155 and a p-value of 0.0002. This also holds for the maximum of the scp_dosage per patient, leading to a correlation coefficient of -0.348 and a p-value of 0.0019. The correlation analysis of the mean value of scp_dosage per patient leads to a correlation coefficient of -0.384 and a p-value of 0.0006.

### Conclusion

scp_dosage and some of its variations are valid outcome predictors. The maximum value of scp_dosage is of great interest as this value might lead to a limit value of scp_dosage that should not be reached during treatment.

# P317

## Leistungsfähigkeit und Genauigkeit eines automatisierten elektronischen Screening tools in einem gemischt-chirurgischen ITS-Patientenkollektiv

***Performance and accuracy of an automated electronic screening tool in a mixed surgical ICU collective***

M. Dengl[1], V. Franz[2], K. Pleul[3], A. Trabitzsch[4], T. Juratli[1], I. Y. Eyüpoglu[1], K. Barlinn[5]

[1]Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Department of Neurosurgery, Dresden, Deutschland
[2]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Anästhesiologie und Intensivmedizin, Dresden, Deutschland
[3]Deutsche Stiftung Organtransplantation, Region Ost, Leipzig, Deutschland
[4]Universitätsklinikum Carl Gustav Carus Dresden, Zentrum für Chirurgie, Dresden, Deutschland
[5]Universitätsklinikum Carl Gustav Carus Dresden, Klinik und Poliklinik für Neurologie, Dresden, Deutschland

### Objective

We previously introduced a simple, computer-assisted, prospective tool designed to address the challenges in identifying potential organ donors in the ICU. This tool screens daily for ascertained scores (RASS and pupillary reflex) in the electronic patient data management system and notifies the recipient on a 12-hour-basis of potential patients. This study aims to evaluate the tool's effectiveness over an extended period, highlighting its potential benefits.

### Methods

The software was implemented in a mixed surgical ICU (traumatic, abdominothoracal, vascular and neurosurgery) from January 2020 to December 2022 (24 months). Its performance was compared with an existing retrospective system that identifies patients who died with an ICD-10-diagnosis of primary or secondary brain damage.

### Results

The tool generated 1225 notifications for 240 different patients (median of 3; mean of 5.1, SD 6.0). Of these patients, 109 (45.4 %) died in the hospital while 34 (14.2 %) were confirmed to be brain dead in the course of the ICU stay and 16 (6.6 %) proceeded to organ donation. The established application identified 102 patients, who died with the diagnosis of primary or secondary brain damage, 19 of whom were not detected by the prospective tool. Reasons for the inability to identify those patients were very short ICU stay, cardiac arrest without return of spontaneous circulation during CPR or documentation inaccuracies. The vast majority of those undetected cases did not meet criteria for potential brain death.

### Conclusion

In this diverse surgical patient cohort, the assistive tool demonstrated potential in increasing awareness for potential organ donation. It proved reasonably accurate and effective for daily use.

# P318

## Perioperative Gewichtsentwicklung nach verschiedenen intrakraniellen neurochirurgischen Eingriffen unterschiedlicher Komplexität und subkutaner Transmitterimplantation im neurowissenschaftlichen Rattenmodell

***Perioperative body weight development after intracranial neurosurgical procedures of different complexity and subcutaneous transmitter implantation in neuroscience rat models***

C. von der Ahe[1], A. L. Ottlewski[1], M. Stenzel[1], F. Decker[1], A. K. Riedesel[1], M. Alam[1], M. R. Oelerich[1], M. Bankstahl[2], H. Potschka[3], V. Buchecker[3], U. Lindauer[4], K. Schwabe[1]

[1]Hannover Medical School, Experimental Neurosurgery, Hannover, Deutschland
[2]Hannover Medical School, Institute for Laboratory Animal Science and Central Animal Facility, Hannover, Deutschland
[3]Ludwig-Maximilians-University, Institute of Pharmacology, Toxicology and Pharmacy, München, Deutschland
[4]RWTH Aachen University, Translational Neurosurgery and Neurobiology, Department of Neurosurgery, Aachen, Deutschland

### Objective

Body weight is one of the most frequently reported measure monitored during experimental settings, as it correlates, at least to some extent, with the degree of pain, distress or suffering. Rat models used in neuroscience cover a wide range of intracranial neurosurgical interventions of potentially different severity levels. We analyzed the relative weight development after different surgical procedures and subcutaneous transmitter implantation in neuroscience models.

### Methods

All rats (male Sprague Dawley, BDIX or Wistar, female Spraque Dawley) were anaesthetized with chloral hydrate (360mg/kg, 10 ml/kg i.p.). Lidocaine hydrochloride (Xylocain® 2%) was used as a local anesthetic on the periost. Rats were further treated with the analgesic carprofen (Rimadyl®, 5mg/kg, s.c.) intraoperative and on the two following days (2.5mg/kg s.c.). Body weight was measured before and up to 7 days after intracranial surgery, i.e. vehicle / 6-OHDA / tumor cell / blood / pilocarpine injection, tumor resection, electrode implantation, induction of a status epilepticus, cerebellar fastigial lesion, as well as cochlear manipulation (intracochlear neomycin injection). Peripheral subcutaneous transmitter implantation was included (without/with bupivacaine for local anesthesia).

### Results

Perioperative weight loss was found after i.e. 6-OHDA injection (97%, $p<0.05$), hearing loss (juvenile rats 92%, $p<0.001$), tumor resection (98%, $p<0.05$) and subarachnoid hemorrhage (95%, $p<0.05$). Cerebellar fastigial lesions and induction of hearing loss in adult rats did not lead to significant weight loss, although 40% (fastigial lesion) and 15% (adult rats with hearing loss) lost weight of more than 5%. Electrode implantation, as well as vehicle or cell injection did not affect weight ($p>0.05$). After subcutaneous transmitter implantation in a first group weight was reduced (98%, $p<0.05$), whereas the following groups, that treated with the long-acting local anesthetic bupivacaine before implantation, did not lose weight.

### Conclusion

To date, weight as a core parameter seems suitable for the grading of severity of intracranial neurosurgical interventions of different complexity in rat models used in neuroscience research, as well as to verify refinement of perioperative analgesia.

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# P319

## Invasives Atemwegsmanagement bei patienten mit aneurysmatische subarachnoidalblutung
*Invasive airway management in patients with aneurysmal subarachnoid hemorrhage*

J. Rodemerk[1], M. Gümüs[1], T. F. Dinger[1], C. Rieß[1], M. Darkwah Oppong[1], Y. Ahmadipour[1], P. Dammann[1], K. H. Wrede[1], U. Sure[1], R. Jabbarli[1]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland

### Objective

Nearly every patient with a ruptured intracranial aneurysm must be ventilated in the intensive care unit (ICU). A range of primary and secondary complications after this event burdens the quality of life of these patients. This study aims to identify the role of invasive ventilation management and elucidate its future part in improving outcomes in aneurysmal subarachnoid hemorrhage (aSAH).

### Methods

All consecutive cases with aSAH treated at our institution between 01/2003 and 06/2016 were eligible for this study. Invasive ventilation parameters like duration of continuous positive airway pressure (CPAP) ventilation, duration of other forms of invasive ventilation, days with sedated ventilation, highest ventilation frequency, highest and mean positive end-expiratory pressure (PEEP) in [mbar], and maximal and mean-maximal inspiratory pressure (Pinsp) in [mbar] were analyzed in univariate and multivariate analyses. The association of ventilation parameters with the primary study endpoints (risk of cerebral infarction, in-hospital mortality, and unfavorable outcome at six months defined as modified Rankin scale>3) was analyzed.

### Results

The final cohort (n = 759) comprised patients between 19 and 90 years old with at least one day of invasive ventilation. Unfavorable functional outcomes were reported in 49% of the cases, ischemic insults occurred in 54.1% of the patients, and the in-hospital mortality rate was 20.6%. Furthermore, extended periods of CPAP ventilation (OR: 1.03, CI: 1.02-1.05), longer sedated ventilation (OR:1.02, CI: 1.01-1.04), and an elevated maximal Pinsp (OR: 1.03, CI: 1.01-1.04) showed higher chances for an unfavorable functional outcome after six months. In addition, ischemic insults were linked to sedated ventilation days (OR: 1.02, CI: 1.01-1.03) and an elevated maximal Pinsp (OR: 1.01, CI: 1.003-1.02). Lastly, in-hospital mortality was shown to be associated with higher PEEPs (OR: 1.02, CI: 1.01-1.03) and an elevated maximal Pinsp (OR: 1.02, CI: 1.01-1.03).

### Conclusion

In conclusion, a variety of ventilation parameters are linked to unfavorable outcomes. Prominent was the association between longer sedation times, risk for ischemic insults, and higher risks of poor functional outcomes post-discharge. These findings underline the critical role of ventilation parameters assessment in managing patient outcomes.

# P320

## Entwicklung eines neuen Protokolls zur Beurteilung der Schwere von Subarachnoidalblutungen im Mausmodell der Circle-Willis-Perforation

***Establishment of a novel protocol for assessing the severity of subarachnoid hemorrhage in circle willis perforation mouse model***

R. Zhang[1], D. Khan[1], S. Muhammad[1]

[1]Medical Faculty & University Hospital Düsseldorf, Heinrich Heine University Düsseldorf, Düsseldorf, Deutschland

### Objective

To enhance the reliability of the Circle of Willis perforation (cWp) mouse model in subarachnoid hemorrhage (SAH) research by addressing issues related to inconsistent bleeding volumes.

### Methods

We introduced the ROB Scoring System, a novel protocol that integrates Rotarod Tests (RT), Open-field Tests (OT) video analysis, and daily Body Weight Loss (BWL) monitoring for precise categorization of SAH severity. Forty C57BL/6 mice underwent cWp induction and were categorized into severity subgroups (severe, moderate, mild) using the ROB system.

### Results

Validation involved comparing ROB outcomes with autopsy results on postoperative days 3 and 7 for acute and sub-acute evaluations. Mortality rates were analyzed via the survival log-rank test, revealing a significant difference among severity groups ($P < 0.0001$). Strong correlations between ROB grades and autopsy findings underscored its precision. The severe group exhibited 100% mortality within 4 days post-SAH onset. Individual parameters (RT, OT, BWL) were insufficient for distinguishing SAH severity levels.

### Conclusion

The ROB Scoring System represents a significant advancement, providing a standardized protocol for precise categorization and addressing inherent bleeding variations in the cWp mouse model. This tool enhances the reliability and effectiveness of SAH research, offering valuable insights for future investigations into this critical area.

# P321

## Lumbalpunktion oder externe Ventrikeldrainage als initiale Behandlung des akuten Hydrozephalus bei aneurysmatischer Subarachnoidalblutung - Eine bizentrische Kohortenstudie

***Lumbar puncture or external ventricular drainage as initial treatment for acute hydrocephalus in aneurysmal subarachnoid haemorrhage – A two-centre cohort study***

F. Wenz[1], R. Tack[2], A. Abdulazim[1], A. van der Zwan[2], M. Vergouwen[2], N. Etminan[1], G. Rinkel[1,2]

[1]Universitätsmedizin Mannheim, Neurochirurgische Klinik, Mannheim, Deutschland
[2]University Medical Centre Utrecht, Utrecht, Niederlande

### Objective

Acute hydrocephalus after aneurysmal subarachnoid haemorrhage (SAH) is typically treated by external ventricular drainage (EVD), which carries a risk for complications, including long-term shunt dependency. Lumbar puncture (LP) may be an effective and less invasive alternative. We compared efficacy and safety of LP versus EVD as initial treatment.

### Methods

We performed a two-centre cohort study comparing two different institutional approaches, with either LP or EVD as initial treatment. SAH patients treated within 72 hours after ictus for acute hydrocephalus, with Glasgow Coma Scale ≥7 and no contraindications for LP were included. We determined the proportion of patients in the LP cohort in which EVD could be avoided and calculated odds ratios (OR) with adjustment for baseline predictors to compare the rates of permanent ventriculoperitoneal shunts, clinical and radiological complications, and poor functional outcome (Glasgow Outcome Scale of 1-3 at 3 months) between the two strategies.

### Results

In one institution, from 2013 admitted SAH patients between 2007 and 2021, 84 with acute hydrocephalus were initially treated with LP, whereas at the other institution, from 367 admitted SAH patients between 2015 and 2021, 77 similar patients were initially treated with EVD. Both groups were well comparable in terms of initial clinical condition and extent of hydrocephalus. In the LP group, 69 patients (82%) showed clinical improvement, and in 65 patients (77%) EVD could be avoided. A permanent ventriculoperitoneal shunt was placed in 8 patients (10%) of the LP group and 52 patients (68%) of the EVD group. Complications occurred less often in the LP-group and there was no significant difference in clinical outcome (detailed results in Table 1).

### Conclusion

LP is associated with a reduced proportion of patients with chronic hydrocephalus and need for ventriculoperitoneal shunt, a smaller proportion of complications and comparable clinical outcomes as EVD and should therefore be considered as initial treatment for acute hydrocephalus after SAH. Further research should elucidate the effects of both treatments on cognitive functioning.

**Table 1:** Outcome measurements of patients with lumbar puncture (LP) and with external ventricular drain (EVD); VP = ventriculoperitoneal; OR = odds ratio; CI = confidence interval; Adjustment was made for age, GCS, rBCI, Hijdra score and modality of aneurysm occlusion.

Abb. 1

| Outcomes | LP patients | EVD patients | crude OR (95% CI) | adjusted OR (95% CI) |
|---|---|---|---|---|
| VP-shunt dependency | 8 (10%) | 52 (68%) | 0.05 (0.02 – 0.12) | 0.04 (0.02 – 0.11) |
| Complications | 18 (21%) | 29 (38%) | 0.45 (0.23 – 0.88) | 0.44 (0.20 – 0.92) |
| Unfavourable outcome | 36 (43%) | 40 (52%) | 0.69 (0.38 – 1.26) | 0.67 (0.32 – 1.40) |

# P322

## Ein atypischer teratoider rhabdoider Tumor bei einem 24-jährigen Patienten mit Neurofibromatose Typ 1 und einer dramatischen Krankheitsentwicklung.

***Uncharted Territory: An atypical teratoid rhabdoid tumor in a 24-year-old neurofibromatosis type 1 patient with a rapid trajectory***

E. Rampeltshammer[1], C. Monoranu[2], C. K. W. Deinzer[3], A. F. Keßler[1], C. Matthies[1]

[1]Universitätsklinikum Würzburg, Neurochirurgische Klinik und Poliklinik, Würzburg, Deutschland
[2]Universitätsklinikum Würzburg, Institut für Pathologie, Abteilung Neuropathologie, Würzburg, Deutschland
[3]Universitätsklinikum Tübingen, Medizinische Onkologie und Pneumologie, Tübingen, Deutschland

### Objective

Neurofibromatosis type 1 (NF1) is a prevalent genetic disorder with an incidence of 1:3,000. While NF1 patients commonly develop benign neurofibromas, these can transform into various malignant and life threatening tumors. Treatment of these malignancies remains complex due to their diverse nature. We report an unusual case mimicking initially a malignant peripheral nerve sheath tumor (MPNST).

### Methods

We evaluated the patient's clinical symptoms, imaging by MRI and F-18-FDG-PET-CT, and histopathological data, supplemented by a comprehensive literature review.

### Results

Despite extensive tumor manifestations, a 24-year-old male with familial NF1 had neglected MRI follow-ups for three years in view of his stable neurological status. Suddenly, the patient exhibited radiating back pain and acute paraparesis below L3 within days. Urgent lumbar MRI and F-18-FDG-PET-CT scan confirmed significant paravertebral tumor progression at L3, infiltrating the spinal canal with heightened F-18-FDG metabolism. Under the suspicion of a transformation from intra-extraspinal neurofibroma to an MPNST, decompression of neuronal structures was performed by microsurgical resection of intra- and paraspinal tumor masses. Histopathology revealed pronounced mitotic activity, nuclear variability, and extensive necrosis. Immunophenotyping, including nuclear SMARCB1/INI1 loss and cytokeratin expression, aligned with AT/RT or epithelioid sarcoma, ruling out epithelioid MPNST. Unfortunately, the patient deteriorated rapidly and passed away three weeks post-admission.

### Conclusion

This case highlights a rare instance of NF1-associated AT/RT or epithelioid sarcoma in an adult patient. NF1 patients bear an 8-13% lifetime risk of MPNST arising from benign neurofibromas. Notably, to date, NF1 association with AT/RT remains undocumented, with sporadic reports of epithelioid sarcoma in NF1. The tumor location is atypical for both entities. Considering AT/RT's potential to arise from other tumors, a connection with NF1 tumor predisposition syndrome is plausible. Ongoing molecular and genetic investigations aim to elucidate the tumor pathogenesis and identify targeted therapeutic strategies for this rare condition.

In conclusion, this case underlines the need for rigorous monitoring and genetic assessments in NF1 patients, enabling prompt and individualized therapeutic interventions.

# Tumor – Verschiedenes 4 | Neurooncology – Various 4

## P323

### Die Therapie von zentralen Neurozytomen
*Treatment of central neurocytoma (CN)*

A. Michel[1], T. F. Dinger[1], R. Jabbarli[1], P. Dammann[1], A. K. Uerschels[1], M. Darkwah Oppong[1], J. Rodemerk[1], Y. Ahmadipour[1], O. Gembruch[1], A. Junker[1], U. Sure[1], K. H. Wrede[2]

[1]Universitätsklinikum Essen, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Essen, Deutschland
[2]Universitätsklinikum Essen, Klinik für Neurochirurgie, Essen, Deutschland

### Objective

Central neurocytomas (CNs), classified as grade 2 tumors by the World Health Organization in 1993, are exceptionally rare (approx.. 0.1-0.5% of all intracranial tumors) intraventricular tumors frequently associated with hydrocephalus. This study aims to present a comprehensive analysis of surgical and adjuvant therapies in patients diagnosed with CN at our center over the past decade (2013-2023).

### Methods

The study comprised all patients who underwent microsurgical tumor removal in our center. Clinical manifestations, surgical and adjuvant therapy approaches, MRI and histological findings, clinical outcomes, and recurrence-free survival were evaluated and compared with the literature.

### Results

A total of 11 patients (6 men, mean age 28.0 years; 5 women, mean age 53.6 years) underwent surgery. Intraventricular tumors were predominant (72.7%, n=8), with only three cases in other regions (pineal region, corpus callosum, and parietal cortex). Headache and visual disturbances were the primary symptoms. All tumors showed contrast enhancement in MRI with 8 tumors displaying diffuse enhancement. Hydrocephalus was observed in 5 cases. The Ki67 index ranged from 2-10%. Residual tumors were detected postoperatively in 27.27% of cases (n=3). The average recurrence-free survival was 50.7 months (surgery and adjuvant radiotherapy: 48.8 months, surgery alone: 52.6 months). Aphasia, hemiparesis, and memory impairment were the most severe postoperative symptoms, with a postoperative Karnofsky Performance Status (KPS) <70% in 5 patients. Subsequent follow-up visits demonstrated a significant reduction in symptoms for all these patients with KPS ≥70%.

### Conclusion

Gross total resection is the recommended first line therapy for CN with a favorable neurological outcome. Adjuvant radiotherapy should be reserved for progression of remnant tumors or tumor recurrences.

# Tumor – Verschiedenes 4 | Neurooncology – Various 4

## P324

### Solitäre fibröse Tumore des zentralen Nervensystems: Eine Fallserie von 49 Patienten.
*Central nervous solitary fibrous tumors: A case series of 49 patients*

J. P. Alker[1], C. Herold-Mende[1], S. Krieg[1], A. Unterberg[1], G. Jungwirth[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland

#### Objective

Solitary fibrous tumors (SFTs)/hemangiopericytoma are rare central nervous tumors exhibiting a high recurrence rate and frequently metastasize to other organs. We conducted a retrospective study to investigate the clinicopathological characteristics and outcomes of this rare tumor type.

#### Methods

We performed a retrospective analysis of all patients who underwent resection of SFTs in our neurosurgery department from 2001-2023. We analyzed the data regarding sex, age at initial diagnosis, WHO grade based on the current WHO grading at that time, tumor localization, resection grade, adjuvant therapy, progression-free, and overall survival.

#### Results

Forty-nine patients were included in the study. The cohort had a median age of 54 years (range 22-86 years) and showed a female predominance of 1.22. SFTs were mainly located in the supratentorial region (56%), followed by 25% in the posterior fossa, and 15% in the spine. Histologically, 13% of the SFTs were WHO grade 1, 63% were grade 2, and 24% were grade 3 tumors at the initial diagnosis. Most patients underwent gross total resection (80%), while subtotal resection was achieved in 20% of the patients. 10% of patients suffered from extracranial metastasis spreading predominantly to the lung, liver, kidney, or bone. 27% of the patients received adjunctive radiotherapy. The median progression-free survival (PFS) of all patients was only 56 months and 80% of the patients survived 212 months with a median follow-up of 78 months (range 0-307 months). The median PFS of patients with grade 1 tumors was 85 months after initial diagnosis, 42 months for patients with grade 2 SFTs, and 56 months for grade 3 tumors.

In univariate analysis, radiation increased overall survival (Log-rank *P*=0.045) and progression-free survival (*P*=0.033) significantly. Systemic therapies, including tyrosine kinase inhibitors or chemotherapy, were only used in selected patients with metastatic disease.

#### Conclusion

Solitary fibrous tumors are rare intracranial malignancies exhibiting a high local recurrence rate. In most patients, safe gross total resection remains the standard of care and adjuvant radiation might improve progression-free and overall survival.

# P326

## Psychologische Faktoren und langfristige Beeinträchtigungen durch Tinnitus bei Patienten mit Vestibularisschwannom nach retrosigmoidaler Mikrochirurgie – eine Querschnittsstudie

***Psychological factors and long-term tinnitus handicap in vestibular schwannoma patients after retrosigmoid microsurgery – A cross-sectional study***

M. Thomas[1], M. Scheer[1], S. Rampp[1,2,3], C. Strauss[1], R. Schönfeld[4], B. Leplow[4]

[1]Universitätsklinikum Halle, Neurochirurgie, Halle, Deutschland
[2]Universitätsklinikum Erlangen, Neurochirurgie, Erlangen, Deutschland
[3]Universitätsklinikum Erlangen, Neuroradiologie, Erlangen, Deutschland
[4]Martin-Luther-Universität Halle-Wittenberg, Klinische Psychologie, Halle, Deutschland

### Objective

Tinnitus is a distressing symptom with a significant impact on the quality of life for vestibular schwannoma (VS) patients following retrosigmoid microsurgery. This cross-sectional study aimed to explore the connection between psychological factors and postoperative tinnitus, investigating its links to personality traits, dizziness, and perceived health benefits.

### Methods

Ninety-three VS patients participated in the study, providing information through questionnaires on demographics, personality traits (TIPI-G), tinnitus severity (THI-12), dizziness impact (DHI), perceived health benefits (GBI), somatization tendencies (SOMS-2), and psychological distress (HADS-D). The analysis utilized Mann-Whitney U-tests, Spearman"s rank-order correlations, and false discovery rate correction.

### Results

The majority of participants reported postoperative tinnitus (77/93), with 41 experiencing it preoperatively. Emotional stability correlated negatively with tinnitus presence, while tinnitus severity was associated with emotional distress. Preoperative somatization tendencies were also positively linked to tinnitus severity. Tinnitus showed additional connections to reduced perceived health benefits and increased levels of anxiety and depression. Notably, age and gender exhibited no significant associations.

### Conclusion

This study reveals the intricate interplay between postoperative tinnitus and psychological factors in VS patients, emphasizing emotional and cognitive dimensions. Tailored psychological interventions addressing the psychosomatic impact of tinnitus may enhance patients' quality of life. Future prospective studies with larger sample sizes are warranted to further explore these relationships.

# P327

## Die Kombinationsbehandlung mit ONC201/TIC10 and ABT-263 hat einen synergistischen hemmenden Effekt auf das Wachstum von Medulloblastomzellen

***ONC201/TIC10 and ABT-263 combined have synergistic antimedulloblastoma activity as identified by BH3 profiling***

A. Spilz[1], A. Hajosch[1], F. Seyfried[2], A. Peraud[1], V. V. Prabhu[3], J. E. Allen[3], M. A. Westhoff[2], M. D. Siegelin[4], C. R. Wirtz[1], G. Karpel-Massler[1]

[1]Universitätsklinikum Ulm, Neurochirurgie, Ulm, Deutschland
[2]Universitätsklinikum Ulm, Kinder- und Jugendmedizin, Ulm, Deutschland
[3]Chimerix, Durham, NC, Vereinigte Staaten
[4]Columbia University, Department of Pathology and Cell Biology, New York, NY, Vereinigte Staaten

### Objective

Medulloblastoma represents one of the most common brain tumors in children. In this study, we identified by BH3 profiling that ONC201/TIC10 sensitizes for Bcl-xL/Bcl-2 inhibition in medulloblastoma and performed a preclinical testing of a combined treatment with ONC201/TIC10 and the Bcl-xL/Bcl-2 inhibitor ABT-263.

### Methods

BH3 profiling was performed to examine apoptotic priming. The combination therapy was tested on established, primary cultured and stem-like medulloblastoma cells using MTT assays. Isobolograms were calculated for thorough evaluation of the nature of the drug-drug interaction. Spheroids were used to examine the effects of the combination therapy in a 3-dimensional setting. AnnexinV/PI staining and flowcytometry were used to detect pro-apoptotic effects. Western blot analyses and knockdown experiments with siRNA were performed for molecular analysis. Extracellular flux analyses served at examining effects on the tumor cell metabolism.

### Results

BH3 profiling showed that ONC201/TIC10 sensitizes PC322 medulloblastoma cells to Bcl-xL/Bcl-2 inhibition. In line with this finding, combined treatment with ONC201/TIC10 and ABT-263 led to a predominantly synergistic anti-proliferative effect on a variety of established and primary cultured medulloblastoma cells. The response towards the combination therapy was independent of baseline c-myc expression. Combined treatment with ONC201/TIC10 and ABT-263 resulted in a significantly enhanced inhibitory effect on spheroid growth. On the molecular level, treatment with ONC201/TIC10 led to a dose-dependent decrease of Mcl-1. Moreover, the combination caused enhanced cleavage of caspases 9 and 3. On the metabolic level, the combination therapy led to a reduction in both, oxidative phosphorylation and the glycolytic rate. In addition, a reduced expression of respiratory chain proteins was found.

### Conclusion

Combined treatment with ONC201/TIC10 and ABT-263 had a predominantly synergistic inhibitory effect on the cell viability of medulloblastoma cells. This effect was associated with downregulation of Mcl-1. Moreover, the combination treatment resulted in a metabolic reprogramming which likely creates a state of energy deprivation. Further studies are warranted.

# Tumor – Verschiedenes 4 | Neurooncology – Various 4

## P328

### *Digitale Sprach- und Sprechtherapie bei Hirntumorpatienten - eine unterschätzte Chance?*
### *Digital speech and language therapy of brain tumour patients – An underestimated opportunity?*

C. Weiß Lucas[1], S. Kochs[1], J. Jost[2], R. Loução[1], M. Kocher[1], R. Goldbrunner[1], D. Wiewrodt[2], K. Jonas[3]

[1]Universitätsklinikum Köln, Zentrum für Neurochirurgie, Köln, Deutschland
[2]Uniklinik Münster, Neurochirurgische Klinik, Münster, Deutschland
[3]Universität zu Köln, Department für Heilpädagogik und Rehabilitation, Köln, Deutschland

### Objective

Communication deficits are common in brain tumour patients and have a severe impact on social interactions and health-related quality of life. Nevertheless, timely detection and appropriate therapy of speech and language deficits are difficult in this patient cohort, not only due to the limited availability of speech and language therapists, but also to the variety of special needs and demanding tumour therapy regimes of the patients. To overcome such logistic problems, the use of digital tools might be a promising option. We, therefore, aimed to determine the current use of such tools and their evaluation by surveying German speech and language therapists.

### Methods

23 therapists (61% <35 years; all females) participated in the conditionally programmed, anonymous online survey in the last term of 2022. The assessed parameters included the frequency of use of telemedicine and other digital technologies in the assessment and/or therapy of acquired neurogenic communication disorders. Moreover, speech and language therapists were asked to rate the extent to which they believed that telemedical vs. in-person settings were therapeutically equivalent and which patient subgroups might be more vs. less suitable for telemedical approaches. Therapists were also asked if they consider the referral rate of brain tumour patients sufficient and, if not, to speculate over possible reasons.

### Results

Only third of the participants (35 %) responded that they used telemedicine and other digital instruments or procedures for the diagnostics or therapy of neurogenic communication disorders, mostly (88 %) for aphasia therapy. In contrast, 78% of the survey participants expressed the opinion that digital participation of brain tumour patients in the diagnostics and therapy of communication disorders should be improved. Most of respondents stated that in their experience, the referral of brain tumour patients to speech/communication therapy happens either too late (91%) or insufficiently (64%), supposedly due to lack of knowledge/awareness of the therapeutic potential, lack of time/workload, as well as different priorities (e.g., tumour control) of the medical staff.

### Conclusion

Achieving a paradigm shift in the inclusion of digital assessment/therapy technologies may be particularly important for HGG patients who not only struggle with neurogenic speech, language and communication disorders, but also with mobility and time limitations due to the effects of the tumour itself and tumour-related therapy.

# Tumor – Verschiedenes 4 | Neurooncology – Various 4

## P329

### Die prognostische Relevanz von funktionalen Skalen und Temporalmuskeldicke bei Patient:innen mit höhergradigen Gliomen.

***The prognostic relevance of temporal muscle thickness compared to functional scales in patients with high-grade glioma***

J. Klingenschmid[1], N. Pichler[1], A. Krigers[1], C. Thomé[1], C. Freyschlag[1]

[1]Medizinische Universität Innsbruck, Klinik für Neurochirurgie, Innsbruck, Österreich

#### Objective

Ongoing research in glioblastoma multiforme (GBM) aims to identify potential prognostic biomarkers to enhance our understanding of the disease and predict future outcomes. One such emerging marker is the measurement of temporalis muscle thickness (TMT), which has shown promise as a surrogate indicator of skeletal muscle mass and sarcopenia. This, in turn, can reflect frailty and provide insights into overall survival (OS). This study aimed to evaluate the utility of TMT as a prognostic marker in high-grade glioma patients, comparing it to functional status assessment scales.

#### Methods

TMT was assessed in 277 patients who underwent surgical treatment for newly diagnosed WHO III and IV gliomas at our institution from 2015 to 2020, using preoperative axial T1 weighted contrast-enhanced magnetic resonance images. Preoperative and follow-up evaluations included the Clinical Frailty Scale (CFS) and Karnofsky Performance Score (KPS).

#### Results

Female gender was found to have a significant association with TMT, while TMT did not exhibit correlations with preoperative and follow-up functional scores, age, WHO classification, IDH mutation, MGMT promoter methylation, EGFR and ATRX expression, or 1p/19q co-deletion. TMT did not demonstrate significant prognostic value for 6, 12, and 24-month OS, while changes in CFS and KPS were found to be significant predictors.

#### Conclusion

Only female gender, and not any other clinical, histological, or molecular markers, showed any relationship with TMT. Functional assessment scores proved to be superior to TMT measurement as reliable prognostic factors for predicting OS in high-grade glioma patients.

# P330

## Die Korrelation des KI-67-Proliferationsindex (KI-67-PI) mit den demografischen, bildgebenden und tumoralen Charakteristika von Patienten sowie dessen Beitrag zur Prognose des Langzeitverlaufs, der Histologie und des WHO-Grads bei primären intrakraniellen Meningiomen (PIM).

***The correlation of KI-67-proliferationsindex (KI-67-PI) with patient's demographic, imaging and tumour characteristics and it's role in predicting long-term course, histology and WHO grade of primary intracranial Meningioma (PIM)***

P. R. Wagle[1], R. Gerlach[1]

[1]Helios Klinikum Erfurt, Klinik für Neurochirurgie, Erfurt, Deutschland

### Objective

To analyse the correlation between KI-67-Proliferations Index (KI-67-PI) with patient´s imaging and tumour characteristics and long-term-course of patients with primary intracranial meningiomas (PIM).

### Methods

In this single-centre retrospective study, all consecutive patients with PIM were analysed from January 2007 to August 2019. Patient´s (age, sex), imaging (location, size, volume, edema, necrosis), and tumour characteristics (WHO grade, histology) were correlated with KI-67-PI. Long term data are retrieved from patient"s follow-up visits.

### Results

The study included 463 PIM in 457 surgically treated patients. Females exhibited lower KI-67-PI than males. ($p < 0.01$, Mann-Whitney U). Age positively correlated with KI-67-PI in both sexes ($p < 0.01$, Spearman), which means patients with higher age had a higher KI-67-PI. KI-67-PI was significantly different between PIM on convexity ($7.15 \pm 5.56$) and at frontal base ($4.66 \pm 2.94$; $p = 0.015$, ANOVA, Tukey´s HSD), while no difference was found in comparison of other locations (Tukey´s HSD). Higher KI-67-PI correlated with larger tumoral volume ($p < 0.01$, Spearman), larger tumoral necrosis and severe peritumoral edema ($p < 0.01$, Kruskal-Wallis). Long-term course categories revealed significant KI-67-PI expression differences between recurrent ($8.24 \pm 5.88$) and non-recurrent PIM ($5.14 \pm 3.53$) ($p < 0.01$, ANOVA, Tukey´s HSD) in a mean follow-up of $61.60 \pm 42.48$ months. Atypical and anaplastic variants of PIM ($12.09 \pm 0.73$) exhibited significantly higher KI-67-PI compared to all other WHO grade 1 histological subtypes ($4.51 \pm 0.13$; $p < 0.01$, Kruskal-Wallis test).

### Conclusion

This study emphasizes that KI-67-PI serves as a key indicator in PIM, correlating to imaging characteristics and predicting tumour aggressiveness and recurrence risk.

# P331

## Supratentorielles Hämangioblastom bei Erwachsenen: Eine systematische Übersicht und ein Vergleich mit infratentoriellen und spinalen Lokalisationen

***Supratentorial hemangioblastoma in adults: And comparison with infratentorial and spinal locations***

D. Jankovic[1], B. Splavski[2], K. Rotim[2], K. Arnautovic[3]

[1]University Medical Center, Department of Neurosurgery, Mainz, Deutschland
[2]Sestre milosrdnice University Hospital Center, Department of Neurosurgery, Zagreb, Kroatien
[3]University of Tennessee Health Science Center, Department of Neurosurgery, Memphis, Vereinigte Staaten

### Objective

Supratentorial hemangioblastomas are benign and highly vascularized neoplasms that appear most often in the spine and posterior cranial fossa. They can also be located in the supratentorial compartment of the brain. We conducted a systematic review of the literature to better understand the clinical insights of supratentorial hemangioblastoma in adults.

### Methods

Using Preferred Reporting Items for Systematic Reviews and meta-analysis guidelines, the authors reviewed the English-language literature in the PubMed/MEDLINE database on supratentorial hemangioblastoma in adults, published in the past 40 years. We analyzed the differences between sporadic hemangioblastomas and hemangioblastomas associated with von Hippel-Lindau disease. In addition, we compared the characteristics of supratentorial hemangioblastomas with infratentorial and spinal cord locations.

### Results

We reviewed 92 articles, describing 157 supratentorial hemangioblastomas in a total cohort of 148 adult patients. Most articles reporting supratentorial hemangioblastomas were published in the United States. Supratentorial hemangioblastomas occur more frequently in women than men. The median age at the time of diagnosis was 44.48 years. The sellar/parasellar region was the most common tumor location, while the most common morphological type was the solid type. Almost 80% of hemangioblastomas were completely resected; the outcome was favourable in more than 3 fourth of patients.

### Conclusion

Given their rarity, the literature on supratentorial hemangioblastomas is limited and based mostly on case reports. We found that the number of publications has increased in the past 21 years. Most articles were published in Asia, followed by Europe. However, the US leads the number of publications by country. The tumor occurred most frequently in the 5th decade of life and more often in women than men. Most patients underwent total tumor resection, which resulted in a favourable outcome in more than 80% of patients. Although the complication rate was less than 10% and the mortality rate was 4%, surgical treatment of supratentorial hemangioblastomas is challenging for neurosurgeons. Given the rarity of these tumors, multicenter studies are needed to further investigate their nature and characteristics.

# P332

## Zusammenhang der strukturellen Eigenschaften des frontalen Aslant-Trakts mit kognitiven Funktionen: neue Erkenntnisse aus 7-Tesla-Diffusionsbildgebung und Perspektiven in der neuroonkologischen Chirurgie

***Harnessing the frontal aslant tract's structure to assess its involvement in cognitive functions: New insights from 7-tesla diffusion imaging and perspectives for neurooncological surgery***

L. Serrano-Sponton[1], F. Lange[2], A. Dauth[2], H. Krenzlin[2], A. Perez[3], E. Januschek[1], S. Schumann[4], D. Jussen[5], M. Czabanka[5], F. Ringel[2], N. Keric[2], G. Gonzalez-Escamilla[6]

[1]Sana Klinikum Offenbach, Neurochirurgie, Offenbach am Main, Deutschland
[2]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurochirurgie, Mainz, Deutschland
[3]Oslo University Hospital HF, Neurologie, Oslo, Norwegen
[4]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Institut für Anatomie, Mainz, Deutschland
[5]Universitätsklinikum der Johann Wolfgang Goethe-Universität Frankfurt am Main, Neurochirurgie, Frankfurt a. M., Deutschland
[6]Universitätsmedizin der Johannes Gutenberg-Universität Mainz, Neurologie, Mainz, Deutschland

### Objective

The first therapeutical goal followed by neurooncological surgeons dealing with prefrontal gliomas is attempting supramarginal tumor resection preserving relevant neurological function. Therefore, advanced knowledge of the frontal aslant tract (FAT) functional neuroanatomy in high-order cognitive domains beyond language and speech processing would help refine neurosurgeries, predicting possible relevant cognitive adverse events and maximizing the surgical efficacy.

### Methods

After evaluating the volume of the FAT, we performed correlational tractography analyses to evaluate the possible relationship between FAT's microstructural properties and cognitive functions in 27 healthy subjects having ultra-high-field (7-Tesla) diffusion MRI. We independently assessed FAT segments innervating the dorsolateral prefrontal cortices (dlPFC-FAT) and the supplementary motor area (SMA-FAT).

### Results

FAT microstructural integrity, measured by the tract's quantitative anisotropy (QA), was associated with a better performance in episodic memory, visuospatial orientation, cognitive processing speed and fluid intelligence but not sustained selective attention tests. Overall, the percentual tract volume showing an association between QA-index and improved cognitive scores (pQACV) was higher in the SMA-FAT compared to the dlPFC-FAT segment. This effect was right-lateralized for verbal episodic memory and fluid intelligence and bilateralized for visuospatial orientation and cognitive processing speed.

### Conclusion

Our results provide novel evidence for a functional specialization of the FAT beyond the known in language and speech processing, particularly its involvement in several higher-order cognitive domains. In light of these findings, further research should be encouraged to focus on neurocognitive deficits and their impact on patient outcomes after FAT damage, especially in the context of glioma surgery.

## P334

### Neuronale Langzeitveränderungen im Sprachnetzwerk bei Patienten mit Tumorrezidiven sprachkritischen Regionen

***Neuroplastic long term-changes in the language network in patients with recurrent glioma in language critical brain areas***

K. Rosengarth[1], K. Hense[2], E. Gerl[2], D. Deuter[2], C. Ott[2], N. O. Schmidt[2], C. Doenitz[2]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Regensburg, Klinik mit Poliklinik für Neurochirurgie, Regensburg, Deutschland

#### Objective

Glial brain tumors in language areas may trigger functional reorganization in language networks on a local and global level. The existence, the nature, and underlying processes of those neuroplastic processes in the language network are still under debate. The aim of this fMRI study was to investigate if there are functional global and local long-term changes due to recurrent brain tumors in language critical areas.

#### Methods

23 patients with glial brain tumors in the language critical areas in the language dominant hemisphere were included in this analysis (mean age 42,83y; 11 females; tumor location: 9 frontal, parietal 3, temporal 11). Patients underwent presurgical fMRI sessions at initial tumor appearance and at recurrent tumor manifestation (mean time between fMRI scans was 919,57 days). During fMRI patients performed covertly a verb, an antonym, and a sentence generation task. fMRI data analysis was done by using SPM12. To assess possible long-term changes in the language system, Dice coefficients of T-maps were calculated. Further cluster sizes in the left and right frontal, temporal, parietal and occipital cortex were compared across the two time points. At least % signal-changes in the left pars opercularis and triangularis of the inferior frontal gyrus, the angular gyrus, the supramarginal gyrus, superior and middle posterior temporal gyrus were calculated and compared across the two time points.

#### Results

Dice indices of language activation T-maps were .56 for the verb task, .56 for the anonym task and .63 for the syntactic task suggesting medium accordance between activation pattern of the 2 fMRI sessions. Cluster size across the 2 fMRI sessions showed significantly increased cluster sizes during the fMRI session at onset of disease compared to the session of tumor recurrence in the left ($p=.022$) and trendwise in the right frontal lobe ($p=.061$) but only for the verb generation task. Finally, % signal changes were significantly higher in all language associated ROIs in the initial fMRI-session compared to the session of tumor recurrence in all language paradigms ($p<.05$).

#### Conclusion

Data of this study suggest medium long-term local effects of brain tumors in the language network in the bilateral frontal lobe language by showing increased cluster size before further tumor treatment. On a global level, fMRI-signal intensity is reduced in the whole language network which could possibly be related to continuous tumor growth or tumor treatment.

# Tumor – Verschiedenes 4 | Neurooncology – Various 4

## P335

### Behandlung postoperativer Sprachstörungen nach Hirntumorresektionen mittels rTMS – eine Pilotstudie
*rTMS-based neuromodulation for treatment of postoperative aphasia after tumor resection – A pilot study*

M. L. Neymeyer[1], L. Rybka[1,2], N. Hoekzema[1,3], H. Schneider[1], M. Engelhardt[1,4], R. Tomasello[5,6], P. Vajkoczy[1], T. Picht[1,5], T. Rosenstock[1,7]

[1]Charité – Universitätsmedizin Berlin, Department of Neurosurgery, Berlin, Deutschland
[2]University of Groningen, Center for Language and Cognition, Groningen, Niederlande
[3]University of Groningen, Speech Lab Groningen, Faculty of Arts, Groningen, Niederlande
[4]Charité – Universitätsmedizin Berlin, Einstein Center for Neurosciences, Berlin, Deutschland
[5]Humboldt University, Cluster of Excellence Matters of Activity, Image Space Material, Berlin, Deutschland
[6]Freie Universität Berlin, Brain Language Laboratory, Department of Philosophy and Humanities, Berlin, Deutschland
[7]BIH – Berlin Institute of Health, BIH Biomedical Innovation Academy, BIH Charité Digital Clinician Scientist Program, Berlin, Deutschland

#### Objective

Postoperative aphasia is a serious complication after brain tumor resection which can occur despite monitoring during awake craniotomies. In addition to a considerable impairment of the quality of life, the oncological prognosis in these patients is also limited. The neuromodulatory application of rTMS is already established in the treatment of stroke-related aphasia. The aim of this study is to investigate the feasibility of rTMS-based neuromodulation to patients with postoperative aphasia after brain tumor resection.

#### Methods

This pilot study aims to include all patients who have experienced new or progressive aphasia after brain tumor resection. The rTMS therapy started in the first 3 days after surgery, with ipsilesional peritumoral inhibitory / low-frequency stimulation (1 Hz; 110% of the individual RMT; duration: 10 min) and contralesional excitatory / high-frequency stimulation in the corresponding area (10 Hz; 110% of the individual RMT; duration: 8 min). During the stimulation, patients continuously work on specific language tasks to activate the language areas intrinsically. This is followed by 30-45 minutes of speech and language therapy (SLT). Beside treatment related side effects, the language outcome – as primary outcome - is assessed using the Aachener Aphasie Test (AAT) before, immediately after therapy, and at 1 and 3 months post-therapy. The second outcomes are examined using the National Institutes of Health Stroke Scale (NIHSS) and. Quality of Life questionnaires.

#### Results

So far, two patients were included. In both cases, therapy was completed without the occurrence of serious side effects. Only one patient experienced a mild, temporary headache during a session, which subsided with the routine postoperative pain medication. Short-term language outcome analysis (immediately after rTMS therapy) revealed clear improvements of the first patient compared to the post-operative deficits (mean AATpre therapy: 196/460; mean AATpost therapy: 291/440).

#### Conclusion

The initial preliminary results indicate that rTMS neuromodulation may be used to treat postoperative aphasia without relevant side effects. Neuromodulatory treatment of postoperative neurological deficits is of great importance not only to improve the patients' quality of life but also their oncological prognosis.

# P336

## Postoperatives Management von Tumoroperationen im Bereich der Pinealis in halbsitzender Position: Komplikationen und intensivmedizinische Herausforderungen

***Postoperative management of tumor surgery in the pineal region in the semi sitting position: Complications and intensive care challenges***

A. Karbe[1], J. Grensemann[2], P. Czorlich[1], J. Forisch[1], T. Sauvigny[1], C. Mende[3], M. Westphal[1], M. Mohme[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Zentrum für Anästhesiologie und Intensivmedizin, Hamburg, Deutschland
[3]Friedrich-Ebert-Krankenhaus Neumünster, Klinik für Neurochirurgie und Wirbelsäulenchirurgie, Neumünster, Deutschland

### Objective

The sitting position remains an important position to have easier access to pathologies in the pineal region, rostral subtentorial lesions or cervical spine. Due to the patients' upright position, it comes with specific risks, which must be considered. The obvious threat is the occurrence of venous air embolism as well as pneumocephalus. Thus, patients undergoing tumor resection in the pineal region require increased perioperative attention. The aim is to identify risk factors which led to a prolonged ventilation time and subsequent intensive care unit (ICU) stay.

### Methods

We retrospectively analyzed 60 patients who underwent tumor surgery in the sitting position from 2008 to 2023 in our centre. Patients were divided into 3 groups according to their length of stay in the ICU (<24 hours, 24-48 hours and >48 hours). We compared the groups regarding peri-and postoperative parameters as well as complication rates. Intraoperative occurrence of venous air embolism was monitored by a transoesophageal echo. If postoperative CT imaging was available, the intracranial air volume was measured using BrainLab software.

### Results

Out of 60 patients, 34 patients (56.7%) were in the ICU for <24hrs, 12 (20%) for 24-48hrs, and 14 patients (23.3%) experienced an extended ICU stay beyond 48hrs. The surgery duration for those with prolonged ICU admissions was on average 56 min longer ($p<0.05$). Ventilation time was 113min in patients staying <24hrs versus 739min in patients with prolonged stay above 48hrs. Symptomatic pneumocephalus was the most frequent cause of an extended ICU stay, occurring in 8 cases. Patients with prolonged ICU stay had an average intracranial air volume of 69.7 $cm^3$, compared to 28.4 $cm^3$ in others ($p<0.05$). In the prolonged ICU stay group, 28.6% of patients developed transient hydrocephalus, compared to 4.4% in patients with <48h ICU stay ($p<0.05$). 25% of patients had an open foramen ovale but with adequate measures clinically significant venous air embolism could be prevented except for one patient.

### Conclusion

The findings suggest that using the sitting position for neurosurgical tumor removal is generally safe. The primary cause for extended hospital stays was identified as hydrocephalus or pneumocephalus. Contrary to prior research, clinically significant venous air embolism was rare, occurring only once.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P337

### Analyse der klinischen Merkmale von Kindern mit intrakraniellen Abszessen in der Post-Covid-19-Ära
*Clinical feature analysis of children with intracranial abscesses in the Post-Covid-19 Era*

M. Middelkamp[1], M. Kania[2], U. Schulze-Sturm[2], F. S. Groth[1], F. Ricklefs[1], L. Dührsen[1]

[1]Universitätsklinikum Hamburg-Eppendorf, Klinik mit Poliklinik für Neurochirurgie, Hamburg, Deutschland
[2]Universitätsklinikum Hamburg-Eppendorf, Klinik und Poliklinik für Kinder- und Jugendmedizin, Hamburg, Deutschland

#### Objective

Intracranial suppurative infections in pediatric patients pose a potentially deadly disease. However, there is limited data available on the management and trends of intracranial abscesses in children. Interestingly, a high frequent series of nine cases occurred from December 2022 to May 2023 after easing measures following the Covid19 pandemic. This retrospective monocentric study aims to analyze clinical features to identify areas for improvement in disease management.

#### Methods

A digital data query identified pediatric patients with intracranial infections. Nine cases were analyzed, and comprehensive clinical information was collected. Statistical analysis was conducted to determine significant feature correlations.

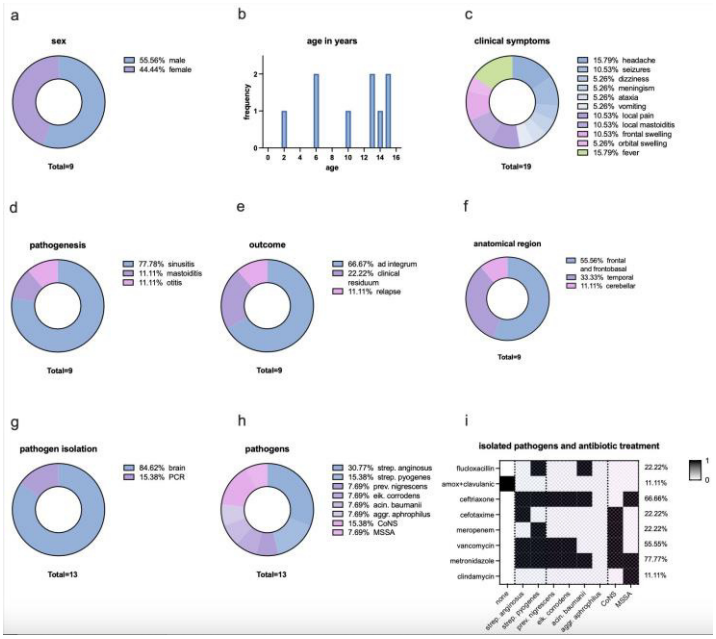
#### Results

The study found a similar sex distribution with a mean age of 10.2 years. Clinical symptoms were equally divided between half neurological symptoms and the other half consisting of swelling, fever, and local symptoms. Sinusitis was identified as the cause in 75 % of the cases. Two-thirds of the cases had a favorable outcome of complete recovery. The frontal region was the most affected anatomical region. Pathogens were isolated in four out of five cases using material from brain surgery. Streptococcal infections accounted for half of the cases, while anaerobic infections and staphylococcal infections accounted for one-quarter each. Pathogens were treated with third-generation cephalosporin in 90% of cases, and metronidazole was used in 75% of cases. The study found significant associations between sinusitis and Streptococcus pyogenes, fever and temporal involvement, frontal/frontobasal involvement and temporal involvement, fever and frontal/frontobasal involvement, sex and metronidazole use, as well as sex and pathogen isolation from brain samples.

#### Conclusion

In our treatment strategy, we had no death events and approximately 22% of patients with clinical residuals. Facing the seriousness of this disease, even in the case of clinical suspicion such as the combination of sinusitis, fever and neurological disease, an unconditional image morphological clarification, ideally using MRI, must be carried out as quickly as possible. Prompt surgical removal of the abscess should be aimed for, postoperative calculated antibiotic therapy should be initiated immediately and covered following the antibiogram. Decreased transmission of respiratory pathogens during COVID-19 pandemic maybe led to a shift of incidence and a seasonal increase of intracerebral abscesses.

Abb. 1


a
sex
55.56% male
44.44% female
Total=9
b
age in years
frequency
age
c
clinical symptoms
15.79% headache
10.53% seizures
5.26% dizziness
5.26% meningism
5.26% ataxia
5.26% vomiting
10.53% local pain
10.53% local mastoiditis
10.53% frontal swelling
5.26% orbital swelling
15.79% fever
Total=19
d
pathogenesis
77.78% sinusitis
11.11% mastoiditis
11.11% otitis
Total=9
e
outcome
66.67% ad integrum
22.22% clinical residuum
11.11% relapse
Total=9
f
anatomical region
55.56% frontal and frontobasal
33.33% temporal
11.11% cerebellar
Total=9
g
pathogen isolation
84.62% brain
15.38% PCR
Total=13
h
pathogens
30.77% strep. anginosus
15.38% strep. pyogenes
7.69% prev. nigrescens
7.69% eik. corrodens
7.69% acin. baumanii
7.69% aggr. aphrophilus
15.38% CoNS
7.69% MSSA
Total=13
i
isolated pathogens and antibiotic treatment
fluoxacillin
amox+clavulanic
ceftriaxone
cefotaxime
meropenem
vancomycin
metronidazole
clindamycin
22.22%
11.11%
66.66%
22.22%
22.22%
55.55%
77.77%
11.11%
none
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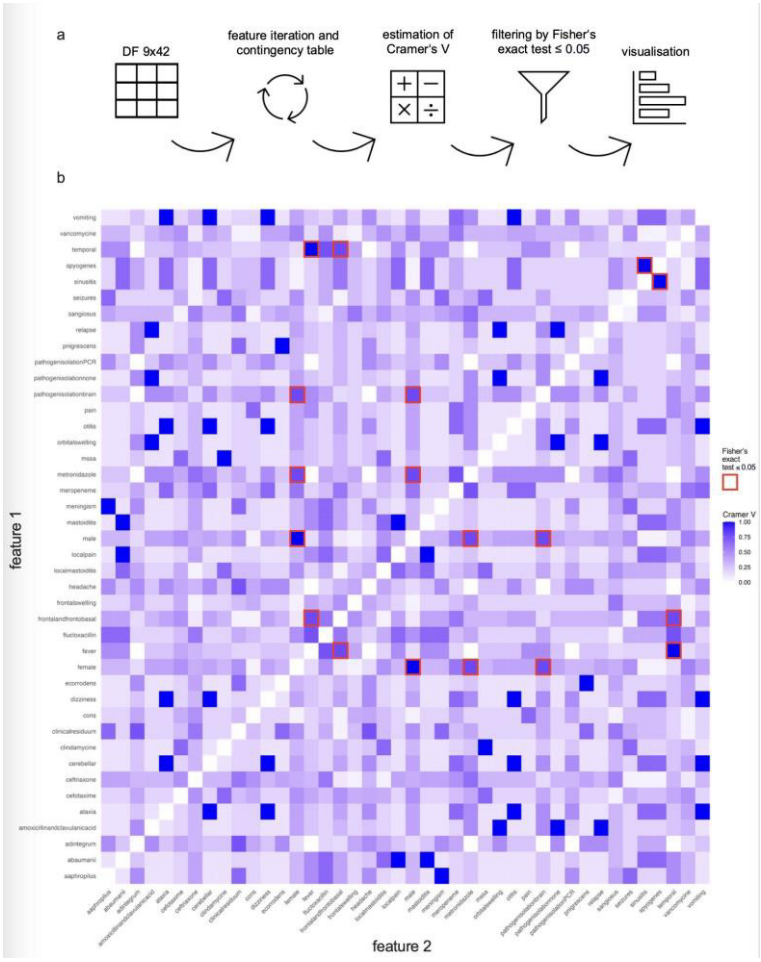
strep. pyogenes
prev. nigrescens
eik. corrodens
acin. baumanii
aggr. aphrophilus
CoNS
MSSA

Abb. 2


a
DF 9x42
feature iteration and contingency table
estimation of Cramer's V
filtering by Fisher's exact test ≤ 0.05
visualisation
b
feature 1
feature 2
Fisher's exact test ≤ 0.05
Cramer V

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P338

### Vergleichende Studie über die Komplikationslast von zwei Ventrikeldrainage-Anlagetechniken bei Kindern mit akutem Hydrozephalus

***Comparative study of the complication burden of two external ventricular drain positioning techniques in children with acute hydrocephalus***

T. Araceli[1], F. Zeman[2], N. O. Schmidt[1], C. Ott[1]

[1]Universitätsklinikum Regensburg, Neurochirurgie, Regensburg, Deutschland
[2]Universitätsklinikum Regensburg, Statistik, Regensburg, Deutschland

#### Objective

The insertion of an external ventricular drain (EVD) is a standard procedure for the treatment of acute hydrocephalus. To compare the regularly adopted surgical procedures in our clinic in terms of complications, the first analysis on a pediatric population was performed.

#### Methods

101 patients were included in this retrospective study (62 males, 39 females, mean age 7,1 years, range from 17,5 to 0 years) and dichotomized considering two different surgical procedures to reach the ventricular system: an electric or mechanical compressed air drill and the BoltKit-System (BS). The first procedure implies an under-scalp drain tunneling, the second one entails the fixation of the EVD in a skull bolted screw. In both techniques a catheter fixation by the skull skin is required.

Statistical analyses were performed balancing gender, age, side and the location of the drainage with the occurrence of complications like cerebrospinal fluid (CSF) infections, multiple insertion attempts, malpositions, revisions and bleedings. The group comparison was conducted using a chi square dependency test.

#### Results

79 patients were treated using the tunneling procedure, 22 the BS procedure. 81 EVDs were placed frontal, 18 occipital, 68 right and 25 left. Revisions (n=22) represented the most frequent complication, followed by CSF infections (n=13), multiple insertion attempts (n=11), malpositions (n=10) and bleedings (n=4). Considering the EVD positioning, CSF infections occured more frequently frontal than occipital (p=0.009). No other differences in terms of complications could be found, not even in relation to the side of the drainage, age and gender. Multiple insertion attempts, malpositions and revisions were significantly higher by the BS-procedure (p=0.017; p=0.037; p=0.019). Regarding CSF infections and bleeding no significant differences between the two procedures could be detected.

#### Conclusion

We could report a higher rate of complications by the BS procedure compared with the tunneling procedure for the treatment of children with acute hydrocephalus. No difference concerning CSF-infections could be described.

Abb. 1

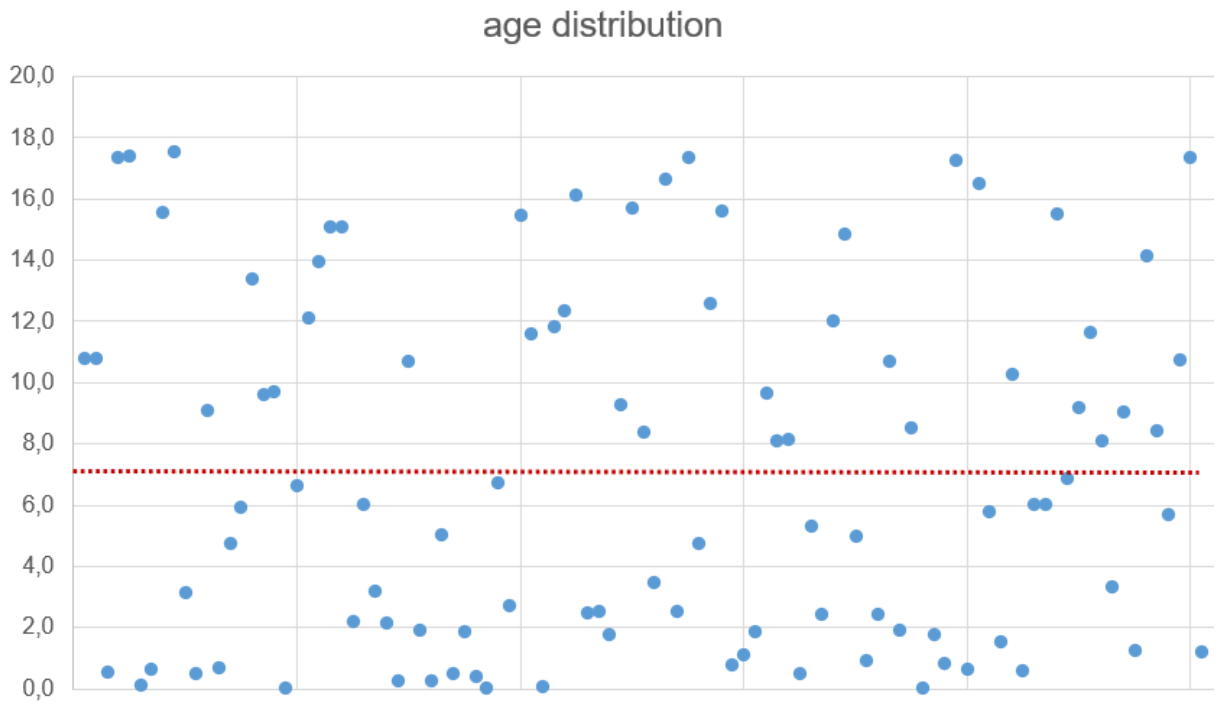
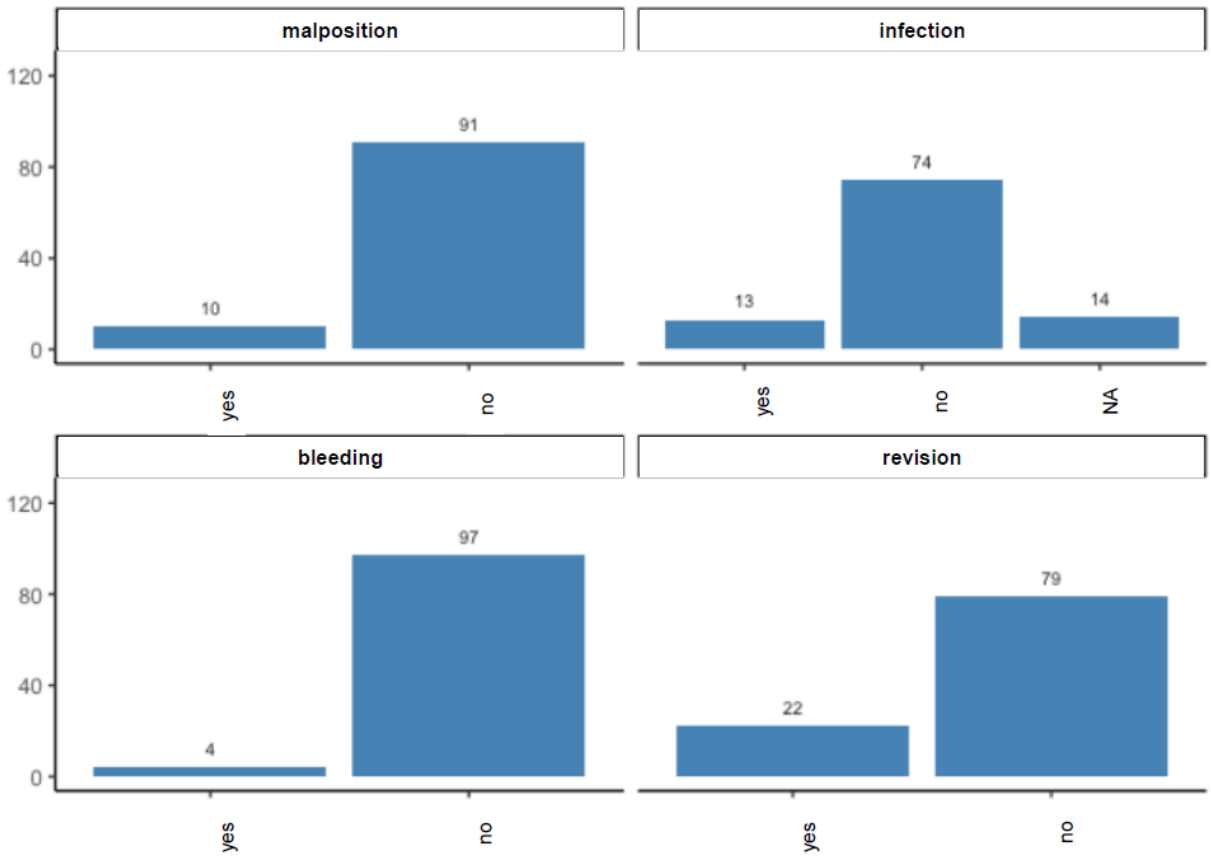

age distribution
20,0
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0

Abb. 2


malposition
infection
bleeding
revision
120
80
40
0
91
10
74
13
14
97
4
79
22
yes
no
NA

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P339

### Aktuell Serie zur transsphenoidalen sellären Chirurgie bei pädiatrischen Patient:innen
*Contemporary series of transsphenoidal sellar surgery in pediatric patients*

S. Ott[1], R. Rotermund[2], J. Flitsch[1], A. Ryba[1]

[1]UKE Hamburg, Neurochirurgie, Hamburg, Deutschland
[2]Diako Krankenhaus, Neurochirurgie, Flensburg, Deutschland

### Objective

Tumors located in the pituitary region are infrequent among childhood, primarily consisting of craniopharyngeomas or pituitary adenomas. Although pituitary adenomas are more prevalent in adults, they make up less than 3% of all supratentorial tumors in children. Unlike their adult counterparts, pediatric pituitary tumors (PPTs) are predominantly secreting tumors and associated with significant morbidity. Due to their rare occurrence and complex nature, PPTs have received limited research attention. Consequently, this comprehensive study aims to explore the epidemiological and clinicopathological characteristics of PPTs

### Methods

This retrospective study examined a total of 124 patients aged <18 years, who underwent transsphenoidal surgery for pituitary region lesions between 2013 and 2023. Parameters assessed included age, gender, clinical hormone production, histopathological and radiographic parameters, surgical features, postoperative complications and recurrences rate.

### Results

Among a total of n=124 pediatric patients, 30.7% underwent surgery to treat histologically confirmed pediatric pituitary tumors (PPTs), with ACTH-secreting adenomas being the most prevalent at 17.5%. We observed an age-dependent distribution pattern among all pituitary lesions, with craniopharyngiomas most frequently occurring in patients under 10 years old, accounting for 67.8% of cases, followed by ACTH-secreting adenomas (7.14%) and chordomas (7.14%). However, in patients older than 10 years, PPTs were the most common pituitary lesions, comprising 36.6% of cases, with corticotrophic (20.4%) and lactotrophic (7.5%) adenomas being the most common subtypes among all PPTs. Importantly, patients with corticotrophic adenomas were significantly younger than those with prolactinoma (12.8 vs. 15.7 years, p=0.0123) and showed a male predominance (1.75:1), whereas prolactinoma occurred more frequently in females (1:2). There were no significant differences in recurrence rates among the various PPT subtypes (p=0.516).

### Conclusion

The current study is one of the largest to date, that examined perioperative features of pediatric pituitary region lesions. The age-dependent distribution pattern highlightes the prominence of craniopharyngiomas in younger patients, whilte PPTs became increasingly prevalent in those older than 10 years with predominant corticotrophic and lactotrophic subtypes. This series contributes a better understanding of PPTs, shedding light on their demographic, clinical and histopathological features.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P340

### Verbesserung der neurologischen Bildgebung bei Kindern: Wirksamkeit und Sicherheit der Magnetresonanztomographie mit schneller Sequenz bei der Beurteilung von Hydrozephalus und intrakraniellen Tumoren

***Enhancing pediatric neuroimaging: Efficacy and safety of rapid sequence magnetic resonance imaging in assessment of hydrocephalus and intracranial tumours***

M. Issa[1], N. Ueding[1], C. Ott[2], C. Dannehl[1], A. Seitz[2], A. Unterberg[1], S. Krieg[1], A. El Damaty[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Neuroradiologie, Heidelberg, Deutschland

#### Objective

Rapid Sequence Magnetic Resonance Imaging (RS-MRI) is a valuable diagnostic tool for assessing hydrocephalus, trauma, and intracranial tumours in pediatric patients. It minimizes the need for anaesthesia and radiation, streamlining clinic procedures, yet its utilization remains limited. This study aims to enhance the efficacy of RS-MRI.

#### Methods

This retrospective analysis included 131 RS-MRIs in 57 pediatric patients with hydrocephalus and intracranial tumours (March 2013 to June 2023). Descriptive analysis covered age, gender, follow-up duration, etiology, symptoms, clinical/radiological benefits, and surgical/nonsurgical complication rates. MRIs included AAHead-Scout, AAHead-Scout-MPR tra, T2 sequence BLADE tra, and T2 TSE 384 p2 tra 5mm, lasting 195 seconds.

#### Results

A total of 131 RS-MRIs in 57 pediatric patients were included, with a mean age of 6.94 ± 4.25 years, and 71.8% were males. The most common diagnostic indication was suspected CSF shunt dysfunction (61.1%), followed by symptomatic pediatric patients with known intracranial tumours (19.8%), and hydrocephalic pediatric patients with CSF shunts and intracranial tumours (18.3%). In 32 (24%) RS-MRIs, patients were treated as outpatients, while the rest (76%) were treated as inpatients. Surgery was indicated in 24 (20%) RS-MRIs, and shunt adjustment in 57 (43.5%) RS-MRIs. The median inpatient stay lasted 4 days (range 1-130 days). Only in 7 (5%) RS-MRIs was a normal MRI with intubation and general anaesthesia necessary, with therapy consequences in 6 cases. Patients with intracranial tumours required a significantly longer inpatient stay (33 vs. 9 days on average, p=0.31) compared to patients with CSF shunt systems.

#### Conclusion

RS-MRI proves to be a safe and efficient diagnostic tool for assessing pediatric patients with hydrocephalus and intracranial tumours, exhibiting high diagnostic yield and a low complication rate. It is strongly recommended to prioritize RS-MRI in children whenever possible.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P341

### Externe Ventrikeldrainage bei pädiatrischen Patienten: Indikationen und Komplikationen
*External ventricular drainage in pediatric patients: Indications and complications*

O. Atallah[1], J. K. Krauss[1], E. J. Hermann[1]

[1]Medizinische Hochschule Hannover, Neurochirurgie, Hannover, Deutschland

#### Objective

External ventricular drainages (EVD) have their specific risks in the pediatric population. We have investigate the indication and complications during the placement of EVD and analyze complications while the EVD is in place.

#### Methods

We retrospectively analyzed the data of all pediatric patients in our institution who received an EVD placement between February 2008 and January 2020. The primary outcome was the occurrence of complications after the placement of the EVD. Demographic and clinical data from all children were analyzed to examine the underlying conditions and complications that lead to the indication of an EVD. Additional clinical data, such as the duration of the EVD stay, the methods used for placement, and the complications while the EVD was in place were examined.

#### Results

Data from 126 patients were analyzed for this study. 72 (57 %) of the patients were male, 54 (53 %) female. The average age of the patients at the time of EVD placement was 5.2 ± 5.0 years with a range of 0–17 years. The patients were divided into three groups, patients with tumors (n=54, 42.9%), patients that required EVD placement after a previously placed shunt needed to be removed due to an infection (n=47, 37.3%), and patients who had suffered an hemorrhage of various causes (n=25, 19.8%). Complications during the placement of the EVD were misplacement of the EVD and hemorrhage, which occurred in four instances in the hemorrhage group (16%) and in one pediatric patient in the infection group (1.85%). During the time of the maintenance of the EVD 19.08% had transient complications. Conversion rates of the EVD into a permanent shunt were similar for patients with tumors (27.7%) and those with hemorrhage (32%).

#### Conclusion

EVD placement is an effective and a relatively safe option to temporarily treat hydrocephalus in children.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P342

### Reduzierte Migration von Tumor Zellen nach RNAi induzierter Herunterregulation von MutT homolog1 in Medulloblastomen

*Impaired migration of tumor cells after MutT homolog1 silencing in paediatric medulloblastoma*

S. Kuhl[1], J. Arrets[1], R. Goldbrunner[1], M. Timmer[1]

[1]Universitätsklinikum Köln, Neurochirurgie, Köln, Deutschland

#### Objective

MutT homolog1 (MTH1), an enzyme that hydrolyses oxidized nucleotides, is essential for cancer cell survival. Their enhanced metabolism results in increased production of reactive oxygen species that damage the deoxynucleotide triphosphate pool and thus DNA. By inhibiting the incorporation of oxidized bases into the DNA to avoid cytotoxic effects, MTH1 plays a crucial role in cancer but not healthy cells. Recent studies have shown a link between inhibition of MTH1 and cancer growth in various cancers. Since MTH1 is highly expressed in adult glioma, we aimed to analyse the expression and function of MTH1 in paediatric brain tumors.

#### Methods

Tumor samples were obtained during neurosurgery and shock frozen in liquid nitrogen. Transcription rate was measured using qPCR, protein expression with western blotting. MTH1 expression rate was evaluated in the following paediatric tumor entities: Astrocytoma, neurofibroma, DNT, plexus papilloma, glioblastoma, ependymoma, medulloblastoma craniopharyngioma and ganglioglioma. Age comparison to young adult and adult patients was done for glioma, medulloblastoma and ependymoma. A pediatric medulloblastoma cell line was cultivated for functional analysis. Expression was inhibited via siRNA nucleofection. CTB assay for cell viability and scratch assay for migration behavior were performed.

#### Results

Comparison of paediatric brain tumors revealed most MTH1 expression in medulloblastoma, with highest level in young adult patients (1.09 vs. 4.15 vs. 1.95). Inhibition of MTH1 in a paediatric medulloblastoma cell line showed reduced migration behaviour compared to untreated cells (wound width 96 h post transfection: 57 % vs. 34 %). A decrease in cell viability after treatment with MTH1 siRNA was not found.

#### Conclusion

These results could suggest MTH1 as a target for tumor growth inhibition, especially regarding tumor cell migration. Experiments with cricotenib as MTH1 inhibitor are ongoing.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P343

### Prognostisches Nomogramm für Langzeitergebnisse bei intrakraniellen pädiatrischen Meningeomen: Eine umfassende Analyse

***Prognostic nomogram for long-term outcomes in intracranial pediatric meningiomas: A comprehensive analysis***

L. Hua[1], L. Ren[1], Y. Gong[1]

[1]Huashan Hospital, Fudan University, Neurosurgery, Shanghai, China, Volksrepublik

#### Objective

Meningioma represents the most common intracranial tumor among adults. However, it is rara in pediatric patients. We are aimed to demonstrated the clinicopathological characteristics and long-term outcome of pediatric meningiomas (PMs).

#### Methods

We enrolled 74 patients with intracranial PMs. Clinicopathological characteristics and progression-free survival (PFS) were analyzed in PMs. PFS were compared between PMs and adult meningiomas (AMs). Univariate and multivariate Cox analysis was employed to evaluate the predictive values of clinicopathological characteristics.

#### Results

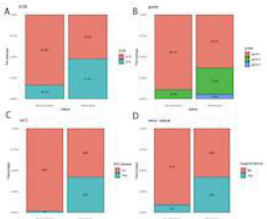
40 females (54.1%) and 34 males (45.9%) patients were identified, resulting in a gender ratio of 1.18:1 in the PM cohort. Of the patients, 9 (12.2%) were diagnosed as neurofibromatosis type 2 (NF2) diseases, 65 (87.8%) were sporadic. The most common tumor location was the convexity (n=29, 39.2%), followed by skull base (n= 23, 31.1%), ventricular (n= 16, 21.6 %) and parasagittal (n= 6, 8.11%). 19 patients (25.7%) experienced recurrence during a median follow-up period of 33 months (range 2 -145.25 months). The 3-, 5-, and 8-year PFS rates was 74.74%, 74.74%, and 59.38%, respectively. When compared to AMs, no significant differences in PFS were observed between the two cohorts, even after propensity score matching (PSM). The multivariate Cox results showed NF2 disease ($p<0.001$) and EOR ($p=0.013$) were independently associated with the PFS of patients with PMs. A nomogram was constructed based on the results of the multivariate Cox analysis. The 3-, 5- and 8-year Area Under the Curve (AUC) of the nomogram was 0.927, 0.930, 0.870, respectively, indicating its superior predictive accuracy for long-term PFS.

#### Conclusion

PMs are characterized by their atypicality of male predominance, ventricular location, and NF2 disease. A nomogram with excellent predictive accuracy for long-term outcome was constructed.

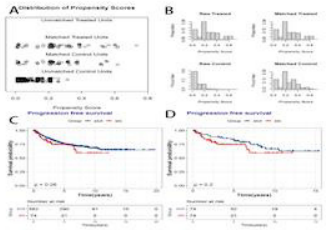
Abb. 1

Fig1



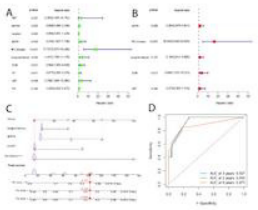
The clinical characteristics comparisons between stable and recurrent patients. **A**: the EOR comparisons between stable and recurrent patients. **B**: the WHO grade comparisons between stable and recurrent patients. **C**: the NF2 disease comparisons between stable and recurrent patients. **D**: the surgical history comparisons between stable and recurrent patients.

Fig2



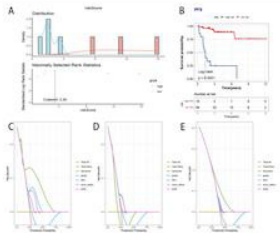
Distribution of propensity scores and Kaplan-Meier survival curves of matched cohorts. **A:** Distribution of the matched samples in the PM and AM cohorts. **B:** Distribution of propensity scores in the PM and AM cohorts. **C:** PFS comparisons between PM and AM cohorts before PSM. **D:** PFS comparisons between PM and AM cohorts after PSM

Fig3



The univariate and multivariate Cox analysis results. **A:** The forest plot of univariate Cox analysis result. **B:** The forest plot of multivariate Cox analysis result. **C:** Nomogram to predict the 3-year, 5-year and 8-year PFS rates of PM patients. **D:** The time-independent ROC curves and AUC values of the nomogram.

Fig4



The risk score of the nomogram. **A:** The optimal cut-off of the risk score generated by the nomogram. **B:** The Kaplan-Meier curve of different risk groups divided by the cut-off 3.45. **C-E:** The DCA decision curve evaluates the superiority of the all factors in predicting the 3-(**C**), 5- (**D**), and 8- (**E**) year recurrent probabilities.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P344

### Der Zusammenhang der COVID-19-Pandemie mit dem Anstieg sinogener und otogener intrakranieller Infektionen bei Kindern: Eine 10-jährige retrospektive vergleichende monozentrische Studie

***The association of COVID-19 pandemic with the increase of sinogenic and otogenic intracranial infections in children: A 10-Year retrospective comparative single-center study***

M. Issa[1], V. Kalliri[1], S. Euteneuer[2], A. Krümpelmann[2], A. Seitz[3], O. Sommerburg[2], J. H. Westhoff[2], S. Syrbe[2], P. Lenga[1], M. Grutza[1], M. Scherer[1], J. O. Neumann[1], I. Baumann[4], A. Unterberg[1], A. El Damaty[1]

[1]Universitätsklinikum Heidelberg, Neurochirurgie, Heidelberg, Deutschland
[2]Universitätsklinikum Heidelberg, Pädiatrie, Heidelberg, Deutschland
[3]Universitätsklinikum Heidelberg, Neuroradiologie, Heidelberg, Deutschland
[4]Universitätsklinikum Heidelberg, Hals-Nasen-Ohr, Heidelberg, Deutschland

#### Objective

Otitis media and sinusitis are common childhood infections, typically mild with good outcomes. Recent studies show a rise in intracranial abscess cases in children, raising concerns about a link to COVID-19. This study compares a decade of data on these cases before and after the pandemic.

#### Methods

This retrospective comparative analysis includes pediatric patients diagnosed with otitis media and sinusitis, who later developed intracranial abscesses over the past decade. We collected comprehensive data on the number of cases, patient demographics, symptoms, treatment, and outcomes.

#### Results

Between January 2013 and July 2023, our center identified 10 pediatric patients (median age 11.1years, range 2.2 – 18.0 years, 60% male) with intracranial abscesses from otitis media and sinusitis. Of these, 7 cases (70%, median age 9.7 years, range 2.2 – 18.0 years) occurred since the onset of the COVID-19 pandemic, while the remaining 3 cases (30%, median age 13.3 years, range 9.9 – 16.7 years) were treated before the pandemic. No significant differences were found in otolaryngological associations, surgical interventions, preoperative symptoms, lab findings, or postoperative antibiotics between the two groups. All patients showed positive long-term recovery.

#### Conclusion

This study reveals 5-fold increase of pediatric otogenic and sinogenic intracranial abscess cases in the last three-years since the onset of the COVID-19 pandemic. While further investigation is needed, these findings raise important questions about potential connections between the pandemic and the severity of otitis media and sinusitis complications in children. Understanding these associations can improve pediatric healthcare management during infectious disease outbreaks.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P345

### Der Einfluss der Helmtherapie auf das morphometrische Outcome nach minimal invasiver Operation von prämaturen Sagittalnahtsynostosen bei Skaphozephalie

***The impact of post-operative head-orthosis on the morphometric outcome after minimally invasive surgery for premature sagittal suture synostosis***

F. Knerlich-Lukoschus[1], A. M. A. Quast[2], R. Lübbeke[2], T. Johanna Katharina[2], H. C. Bock[3], P. F. Meyer-Marcotty[2]

[1]UMG, Neurochirurgie Schwerpunkt Kinderneurochirurgie, Göttingen, Deutschland
[2]UMG, Zahn-, Mund- und Kieferheilkunde / Poliklinik für Kieferorthopädie, Göttingen, Deutschland
[3]Universitätsmedizin Göttingen, Neurochirurgie Schwerpunkt Kinderneurochirurgie, Göttingen, Deutschland

#### Objective

One surgical option for the treatment of premature sagittal suture synostosis is to excise the ossified sagittal suture and weaken the parietal cranial bones in a minimally invasive procedure during the first months of life. The subsequent head-orthosis therapy is often viewed as disadvantage and its necessity is sometimes doubted. In the case series presented, the postoperative results after minimally invasive surgery with and without subsequent orthosis-therapy was compared.

#### Methods

Until 10/2021, orthosis-therapy was not performed routinely in our clinic after minimally invasive surgery for sagittal suture synostoses. From 10/2021 on, head-orthosis was routinely applied after this procedure. Bildren, who were operate < 4 months of age (m) were included in the study. From the first group, children who received standardized 3D-scans pre- and postoperatively were retrospectively evaluated (n=6 from 16). From the other cohort, data from children who had completed helmet therapy after minimally invasive surgery were collected (n=7 from 22). 3D-scans of children without synostosis or plagiocephaly (n=25) served as a control group. Demographic and morphometric data (cephalic index (CI), head circumference, volume; vertex height index (VHI) pre- and postoperatively) were collected pre- and post-operatively (T1=3 to 4 months of age (m), T2=6 to 7 m, T3=10 to 12 m).

#### Results

The preoperative CI (%) was 71±2.21 in the orthesis-group, 72.1±1.75 in the “non-orthesis-group”, and 77.90±1.92 in the control-group. 220.23±29 days postoperatively, the CI was 78.02±1,98 in the orthesis-group and 73.03±1.41 in the non-helmet group (control group: 78.02±0.53). After completion of helmet therapy (T3), the CI in this group was 77.17±1.85 (control group 76.93±0.5), and 68.60±1.40 in the age-matched non-helmet group (p

#### Conclusion

In the head-orthosis group, the CI normalized postoperatively and remained stable over the examined 12-months-period. The group without consecutive head-orthosis remained below the CI norm. There were no treatment-group differences with regard to head-circumference, the VHI, and volume. Since children who were not treated with a head-orthosis rarely received 3D-scans, the case numbers presented are small. However, the presented preliminary data confirmed the importance of post-operative head-orthosis therapy in the minimally invasive procedures.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## J-Cz 001

### Die Rolle der Operation bei rezidivierenden Ependymomen bei Kindern
*The role of surgery in recurrent ependymomas in pediatric population*

A. Mrlian[1], M. Smrčka[1], D. Laštovička[1]

[1]University Hospital Brno, Department of Neurosurgery, Brno, Tschechien

#### Objective

The role of surgery in recurrent ependymomas and its contribution to the outcome are not well defined yet. However, gross-total resection (GTR) has shown a strong benefit in newly diagnosed patients with an improvement in progression-free survival, its impact after recurrence is not known. Moreover, the role of the surgery in distant relapses or multiple local recurrences is similarly less well understood. The objective of this research was to estimate the effect of GTR after the recurrence on survival interval.

#### Methods

18 patients with ependymomas who underwent surgery for recurrent ependymomas between January 2008 and December 2023. Surgical treatment was stratified as GTR, subtotal resection (STR), or a biopsy. Kaplan-Meier analysis was performed for PFS and overall survival (OS), and the log-rank test was used to assess statistical significance. The Cox regression model was used for multivariable analysis.

#### Results

18 children were involved in the study with a first ependymoma recurrence and follow-up data were collected. The median age was 5.76 years (95% CI 4.23–7.39 years) with a mean follow-up of 5.92 years. In 16 patients (83%), the original tumour was located in the infratentorial space. The 5-year PFS rates for the GTR and STR groups were 57.1% and 23.8%, respectively. The 5- and 10-year OS rates were 48.3% and 48% in the GTR group and 41% and 16.7% in the STR group, respectively. 11 patients presented with a second recurrence. The 5-year PFS and OS rates in patients who had GTR after a second recurrence were 33% and 50%, respectively.

#### Conclusion

GTR of local recurrent ependymomas can result in longer long-term survival in first and second recurrences. Further and larger studies and the comparison with other – higher case load centres are necessary to elucidate the role of surgery in distal recurrences.

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P347

### Lagebedingte Schädeldeformitäten – eine überarbeitete Handlungsempfehlung
*Positional cranial deformities – A revised management recommendation*

A. Neumeister[1], S. Brand[2], F. Koch[3], C. Senft[1], F. Schwarz[1], D. Löschner[1]

[1]Universitätsklinikum, Klinik für Neurochirurgie, Jena, Deutschland
[2]Thüringen-Kliniken "Georgius Agricola" GmbH, Klinik für Orthopädie und Unfallchirurgie, Saalfeld, Deutschland
[3]Schön Klinik München Harlaching, Klinik für Orthopädie und Unfallchirurgie, München, Deutschland

#### Objective

Positional cranial deformities have been increasing worldwide for decades. The impact of the severity of plagiocephaly on the outcome of helmet therapy has been underreported. The aim of this study was to provide an updated summary of recommendations for the treatment of positional cranial deformities. In addition, own results on the influence of severity on the outcome of helmet therapy were considered.

#### Methods

In a retrospective analysis, 25 patients with positional cranial deformity who were treated with helmet therapy between 2016 and 2023 were included. The cranial vault asymmetry (CVA) was measured using a 3-dimensional camera. The patients were divided into moderate (CVA ≤ 12 mm, n = 5) and severe plagiocephaly (CVA > 12 mm, n = 20). The mean differences in the CVA of all patients before and after helmet therapy were tested for statistical significance using Student´s t-Test. The outcome results between the 2 groups were tested for statistically significant difference using Welch´s test.

Furthermore, the evidence-based guideline of the Congress of Neurological Surgeons for the treatment of positional cranial deformities from 2016 was updated, considering the age-dependent step therapy of Linz et al. as well as Jung and Yun.

#### Results

Of the 25 patients, 15 were male and 10 female. Helmet therapy was initiated at an age of 6.6 months (SD 1.88) and lasted 5.8 months (SD 1.62) on mean. The mean CVA decreased in the entire study population from 13.85 mm (SD 4.88) before to 5.95 mm (SD 3.74) after helmet therapy (*figure 1*). The mean CVA in the mild plagiocephaly group reduced by 2.38 mm and in the severe group by 9.27 mm. The mean difference of -6.89 mm between the 2 groups was statistically highly significant ($p < 0.001$, 95 % CI -9.5 to -4.3).

The modified recommendation overview synthesizing the current data and including the own results was summarized in *table 1*.

#### Conclusion

When treating positional cranial deformities, various aspects must be considered. This overview is intended to simplify the treatment decisions.

Abb. 1

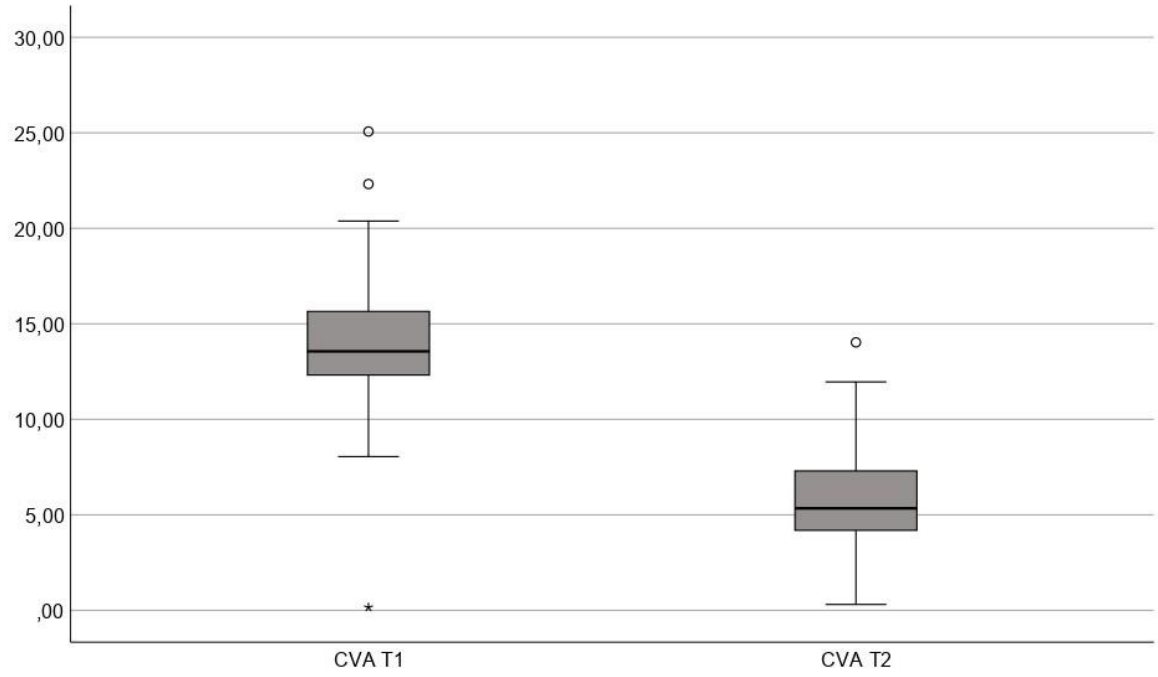



Abb. 2

Table 1: Revised recommendation of age-dependent management options in the case of positional cranial deformities modified according to Jung and Yun 2020

| Age | Management recommendation of positional cranial deformities |
|---|---|
| < 4 months | (1) Preventive interventions: information on repositioning, active positioning therapy, moving the child's bed, changing position when breastfeeding, changing the baby seat, supervised tummy time 30 min/d<br>(2) Offer physiotherapy with a focus on manual therapy, if there is no improvement after 4 weeks, eventually consider ergotherapy and osteopathy<br>(3) Physiotherapy is always indicated in the presence of torticollis<br>(4) Ruling out craniosynostosis in the clinical examination, consultation with neurosurgery if necessary |
| 4 – 6 months | (1) Continue positioning and physiotherapy in mild and moderate plagiocephaly cases (CVA < 12 mm)<br>(2) In severe plagiocephalic cases (CVA > 12 mm), immediate start of helmet therapy |
| > 6 months | (1) In mild and moderate plagiocephalic cases without improvement after positioning therapy, informing parents about the possibility of helmet therapy without clear evidence for these patients<br>(2) Otherwise continue positioning and physiotherapy until the age of 1 year with close re-evaluation of helmet therapy (e.g. monthly 3D measurement) |

# Hydrozephalus und pädiatrische Neurochirurgie – Verschiedenes 2 | Hydrocephalus and Paediatric Neurosurgery – Various 2

## P348

### Überlebensrate einer programmierbaren Ventilkette bei Erwachsenen
*Survival rate of a of programmable valve chain in adults*

M. Hülser[1], J. Oertel[1]

[1]Klinik für Neurochirurgie, Universitätsklinikum des Saarlandes, Homburg a. d. Saar, Deutschland

### Objective

Despite the rising use of programmable pressure valves, the rate of valve survival of a combination of programmable differential valves and gravitational valves remains unclear. Therefore this study aimed to analyse the valve survival rate and causes of revision surgery of a programmable valve chain.

### Methods

The retrospective study included all implantations of a valve chain (M.blue plus, Miethke) in a single centre over a time period of three years. Demographic data, aetiology of hydrocephalus and reason for revision procedures were analysed. Furthermore, the shunt resp. valve survival were estimated using the Kaplan-Meier function. Statistical analysis was performed using SPSS. The significance level was set at $p \leq 0.05$.

### Results

Over a mean study period of 3 years 346 cases of valve implantation were included. The aetiology of the hydrocephalus did not have any impact on shunt endurance. Twenty-two revision surgeries due to infection (n=13), valve obstruction (n=6) and others (n=3) occurred. Shunt survival time at 18 months was 88% and valve survival time at 18 months was 97%.

### Conclusion

The combination of programmable differential and gravitational pressure valves shows optimal survival time.

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