



Conference Report

Abstracts of the 2021 Annual Virtual Meeting of the Swiss Society of Neurosurgery, September 16–17, 2021

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Abstract: On behalf of Swiss Society of Neurosurgery together with Association of neurosurgical nursing staff Switzerland, we are pleased to present the Abstracts of the 2021 Annual Meeting, that was held virtually from 16–17 September 2021. Fifty-one (51) abstracts were selected for presentation as oral presentations and forty (40) abstracts were selected as poster presentations. We congratulate all the presenters on their research work and contribution

Keywords: neurosurgery; neurosurgery nursing

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O01–O51 Oral Presentations

P01–P40 Poster Presentations



Citation: Guzman, R. Abstracts of the 2021 Annual Virtual Meeting of the Swiss Society of Neurosurgery, September 16–17, 2021. *CTN* **2021**, *5*, 19. <https://doi.org/10.3390/ctn5020019>

Academic Editor: Claudio Bassetti

Received: 13 September 2021

Accepted: 13 September 2021

Published: 15 September 2021

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O01

A Novel Peroral Approach and Guidance Tool for Trigeminal Rhizotomy

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Aims: Ganglion Gasseri rhizotomy is a viable option for the treatment of trigeminal pain (TP). While its therapeutic importance as minimally invasive method is generally agreed on, many different surgical variations and technical nuances exist. Here, the authors evaluate a novel peroral trigeminal rhizotomy technique and three-dimensional printed patient specific guidance tool (3D-PSGT) with respect to their applicability and safety.

Methods: Between March 2018 and January 2020, 11 peroral balloon compression rhizotomy procedures with a 3D-PSGT were performed in 10 consecutive TP patients (6 female, mean age 57 yrs). The procedure duration, complications, side effects and trigeminal function were registered, and the therapeutic effect was gauged from reduction of TP and use of analgesics.

Results: All rhizotomy procedures were successful at the first attempt. Apart from fluoroscopy, no auxiliary material was necessary. The average length of surgery was 19 min (range, 11 to 27 min). Six patients indicated complete analgesia and 3 patients pain relief, in one patient persistence of TP was observed during follow-up examinations of up to 20 months. Three patients reported of new mild to moderate facial hypesthesia affecting the trigeminal branches V2, V3 and V1-3, respectively. No masticatory musculature or corneal affections and device-related complications occurred.

Conclusions: The custom-made device and peroral approach allow to rapidly, reliably and safely pass the foramen ovale and perform trigeminal rhizotomy efficiently, and minimize the need for radiation exposure, further equipment, additional imaging techniques and data processing. Although exclusively used for balloon compression thus far, the method could also be applied for alternative procedures such as radiofrequency and glycerol rhizotomy.

O02

Neuromodulation of Astrocytes and Microglia in Chronic PainA. Hopf¹, B. Osmani² and R. Guzman¹¹ University Hospital Basel, Basel, Switzerland² University of Basel, Basel, Switzerland

Aim: Spinal Cord Stimulation (SCS) in chronic pain can reduce or even stop opioid medication and is more cost-effective than pharmacological treatments (1,2). Spinal cord implants enter the epidural space and deliver mild electric currents causing a hyperpolarization of the neurons and therefore masking the pain signal from reaching the brain. The mechanism is based on the gate control theory as described by Wall and Melzack in 1965 (3). However, recent work show that microglia and astrocyte induced neuroinflammation is a key mechanism underlying chronic pain (4–7). It could be shown that SCS counteract microglia (CD11b) and astrocytes (GFAP) activation and induce the release of inhibitory neurotransmitter (GABA, serotonin, opioids) in the spinal dorsal horn which reduce central excitability (8). Our goal is to fully understand the impact of electrical stimulation on microglia and astrocyte activation for modulation of the neuroinflammatory response in pathologies such as chronic pain.

Methods: An in-vitro electrical stimulation device was established which allows us to control electrical stimulation parameters and to analyze cell behavior. Immortalized murine microglia cells (BV2 cells) were electrically stimulated using various Voltage, frequency and stimulation duration. Proliferation, viability and cytokine secretion were measured following stimulation with different protocols.

Results: BV2 cells were activated using 100 ng/mL LPS for 24 h. Following activation, secretion of the pro-inflammatory cytokines TNFalpha and IL-6 increased from 31.9 ± 1.3 ng/mio cells to 961.3 ± 67.7 ng/mio cells ($p < 0.001$) and from 3.7 ± 0.1 ng/mio cells to 312 ± 32.5 ng/mio cells ($p < 0.001$). Following, 4V Alternate current stimulation at 40 Hz a reduction of TNFalpha and IL-6 secretion from 961.3 ± 67.7 ng/mio cells to 794.4 ± 52.5 ng/mio cells ($p = 0.018$) and from 312 ± 32.5 ng/mio cells to 245.8 ± 8.4 ng/mio cells ($p = 0.017$) was observed. Whereas 1V direct current stimulation did not alter IL-6 secretion significantly.

Conclusion: Extended analysis of secreted factors and phagocytic capabilities of BV2 cells are required to further reveal the impact of electrical stimulation on microglia. Based on these preliminary data, we conclude that defined electrical stimulation parameters can modulate cytokine secretion of BV2 cells which could be beneficial for clinical application by attenuate neuroinflammation and therefore treating the cause and not the symptoms of chronic pain.

O03

Use of Virtual Reality to Improve the Perioperative Management and in Particular the Immediate Preoperative Stress of Neurosurgical PatientsP. Vayssière¹, P. Constanthin¹, B. Herbelin², P. Bijlenga¹, O. Blanke² and K. Schaller¹¹ HUG Hôpitaux Universitaires Genève, Genève, Switzerland² EPFL SV BMI LNCO, Genève, Switzerland

Background: Hospitalized patients suffer from physical, emotional and social distress. One aspect responsible for this suffering is surgery and preoperative interventions (premedication, implementation of music . . .) have only shown moderate success in decreasing surgical-related anxiety, resulting in both patients' dissatisfaction and clinicians' frustration. Virtual Reality (VR) is an exciting new technology allowing complete immersion in a virtual environment, leading to a total escape without physical movement. Its positive effects have been studied since the 90s in pain and anxiety management, neurorehabilitation and

psychotherapy. In this study, we tested the effect of a new technology allowing concomitant coupling of both VR and hypnosis (HypnoVR), hypothesizing that the use of such technology might reduce preoperative anxiety, resulting in decreased postoperative pain and distress.

Methods: Patients undergoing surgery (both spinal and cranial) in our department were submitted to one session of HypnoVR just before anesthesia. The effects of this session were then analyzed by measuring patients' intraoperative stress parameters (such as blood levels of the stress hormone cortisol as well as the quantity of opioids and hypnotics used by anesthesiologists) as well as postoperative levels of pain and satisfaction of the patients.

Results: A preliminary analysis with the first ten patients is ongoing. The study will be finished in summer 2021.

Conclusions: These preliminary data will hopefully confirm the usefulness of VR as a tool to reduce preoperative anxiety, resulting in decreased postoperative pain, distress and neurosurgical complications.

004

Combined Approaches for Large Vestibular Schwannomas: Long-Term Follow-Up in a Series of 50 Consecutive Patients

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Background: The microsurgical management of large vestibular schwannomas (VS) yields a high risk for the facial and cochlear nerve functions. Gamma Knife radiosurgery (GKRS) allows optimal functional results in small- and medium-size VS, but cannot be used upfront in large vs. because of the high rate of volume-related side effects

Methods: In this context, we developed of a new treatment paradigm of combined approach with microsurgery and GKRS, aiming at optimal functional outcome for the facial and cochlear nerves in patients with large vs. (i.e., Koos grade IV). Data pertaining to patient characteristics, surgical and dosimetric features and outcome were collected prospectively at time of treatment and during the follow-up course. We report our long-term follow-up using this approach on 50 consecutive patients.

Results: The mean presurgical tumor volume was 11.25 cm^3 (1.47–34.9) and mean follow-up after surgery was 39.4 months (range 6–102). All cases had normal facial nerve function (HB I) before surgery, except for one who was in HB IV, and one in HB III. Postoperative status showed normal facial nerve function (House-Brackmann grade I) in all patients, with the exception of the one who was in HB III preoperatively and which remained in HB III after surgery. In a subgroup of 29 patients in which cochlear nerve preservation was attempted at surgery (patients with residual hearing before surgery), 27 of them (93.1%) retained residual hearing. 19 patients had normal hearing (Gardner-Robertson class 1) before surgery, and 16 (84.2%) retained normal hearing after surgery. The mean duration between surgery and GKRS was 6.2 months (4–13.9, median 6 months). The mean tumor volume at the time of GKRS was 3.3 cm^3 (0.5–9.9), which corresponds to a mean residual volume of 31.7% (range 3.6–50.2) of the pre-operative volume. There was a tendency towards larger postoperative residual volume in patients with attempt to cochlear nerve preservation. The mean marginal prescription dose for GKS was 11.9 Gy (range 11–12, median 12 Gy). Four patients were considered a failure and benefitted from a second combined approach in 3 cases and only GKRS, in one case. Three patient benefitted from a VP shunt.

Conclusion: Our data suggest that the combined management of large vs. with planned subtotal resection followed by GKRS may yield an excellent clinical outcome with respect to retaining facial and cochlear nerve functions.

O05

Biologically Effective Dose Correlates with Linear Tumor Volume Changes after Upfront Single-Fraction Stereotactic Radiosurgery for Vestibular Schwannomas

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Introduction: Vestibular schwannomas (VSs) are benign, slow-growing tumors. Management options include observation, surgery, and radiation. In this retrospective trial, we aimed at evaluating whether biologically effective dose (BED) plays a role in tumor volume changes after single-fraction first intention stereotactic radiosurgery (SRS) for VS.

Methods: We compiled a single-institution experience (n = 159, Lausanne University Hospital, Switzerland). The indication for SRS was decided after multidisciplinary discussion. Only cases with minimum 3 years follow-up were included. The Koos grading, a reliable method for tumor classification was used. Radiosurgery was performed using Gamma Knife (GK) and a uniform marginal prescription dose of 12 Gy. Mean BED was 66.3 Gy (standard deviation 3.8, range 54.1–73.9). The mean follow-up period was 5.1 years (standard deviation 1.7, range 3–9.2). The primary outcome was changes in 3D volumes after SRS as function of BED and of integral dose received by the VS.

Results: Random-effect linear regression model showed that tumor volume significantly and linearly decreased over time with higher BED (p less than 0.0001). Changes in tumor volume were also significantly associated with age, sex, number of isocenters, gradient index, and Koos grade. However, the effect of BED on tumor volume change was moderated by time after SRS and Koos grade. Lower integral doses received by the VSs were inversely correlated with BED in relationship with tumor volume changes (p less than 0.0001). Six (3.4%) patients needed further intervention. For patients having uniformly received the same marginal dose prescription, higher BED linearly and significantly correlated with tumor volume changes after SRS for VSs.

Conclusion: ED could represent a potential new treatment paradigm for patients with benign tumors, such as VSs, for attaining a desired radiobiological effect. This could further increase the efficacy and decrease the toxicity of SRS not only in benign tumors but also in other SRS indications.

O06

Neuropsychological Outcomes after Surgery for Olfactory Groove Meningiomas

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Background: In recent years, several studies have reported abnormal pre- and postoperative neuropsychological functioning in patients with meningiomas located in the prefrontal cortex (notably the ventromedial region). In the case of olfactory groove meningiomas, the tumor is in direct contact with the inferior aspect of the prefrontal cortex, a cortical region with crucial roles in decision-making, cognition and memory functions, potentially negatively impacting neuropsychological functions.

Methods: We retrospectively compared pre- and post-operative neuropsychological testing of 17 patients undergoing surgical removal of olfactory groove meningiomas in our institution between January 2013 and December 2018. Neuropsychological results were

obtained from the patients' medical history and normalized as z-scores of their respective cognitive functions.

Results: Assessment of cognitive follow-up showed an important heterogeneity among patients. Pre-operative cognitive impairment was observed in most patients, particularly in cognitive flexibility (mean z-score: -1.35). Immediate post-operative cognitive status showed an overall impairment in all domains of cognition, significant for the domains of attention ($p = 0.0273$) and flexibility ($p = 0.0234$). The late follow-up at one-year showed a trend towards general improvement, although, attention and flexibility remained impaired.

Discussion: Olfactory groove meningiomas impact pre-frontal cortex cognitive functions, particularly in the domain of cognitive flexibility. After an initial postoperative worsening, patients tend to improve in most aspects after one year, aside from cognitive flexibility and attention.

O07

Correlation of Neurophysiological Monitoring of the Laryngeal Adductor Reflex with Sensorimotor Laryngeal Outcome in Skull-Base and Brainstem Surgery

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Background: Intraoperative injury to the vagus nerve and its reflexive pathways may induce swallowing deficits, aspiration, and pneumonia. We did correlate intraoperative changes of the laryngeal adductor reflex (LAR) with postoperative laryngeal function after complex posterior fossa and brainstem surgery.

Methods: In a multi-center study, we monitored 53 patients during skull base and brainstem surgeries. LAR was recorded from an endotracheal tube with imbedded electrodes or hook-wires electrodes. A LAR significant change (LAR-SC) defined as $\geq 50\%$ amplitude decrement or loss, was classified as either transient or permanent injury to the vagus or medullary pathways by the end of the surgery.

Results: Patients with permanent LAR loss ($n = 5$) or LAR-significant alterations ($n = 3$), developed postoperative laryngeal dysfunction such as aspiration/pneumonia and permanent swallowing deficits (5.6%). All seven patients with transient LAR-SC or loss, reverted by changing the surgical approach, did not present permanent deficits.

Conclusions: Permanent significant amplitude decrement or loss of the laryngeal adductor reflex correlated with postoperative laryngeal dysfunction. LAR predicted not only motor but also sensory dysfunction of the vagus nerve and reflexive medullary pathways. In contrast, a LAR-SC or loss, averted by a timely surgical adjustment, prevented irreversible damage. Monitoring of the LAR may enhance safety to resect complex posterior fossa and brainstem lesions.

O08

Perioperative Continuation versus Discontinuation of Low-Dose Aspirin in Cranial Neurosurgery: A Systematic Review and Meta-Analysis of Risks and Benefits

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Background: Discontinuation of aspirin (ASA) prior to cranial neurosurgical procedures is common practice among neurosurgeons. However, patients treated with ASA for secondary prevention bear a higher risk for perioperative thromboembolic complications. The aim of this meta-analysis is to analyze the risk and benefit of perioperative continuation versus discontinuation of ASA.

Methods: This study is a meta-analysis, performed according to the PRISMA-guidelines. The PubMed and Embase databases were searched for relevant publications. Inclusion criteria are studies reporting haemorrhagic and/or thromboembolic complications in patients in whom ASA was either continued or discontinued during the perioperative phase of cranial neurosurgical procedure.

Results: 9 publications met the eligibility criteria, corresponding to a cumulative cohort of 865 patients. ASA was discontinued preoperatively in 254 patients (29.4%) and continued in 611 cases (70.6%). 567 patients (65.5%) were operated in an elective and 298 (34.4%) in an emergency setting. In the elective surgery group, the surgery types were tumour surgeries (intra- and extra-axial) (315; 55.6%) and bypass surgeries (252; 44.4%). In the emergency surgery group, the surgery types included burr holes and mini-craniotomies in 164 cases (55.0%) and craniotomies/craniectomies in 134 cases (45.0%). In the elective surgery group, the haemorrhagic complication rate was 1.96% in the ASA continuation group versus 3.14% in the ASA discontinuation group ($p = 0.368$). In the emergency surgery group, the haemorrhagic complication rate was 32.0% in the ASA continuation group versus 25.3% in the ASA discontinuation group ($p = 0.278$). The total hemorrhagic complication rate in the emergency surgery group was significantly higher than in the elective surgery group (29.9% vs. 2.3%; $p < 0.001$). The rate of thromboembolic complications was consistently reported only in the elective surgery group. There was no difference in the rate of thromboembolic events in the ASA discontinuation and continuation group (1.89% vs. 2.08%; $p = 1$).

Conclusion: Continuation of ASA in elective and emergent cranial surgeries appears to be safe. The potential benefit of ASA continuation for patients at high risk for thromboembolic complications needs to be analysed in further studies. The hemorrhagic complication rate in emergent surgeries is significantly higher compared to elective surgeries, independently of the preoperative ASA discontinuation status.

009

Increased Oxytocin Release Precedes Hyponatremia after Pituitary Surgery

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Purpose: The syndrome of inappropriate secretion of antidiuretic hormone (SIADH) is a well-known complication of transsphenoidal pituitary surgery, related to inappropriate secretion of arginine vasopressin (AVP). Its diagnosis is based on hyponatremia, with a peak of occurrence around day 7 after surgery and, to date, no early marker has been reported. In particular, copeptin levels are not predictive of hyponatremia in this case. Oxytocin (OXT) is secreted into the peripheral blood by axon terminals adjacent to those of AVP neurons in the posterior pituitary. Besides its role in childbirth and lactation, recent evidences suggested a role for OXT in sodium balance. The contribution of this hormone in the dysnatremias observed after pituitary surgery has however never been investigated.

Methods: We analyzed the urinary output of OXT in patients subjected to transsphenoidal pituitary surgery.

Results: While OXT excretion remained stable in patients who presented a normonatremic postoperative course, patients who were later diagnosed with SIADH-related hyponatremia presented with a significantly increased urinary secretion of OXT 4 days after surgery.

Conclusion: Taken together, these results show for the first time that urinary OXT output remains normally stable after transsphenoidal pituitary surgery. OXT excretion however becomes abnormally high on or around 4 days after surgery in patients later developing

hyponatremia, suggesting that this abnormal dynamics of OXT secretion might serve as an early marker for transsphenoidal surgery-related hyponatremia attributed to SIADH.

O10

GLOW400 Augmented Reality Fluorescence in Surgical Microscopy for Tumor Cell Detection

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Introduction: Fluorescence microscopy after 5-Aminolevulinic acid (5-ALA) administration is a standard technique in high grade glioma surgery. At the time of writing this article the only 5-ALA visualisation filter with FDA Class II clearance is the FL400 filter. A major drawback of 5-ALA surgery is that the surgeon has to work in a dark field and only sees the fluorescent areas but not the critical anatomical surroundings. To overcome this problem, a novel technology (GLOW400) has been developed by Leica Microsystems that allows augmentation of the white light image with the information gained through fluorescence imaging.

Aim: In this study we compared Leica's GLOW400 to its FL400 to assess if the fluorescence information in GLOW400 is inferior, or not, to the FL400.

Methods: All experiments were performed using the ARveo neurosurgical microscope from Leica Microsystems equipped with the FL400 and GLOW400 fluorescence modules. Imaging was carried out at working distances between 250–400 mm, magnifications of 2 to 6-fold and fluorescence illumination intensities of 25–100%. Protoporphyrin IX was used to test fluorescent signals. A GBM cell line was used to image cellular fluorescence after 5-ALA uptake. The impact of working distance, intensity, concentration/cell number and magnification upon detection and visualization of the fluorescence signal were analyzed.

Results: Generally, we were able to visualize the fluorescence signal in both GLOW400 and FL400 modes across the tested parameters. Neither working distance nor magnification impaired the fluorescence signal detection and visualization in the novel GLOW400 mode, whereas in the classical FL400 mode, working distance and magnification—but not intensities—have a significant impact on the fluorescence signal. However, an increased variability of the detected fluorescence signal was observed when a higher magnification above 4-fold was used in both modules. Experiments using GBM cells showed that the novel GLOW400 mode is superior to the classical FL400 in terms of coefficient of variation of the fluorescent signal. Furthermore, both modes allow to distinguish a minimum of 1×10^6 cells in a volume of 100 μ L regardless of magnification and intensity.

Conclusions: Through this new viewing mode, a new way of analyzing the efficiency of the resection process is being introduced, one that could offer a better visualisation in a real time motion manner of the surrounding tissue and reduce the artefacts.

O11

Prediction of Sphenoid Sinus Septation Using Magnetic Resonance Imaging Compared to Computed Tomography for Presurgical Assessment in Transsphenoidal Pituitary Surgery

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Background: Magnetic resonance imaging (MRI) and computed tomography (CT) are the most common preoperative imaging modalities for transsphenoidal pituitary surgery. It remains unclear whether both modalities are necessary as a standard approach for presurgical assessment. The study aims to evaluate if MRI alone is sufficient to identify relevant intra-sphenoidal anatomical variations when compared to CT.

Methods: Retrospective cohort study of 109 consented patients with complete imaging that underwent transsphenoidal pituitary surgery at the University Hospital Basel between 2009–2016. Preoperative MRI (T1 and T2 sequences) were compared to CT (gold standard) and the intra-sphenoidal anatomy was assessed. A “correctly” identified posterior termination at the skull base was defined as: 1. true presence or absence of a bony septum contact to the sella; 2. paraclival or cavernous carotid artery; 3. evident asymmetry, when compared to CT. Sensitivity and specificity analysis and intrareader variability testing using Cohens Kappa coefficient were performed.

Results: After exclusion of 38 patients with tumor infiltration along the posterior wall of the sphenoid sinus, 71 out of 109 patients were eligible for analysis. MRI was able to identify the correct number of intra-sphenoidal septa in 65 (92%) patients when a combination of both modalities was used. Hence, MRI was able to reliably identify the existence of an intra-sphenoidal septum with a sensitivity of 99%. A correct posterior termination at the sella turcica was identified in 66 (97%), a posterior termination along the carotid artery in 63 (93%), and an evident asymmetry in 63 (93%) of cases. Hence, MRI had a sensitivity of 94%, 97% and 92%, respectively. However, accuracy was less for accessory septa within this study. Cohens Kappa coefficient revealed a fair to moderate intra-reader variability for the main assessor of this study (first author).

Conclusion: MRI alone is feasible to reliably detect the posterior termination of a single intra-sphenoidal septum in cases without tumor infiltration of the posterior sphenoidal sinus wall. A restriction of preoperative CT-scans to more complex anatomical configurations detected in pre-surgical MRI potentially avoids unnecessary imaging and, thus, radiation exposure and overall costs. Further studies are warranted to specifically confirm these findings and potential benefits.

O12

Impact of Primary Medical or Surgical Therapy on Prolactinoma Patients' BMI and Metabolic Profile in the Long-Term

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Objectives: High prolactin levels have been associated with weight gain and impaired metabolic profile. While treatment with dopamine agonist (DA) has been related to improve these parameters, there is a paucity of surgical series on its comparative effect in prolactinoma patients.

Methods: In this retrospective, comparative study, consecutive patients affected for prolactinomas were enrolled if treated with first-line transsphenoidal surgery (TSS) or with DA. Patients with prolactinomas Knosp grade > 2 and those with a follow-up <24 months were excluded, as were patients with missing laboratory metabolic parameters at baseline and in the long-term. Effects of either treatment on BMI and the metabolic profile were analyzed, and independent risk factors for long-term obesity were calculated.

Results: The first treatment was TSS for 12 (40%) and DAs for 18 (60%) patients. At diagnosis, no significant differences between the two cohorts were observed with regard

to adenoma size, Knosp grading, baseline PRL levels, prevalence of hypogonadism, or laboratory metabolic parameters. Mean follow-up was 51.9 months (2–158). In the long-term, both TSS and DAs led to the control of hyperprolactinemia (92% vs. 72%) and hypogonadism (78% vs. 83%) in the majority of patients. While a significant decrease in patients' BMI and fasting glucose were observed, changes in the lipid profile were marginal and independent of the treatment modality. Baseline increased BMI but not the primary treatment strategy was an independent predictor for long-term obesity.

Conclusions: Over the long-term, patients' BMI and FG improves, yet changes in the metabolic profile are marginal and independent of the primary treatment. It is presumable that not DAs per se, but rather the control of hyperprolactinemia play a role in patients' metabolic profile alterations.

013

Perioperative Complications of Patients with SARS-CoV-2 Infection Undergoing Neurosurgical Operations

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Background: The outbreak of coronavirus disease 2019 (COVID-19), originating in Wuhan, China, has been rapidly evolving resulting in an epidemic, having infected 158,651,638 people according to the World Health Organization. Patients suffering from COVID-19 have also been described to suffer from neurologic symptoms apart from the better-known flue-like symptoms. Some studies showed that patients suffering from COVID-19 also developed intracranial haemorrhages (ICH) which is in contrary to the otherwise known hypercoagulable state of patients with COVID-19 infections. So far, no study has investigated the perioperative complications, either thromboembolic or haemorrhagic, in patients with SARS-CoV-2 undergoing a neurosurgical intervention.

Methods: We conducted a retrospective cohort study including patients from March 2020 until March 2021 undergoing neurosurgical operations and suffering from SARS-CoV-2 (either at the time of surgery or within 10 days after surgery). Our primary outcome parameter is 30-day hemorrhagic or thromboembolic complication while secondary outcome parameters are overall morbidity and mortality. We additionally compared the primary outcome as well as overall complications, and mortality to a retrospective COVID-19 negative cohort of patients.

Results: We included 10 patients with a mean age of 56.00 (± 14.91) years. Two patients were already SARS-CoV-2 positive preoperatively, the remaining eight patients tested positive after receiving surgery (5.75 (± 3.96) days). Twelve postoperative complications occurred in 5 patients. Three postoperative thromboembolic complications (30%) were observed with two cerebral sinus vein thrombosis and one pulmonary embolus. Two patients suffered from a postoperative hemorrhagic complication (20%). Mean postoperative GCS and mRS was 14.30 (± 1.57) and 1.50 (± 1.58), respectively. COVID-19 positive patients showed a significantly higher rate of postoperative complications and mortality compared to a historical cohort of COVID-19 negative patients treated at our institute before the SARS-CoV-2 pandemic (6 (60.0%) vs. 25 (12.3%), $p = 0.001$ and 2 (20.0%) vs. 8 (1.3%), $p = 0.001$, respectively).

Conclusion: Patients undergoing neurosurgical operations with concomitant COVID-19 infection seem to have a higher postoperative thromboembolic complication rate. Taking into account the individual risk of each patient, a higher dose or earlier commencement of prophylactic heparin might be indicated.

O14

Microendoscopic Procedure for Degenerative Cervical and Lumbar Disorders. The Influence of the Tubular Workspace on Instrument Angulation, Clinical Outcome, Complications, and Repeated Procedure

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Aim: Long-term clinical outcome and repeat procedure rate for microendoscopic spine surgery (MESS) have been investigated only by a few studies. The effect of instrument angulation on operative parameters and outcomes was not assessed so far.

Material and Methods: Between January 2011 and March 2018 a total of 268 consecutive MESS procedures have been performed via two MESS systems. Patients' charts and endoscopic video recordings were reviewed to assess intraoperative complications, pain levels, sensorimotor deficits, functional outcome, and repeated procedures. Patients were contacted for final follow-up assessment of clinical outcome via a standardized questionnaire including Neck disability index (NDI), Oswestry disability index (ODI), and Odoms criteria. Instrument angulation for both MESS systems, which differ from each regarding the working space, was assessed using a computer model.

Results: Sixty-one posterior cervical foraminotomy (PCF) and 207 lumbar procedures for disc herniation (LDH), lateral recess stenosis (LRS), and synovia cyst (LSC) were performed. The mean follow-up for cervical and lumbar patients was 6 and 5 years, respectively. At the final follow-up, 69% had no arm pain, 76% of patients had no leg pain, mean NDI was 10%, mean ODI was 12.4%. Clinical success according to Odoms was 80% for cervical and 87% for lumbar procedures. The repeated procedure rate at the index level was 13% at the cervical, and 10% at the lumbar spine of which 7.7% were for recurrent LDH. The surgical time and repeat procedure rate were significantly lower for the modern version of the MESS system whereas clinical outcome and rate of complication were similar.

Conclusion: MESS achieve high rates of pain relief and clinical success for the treatment of degenerative cervical and lumbar spine disorders. Increased instrument angulation lowers the surgical time and repeated procedure rate.

O15

Intraoperative Use of 3-Dimensional Fluoroscopy (O-Arm) in Spine Deformity Surgery, Outcome on Screw Accuracy and Radiation Exposure in a Single Center Case Serie

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Aim: Intraoperative 3-dimensional fluoroscopy (O-arm/Stealth) navigation has been described to improve accuracy and safety in pedicle screw placement. However, the efficiency on screw accuracy and the radiation exposure in long thoracolumbar deformity surgery remains unclear. The aim is to describe pedicle screw accuracy and radiation exposure in a single center case series of patients who underwent long thoracolumbar fusion surgery with the use of 3-dimensional fluoroscopy (O-Arm).

Methods: All patients aged > 18 years who underwent long thoracolumbar spine fusion (defined as more than 4 level fused) using O-Arm January 2016 to December 2018 were retrospectively reviewed. Primary outcome was pedicle screw accuracy according to the Heary grade and radiation exposure. Secondary outcomes were: revision surgery because of screw misplacement, peri and postoperative complications, length of surgery,

and revision surgery within 3 years. Misplaced screws were defined as Heary Grade III or higher.

Results: A total of 1477 screws were placed in 91 patients, on average 16.41 ± 5.77 screws per patient. Etiology of deformity was degenerative in 86.8% of patients, traumatic in 7.7%, tumor in 3.3%, and infection in 2.2%. 1208 pedicle screws (81.8%) were available for Heary grade evaluation on postoperative CT-scan. 99.1% of the evaluated pedicle screws were Heary grade I or II, 0.8% Heary Grade III, 0.1% Heary Grade IV and 0% Grade V. Patients had, on average $3.6 (\pm 1.5)$ O-arm spins Fluoroscopy attributed effective dose was minimal and less than 2 mSv (0.46 ± 0.44) for all the patients assessed. For the cone-beam portion of the effective dose estimates, the average effective dose was 29.54 ± 14.29 mSv and effective dose per spin 8.25 ± 2.65 mSv. Cumulative effective dose per patient for fluoroscopy and CBCT combined was 30.00 ± 14.59 mSv. Revision surgery rate for screw misplacement was 0%. No postoperative neurological worsening or vascular injuries were recorded.

Conclusions: Despite effective doses similar to neuroendovascular procedures reported in the literature, the use of O-arm in deformity surgery resulted in high screw accuracy, no need for surgical revision due to screw mispositioning, reduced additional imaging and no radiation exposure for the surgical team.

O16

Posterior Screw Stabilization Associated with “Armed Kyphoplasty” Avoids Corpectomy in Complex Thoraco-Lumbar Spine Fractures

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Objectives: Complex unstable osteoporotic, traumatic or neoplastic thoraco-lumbar fractures, generally require fracture reduction and stabilization of the vertebral body. Posterior instrumentation alone, as well as standard cement-augmentation techniques might represent an undertreatment, while corpectomy carries significant morbidity. The aim of the present study is to evaluate feasibility, safety and results of a combination between the recent minimally-invasive “armed kyphoplasty” (AK) techniques and surgical posterior stabilization, in a series of complex unstable thoraco-lumbar fractures.

Methods: 24 consecutive patients were treated with combined AK-posterior instrumented surgery, performed in 7 years in a single institution. In case of spinal cord compression, laminectomy was performed. Both minimally invasive and open surgery techniques were used for posterior instrumentation. Screws were placed under navigation or fluoroscopic guidance; AK was performed with single C-arm or biplane fluoroscopic guidance. CT-scan was obtained at the end of the procedure, and standing plain films within the first postoperative days. Patient were followed-up according to clinical standards. Technical success, periprocedural complications, clinical and imaging results were evaluated during follow-up.

Results: 25 fractures were treated. Fracture etiology was either neoplastic (40%), traumatic (32%) and osteoporotic (28%). Two thirds of the cases were treated with open surgery and one third with MI techniques. In 13 cases (52%) a laminectomy was performed. During the first month of follow-up, we reported 1 surgical site infection (4%), 1 adjacent fracture (4%) and 1 screw pull-out (4%) which required treatment; two patients (8%) died due to complications of the underlying disease. Mean pre and post Cobb angle was $20.14 \pm 6.19^\circ$ and $11.66^\circ \pm 5.24^\circ$ ($p < 0.0001$). Mean pre and post VAS was 6.53 ± 0.71 and 2.63 ± 0.75 ($p < 0.0001$). We observed no mobilization of the AK devices nor fractures of the treated levels.

Conclusions: Combined posterior stabilization and AK is a feasible, safe and effective technique to treat complex thoracolumbar spine fractures of all etiologies. Giving anterior and posterior support ensures a higher stability and prevents hardware failure or worsening of the treated fracture, avoiding highly invasive surgical approaches. Further investigation

with larger series is needed to obtain better evidence and implement this technique in daily practice.

O17

The Surgical Treatment of Pyogenic Spondylodiscitis Using Carbon Fiber Reinforced PEEK Implants. Personal Experience of a Series of 81 Consecutive Patients

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Aims: Pyogenic spondylodiscitis (PSD) is a complex disorder that often required postoperative imaging. Carbon fiber reinforced PEEK (CFRP) is radiolucent and offers an optimal assessability of anatomical structures.

Methods: A retrospective file-review of patients who were operated on for PSD using CFRP-implants was performed to assess the clinical outcome, implant-associated complication, and revision surgery. A minimum follow-up of 3 months was required for evaluation of clinical and radiographical data which included CT and MRI assessment to determine implant stability and assessability of soft tissue and neural structures using a grading system.

Results: Eighty-one consecutive patients with a mean of 69.5 years were identified. Debridement and stabilization were performed in 8 cervical, 17 thoracic, and 57 lumbar procedures, 72 interbody fusion procedures using cages were performed. Intraoperatively no implant-associated complication was noted. The mean follow-up was 7 months at which 52 patients attended. Improved mobility and reduced pain levels were reported by 87%, and MRI assessability was graded ideal. Residual sign of infection was seen in five cases, which influenced antibiotic therapy. Asymptomatic radiolucent zones were identified in 13 (16%) and screw loosening in two (2.4%) patients. In one case the pedicle screw tip broke and remained within the vertebral body. Repeated procedure due to progressive vertebral body destruction, implant loosening, or subsidence was performed in five (6.1%) patients.

Conclusion: The surgical treatment of PSD using CFRP is safe. The repeat procedure rate due to implant loosening is 6.1%. Minimal artifacts offer ideal assessability of soft tissue structures on an MRI.

O18

Combined i-CT Navigation and Neuromonitoring in Lumbar Lateral Interbody Fusion May Reduce Postoperative Neurological Deficits: Single Center Experience

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Introduction: The use of lateral lumbar interbody fusion (LLIF) has significantly increased in recent years, because of high fusion rate. However, risk of postoperative neurological deficits (pND) after LLIF can reach 33%. The anatomical relationship of lumbar plexus can change significantly interindividually and due to lateral positioning. We propose the use of combined intraoperative-CT navigation (i-CT-nav) and neuromonitoring (IONM) during LLIF to reduce pND.

Material and Methods: We retrospectively collected data of patients who underwent one or two level LLIF using i-CT-nav (AIRO-Brainlab) and IONM between January 2017 and December 2019. After i-CT image acquisition the skin incision and trajectory to the disc space were established. IONM consisted of free running electromyography (EMG) and transcranial motor evoked potential (MEP) of thigh and leg muscles, and when possible cremasteric/inguinal and abdominal muscles. Under direct visualization of psoas muscle, mapping with monopolar probe of region of interest at different stimulation intensity (2–15 mA) was performed. A specific muscle retractor was placed in a silent area. The

position of the retractor and the range of its distraction was modified depending on EMG or MEP changes. Expandable cages were inserted under continuous neuromonitoring and fluoroscopic control. A suitable radiological space distraction was performed based on any EMG or MEP alterations. A control CT-scan was acquired to evaluate the cage position.

Results: 21 patients with mean follow up of 9 months were included in the study, 15 females (71%) and 6 males (29%), with mean age of 69 years. Most common indication was adjacent disc disease (12 cases, 57%). In 16 cases only 1 level was treated, in the rest 2 levels. Two patients (10%) experienced a transient motor deficit of the thigh, lasting less than 3 months. Four patients presented a sensory deficit of thigh: in 3 cases (14%) the deficit was long lasting while in one case (5%) it resolved within 3 months. No intraoperative cage repositioning was needed, and no surgical revision occurred in follow-up. Lumbar pain resolved in 14 patients (67%) in 1 month.

Discussion and Conclusion: The combined use of i-CT and IONM is feasible, safe and allows surgeon a better understanding of the individual real time anatomy during LLIF. In our cohort patients showed lower postoperative neurological deficits compared to data reported in the literature.

O19

Impact of Frailty and Sarcopenia on Revision Surgery and Proximal Junctional Failure in Long Thoracolumbar Deformity Fusion Surgery

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Aim: Patients undergoing long thoracolumbar spine fusion experience a high rate of morbidity and complications. Previous studies have described the modified frailty index (mFI 5 and mFI11), Charlson Comorbidity Index (CCI) and Sarcopenia as predictors of worse postoperative outcome in diverse surgical disciplines. Clear data evaluating frailty and sarcopenia on proximal junctional failure (PJF) and need of revision surgery in patients undergoing long thoracolumbar spine fusion are lacking. The aim is to evaluate the effect of frailty and sarcopenia on revision surgery and PJF.

Methods: All patients aged > 18 years who underwent long thoracolumbar spine fusion (defined as more than 4 level fused) from January 2016 to December 2018 were retrospectively reviewed. The mFI5, mFI11, CCI and the L3-TPA:VA ratio were calculated for each patient. The rate of postoperative revision surgery, proximal junctional failure within 2 years after surgery were collected.

Results: A total of 90 patients were included in the cohort. The mean patient age at surgery was 60.2 ± 14.7 years. Patients with postoperative PJF were significantly older (mean age 67.6 ± 5.1 vs. 59.2 ± 15.2 years, $p < 0.001$). Lower mFI-5 correlated with higher rates of PJF ($p = 0.002$) and need for revision surgery ($p = 0.098$). Lower mFI-11 was significantly associated with increased rate of PJF ($p = 0.001$), however no significant difference was seen for revision surgery. Patients with a lower CCI were more likely to experience postoperative PJF ($p < 0.001$) and undergo revision surgery ($p = 0.007$). Patients with postoperative PJF had a lower L3-TPA:VA ratio compared to patients without PJF, although without significant difference ($p = 0.290$). Patients with lower L3-TPA:VA ratio were more likely to undergo revision surgery ($p = 0.033$).

Conclusions: Patients with lower mFI-5, mFI11 and CCI had higher rate of PJF and revision surgery within 2 years after surgery. Patients with postoperative PJF tended to have a lower L3-TPA:VA ratio compared to patients without PJF. The rate of revision surgery was higher in sarcopenic patients.

O20

Minimally Invasive versus Conventional Open Approach for Correction and Posterior Spinal Fusion in Patients with Adolescent Idiopathic Scoliosis

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Background: The most popular surgical treatment method for adolescent idiopathic scoliosis (AIS) is posterior spinal fusion. Recent advances in implant designs allow for minimally invasive (MISS) approaches. However, these have not yet made a breakthrough in spinal deformity. Tissue damage is less with MISS techniques, but intraoperative orientation is more challenging. Few studies have analysed surgical/patient outcomes in MISS treated AIS; even fewer have compared MISS with the open approach. We compared the results of AIS patients treated using MISS with those of a historical cohort treated using traditional open methods.

Methods: This was a single-center retrospective analysis of data collected prospectively within the EUROSPINE Spine Tango Registry framework. Inclusion criteria were: idiopathic scoliosis; posterior spinal fusion; major coronal Cobb $< 80^\circ$; aged ≤ 30 years. We identified 66 patients operated using conventional methods (OPEN) from 2005 to 2015, and 26 patients using a minimally invasive posterior transmuscular approach (MINI-OPEN) from 2016 to Feb 2020. Complications, blood loss, operation time, and length of stay were documented on Tango forms. Pre and postop whole spine standing X-rays were analysed. Patients completed the Core Outcome Measures Index (COMI) pre and at 3 and 12mo postoperatively.

Results: Baseline characteristics were similar in both groups, as was the preop main curve ($57.5 \pm 9.1^\circ$ MINI-OPEN, $59.4 \pm 9.7^\circ$ OPEN; $p = 0.39$). Blood loss was significantly less in the MINI-OPEN group (472 ± 273 mL vs. 1218 ± 731 mL; $p < 0.0001$). Operating time was significantly longer in the MINI-OPEN group (473 ± 92 min vs. 320 ± 104 min; $p < 0.0001$). Length of stay was almost half in the MINI-OPEN group (5.4 ± 1.4 days vs. 9.19 ± 2.7 days, respectively; $p < 0.0001$). The % coronal correction of the main curve was not significantly different between the groups ($76.5 \pm 9.6\%$ MINI-OPEN vs. $71.9 \pm 11.7\%$ OPEN; $p = 0.08$). The pattern of reduction in COMI from preop to 3mo FU and from preop to 12mo FU was significantly different ($p < 0.05$), with MINI-OPEN showing slightly better results.

Conclusions: Compared with the conventional open approach, the minimally invasive approach was associated with a significantly lower blood loss and shorter hospital stay and slightly better short-term patient rated outcomes. Refining the surgical technique and decreasing the surgical invasiveness reduces the suffering of the patients immediately after surgery and is associated with slightly better patient outcome at 3 and 12 months.

O21

Predictive Outcome Value of Angular Craniometry in Surgical Treatment of Cerebellar Tonsillar Herniation

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Objective: Treatment of isolated, symptomatic tonsillar herniation through the foramen magnum classically consists in decompressive surgery of the posterior fossa (PFD) and expansile duroplasty. The authors aimed at assessing the role of abnormal primary cranial and secondary craniocervical angular craniometric parameters in patients undergoing PFD on the postoperative clinical outcome and complication rate.

Methods: A retrospective review of clinical and radiological data of pediatric patients (< 18 years) that underwent posterior fossa decompression surgery at the Pediatric Neuro-

surgery Department of the Hospital “Femme Mère Enfant” in Lyon, France, over a 20-year study period from 2001 to 2020 was performed. Preoperative T1w MRI images were screened for: basal angle, Mc Rae line, Chamberlain line and clivoaxial angle. The association of angular craniometrics parameters with clinical outcome criteria was investigated and the CCOS (Chicago Chiari Outcome Scale) was applied for objective assessment.

Results: Of 100 patients eligible for data analysis, 45 showed a secondary variant of CM and 55 patients were identified with isolated CM-1. 34% (n = 19) had a basal angle > 133° consistent with platybasia. Basilar Invagination was confirmed in 20% (n = 11) of the total cohort, with a higher rate in the platybasia group (52.6%). An abnormal clivoaxial angle < 145° was found in 62% (n = 34). CCOS was lower in patients with BI (p = 0.04) and pathologic CXA (p = 0.01), but no linear correlation was seen with platybasia. Complications were higher in BI, platybasia and pathologic CXA patients (p = 0.05, 0.001 and 0.01, respectively). Conversely, no statistical significance was observed concerning the rate of surgical revisions.

Conclusion: Our results confirm the correlation between primary and secondary craniometrics angular parameters, identify a relatively high rate of anomalies of the craniocervical junction in patients with tonsillar herniation and suggest that craniocervical angular geometrics may have a predictive outcome value in patients undergoing PFD surgery.

O22

Outcome of Dermabond™ Prineo™ for Wound Closure in Pediatric Spine Surgery

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Purpose: Tissue adhesive glue is well established for the closure of wound lacerations and short surgical incisions in children. In adults Dermabond™ Prineo™ skin closure system (DPSCS), which consists of both tissue adhesive glue and a self-adhesive mesh, for closure of surgical incisions has been reported. We aimed to investigate the outcome of DPSCS for spinal wound closure in children after intra- and extradural procedures.

Methods: In a prospective database including consecutive patients undergoing spine surgery at our institution since 2018 demographic and surgical data were collected. Wound healing during hospitalization, at two weeks, and three months follow-up were evaluated and cosmetic outcome scored. A parental survey on wound care and outcome (Visual analogue scale for cosmetic scores (Range 1–10)) was performed.

Results: 29 children (17 boys and 12 girls) underwent surgery at a median age of 3.8 years (6 days–17 years) for lipoma of the filum terminale (n = 13), lumbar lipomyelomeningocele (n = 5), spasticity (n = 6) and other pathologies (n = 5). DPSCS was removed after a mean of 14.5 days, and at three months the vast majority showed (21/29, 72%) good cosmetic outcome. Cosmetic outcome, assessed subjectively by the parents in 15 children 15 months after surgery showed an average VAS score of 7. Encountered difficulties included accidental removal of DPSCS (n = 1) maceration of a cutaneous haemangioma (n = 1) and CSF leak in a redo-surgery (n = 1).

Conclusion: DPSCS is safe and leads to satisfactory cosmetic outcome for spinal wound closure in children. Its simple application and the fact that it doesn’t need to be changed for 2 weeks facilitated professional and parental care. A survey revealed high parental satisfaction with the cosmetic outcome. Nevertheless, in cases of skin malformations and redo-surgery traditional skin suturing might be more suitable.

O23

Incidence of Localized Amyloid in Ligamentum Flavum of Patients with Lumbar Spinal Stenosis

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Introduction: Wild-type transthyretin amyloid (ATTRwt) can form deposits in heart, tendons and ligaments, including ligamentum flavum. Cardiac involvement is the most devastating manifestation of ATTRwt, and retrospective analysis of patients with cardiac ATTRwt suggests that lumbar spinal stenosis (LSS) may precede diagnosis of heart involvement by many years, making identification of ATTRwt during decompressive surgery for LSS a potential tool for early diagnosis. Up to now, histological work-up of ligamentum flavum is not routinely performed.

Methods: This is a prospective, single-center study assessing the incidence of ATTRwt in unselected adult patients with LSS (NCT03661059). Patients with known systemic amyloidosis were excluded. Tissue samples from ligamentum flavum were analyzed centrally in the German Reference Laboratory in Kiel for the presence of amyloid by Congo red staining, and via immunohistochemistry for amyloid subtype. The study was approved by the competent ethical board (BASEC 2019-00936; CE 3481).

Results: Between 17.02.2020 and 12.10.2020 we performed 145 LSS decompression surgeries. Thirty-seven (25.5%) patients were enrolled in the study. Amyloid deposits were found in 32 (86.5%) patients. Transthyretin amyloid was present in 28 (87.5%) of the positive tissue samples, while subtyping was not conclusive in 4 (12.5%) patients. The median age at surgery was 71 years (50–86), 22 (59%) patients were >70 years of age. No difference in sex ($p = 0.27$), previous surgery for carpal tunnel syndrome ($p = 0.62$) or prior LSS surgery ($p = 0.58$) was observed between patients with and without amyloid deposits. Patients aged > 70 years were significantly more likely to test positive for ATTRwt deposits ($p = 0.017$).

Conclusions: We report, for the first time, prospective data on the incidence of local ATTRwt in unselected patients undergoing surgery for LSS. Eighty-six percent of the patients show amyloid deposits in the ligamentum flavum. The occurrence of ATTRwt deposits is correlated with older age. Updated results will be presented at the conference.

O24

Distance to First Symptoms Measured by the 6-Minute Walking-Test Differentiates between Treatment Success and Failure in Patients with Degenerative Lumbar Disorders

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Aim: The smartphone-based 6-min walking test (6WT) is an established digital outcome measure in patients undergoing surgery for degenerative lumbar disorders (DLD). In addition to the 6WTs primary outcome measure, the 6-min walking distance (6WD), the patient's distance to first symptoms (DTFS) and time to first symptoms (TTFS) can be recorded. This is the first study to analyse the psychometric properties of the DTFS and TTFS.

Methods: 49 consecutive patients (55 ± 15.8 years) completed the 6WT pre- and 6 weeks (W6) postoperative. DTFS and TTFS were assessed for reliability and content validity using disease specific patient-reported outcome measures. The Zurich Claudication Questionnaire patient satisfaction subscale was used as external criterion for treatment success. Internal and external responsiveness for both measures at W6 were evaluated.

Results: There was a significant improvement in DTFS and TTFS from baseline to W6 ($p < 0.001$). Both measures demonstrated a good test-retest reliability ($\beta = 0.86$, 95% CI 0.81–0.90 and $\beta = 0.83$, 95% CI 0.76–0.87, both $p < 0.001$). The DTFS exceeded the 6WD capability to differentiate between satisfied (82%) and unsatisfied patients (18%) with an AUC of 0.75 (95% CI 0.53–0.98) vs. 0.70 (95% CI 0.52–0.90). The TTFS did not demonstrate meaningful discriminative abilities.

Conclusion: Our study shows that the DTFS provides additional information, which is helpful in estimating disability and response to surgical treatment of DLD. The DTFS demonstrated both a higher external responsiveness and a better correlation with subjective outcome measures than the TTFS.

O25

Negligible Systemic Uptake of Suprafascial Vancomycin Powder Following Instru-Mented Posterior Spinal Fusion—Preliminary Results from a Randomized Clinical Trial (VANCO Trial)

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Aims: Intrawound vancomycin powder is an emerging strategy to reduce surgical site infections (SSIs) in spine surgery. However, there are concerns relating to its safety profile and toxicity. Data on systemic uptake of suprafascially administered vancomycin powder following instrumented spinal fusion is lacking. Our aim was to study the systemic uptake and safety of suprafascially administered vancomycin powder in the early postoperative phase following open instrumented posterior spinal fusion.

Methods: This was a substudy of an ongoing randomized clinical trial. Patient enrollment started in November 2019. Eligible adult patients were randomized 1:1 to either receive suprafascial vancomycin powder before wound closure or not to receive vancomycin powder. Serum vancomycin levels were assessed on postoperative days 1 and 2, serum creatinine levels were measured pre- and postoperatively. Adverse events up to 6 weeks following surgery were recorded.

Results: Among 34 randomized patients (mean age 62 years, range 31–84 years; 18 [53%] women), 17 received of vancomycin powder. No detectable serum vancomycin levels (>4.0 mg/L) were found. Rates of adverse events in the vancomycin and control group, respectively, were 23.5% (4/17) vs. 17.6% (3/17) (OR 1.43; 95% CI, 0.27–7.68; $P = 1.00$). No patient had nephrotoxicity or ototoxicity in either group.

Conclusion: Suprafascial vancomycin powder in open instrumented spinal fusion surgery is safe and results in negligible systemic uptake. Final results of the VANCO trial need to be awaited for conclusive data on the efficacy of vancomycin for SSI prevention and its impact on wound healing.

O26

Complex Combined Neurosurgical and Orthopedic Spinal Procedures in Pediatric Patients: A Case Based Study

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Introduction: Correction of spinal deformity in pediatric patients with associated neurological abnormalities, often related to syndromic or genetic diseases, requires complex multidisciplinary treatments and procedures. Many patients undergo combined neurosurgical and orthopedic spinal surgeries either as a single-stage treatment or by interval staging of the deformity correction and the neurosurgical procedure. Our aim is to present our single-center experience in patients who underwent complex combined neurosurgical and orthopedic spinal procedures within the last 7 years.

Methods: A retrospective review of all pediatric patients (<18 years old) undergoing a surgical procedure involving a pediatric neurosurgeon and an orthopedic spine surgeon over a 7-year period was performed. Medical charts of these patients were searched for baseline characteristics, underlying disease or syndrome, pathology indicating surgery, surgical procedure, results of intraoperative spinal cord monitoring and postoperative complications.

Results: Out of all neurosurgical patients treated between the year 2013 and the year 2020, we included 32 patients undergoing a total of 34 combined, neurosurgical and orthopedic spinal procedures. 56% (n = 19) were females and 44 (n = 15) males, with a mean age of 14.4 years. 7 patients suffered from a syndromic or genetic disease, 9 patients presented with a neuromuscular scoliosis associated with cerebral palsy, in 5 patients the reason for surgery was neoplastic, one had suffered a trauma, 8 patients presented with segmental instability and 4 patients underwent stabilization procedure due to scoliosis combined with a congenital malformation (e.g., chiari malformations, tethered cord). Intraoperative neuromonitoring was used in 88% of the cases. Surgical morbidity rate was 18.7% and mortality rate was 0%.

Conclusion: In pediatric spine diseases that are associated with neurosurgical pathologies, the treatment can be often very challenging. Good collaboration between highly specialized pediatric neurosurgical and pediatric orthopedic spinal teams and correct timing of procedures is needed to achieve good outcome in these complex cases. In our experience, this is best performed in a specialized center with an established, interdisciplinary approach.

O27

Randomized Study Comparing Virtual Reality and Conventional On-Screen Teaching of Cerebrovascular Anatomy

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Introduction: Clipping of aneurysms requires years of training, which have traditionally been obtained by learning through observation, to successfully understand the 3-dimensional neurovascular anatomy. Nowadays, with fewer operative aneurysm clippings, work hours regulation and increased patient safety concerns, novel teaching methods are required for young neurosurgeons. Virtual reality (VR) models offer the opportunity to either train a specific surgical skill or prepare for an individual surgery. With this study we aimed to compare the spatial orientation between traditional 2-dimensional images and 3D VR models in neurosurgical residents or students.

Methods: Residents and students were randomly assigned to describe four aneurysm cases, which could be either 2D images or 3D VR models. The time-to-aneurysm detection as well as a spatial anatomical description was assessed via an online questionnaire and compared between the groups. The aneurysm cases were ten selected patient cases, treated at our institution.

Results: Overall, time-to-aneurysm detection was shorter, with a trend towards statistical significance, in the 3D VR model compared to 2D images (25.77 (± 37.26) vs. 45.70 (51.94), $p = 0.052$). No significant difference was observed for residents (3D VR 24.47s (± 40.16) vs. 2D 33.52s (± 56.06), $p = 0.564$), while in students a significant shorter time-to-aneurysm was measured using 3D VR models (26.95s (± 35.39) vs. 59.16s (± 44.60), $p = 0.015$). No significant difference between the modalities for anatomical and descriptive spatial mistakes was observed. Most participants (90%) preferred the 3D VR models for aneurysm detection and description, and only one participant (5%) describe VR related symptoms like dizziness or nausea.

Conclusion: Virtual Reality platforms facilitate aneurysm recognition and understanding of its spatial anatomy, which could make them the preferred method compared to 2D images in the years to come.

O28

Gender Disparities in Neurosurgery: A Multinational Survey on Gender-Related Career Satisfaction

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Aim: Gender disparities are still an important topic in our current neurosurgical practice. We sought to assess how gender-related career satisfaction is perceived amongst the neurosurgical community with the aim to understand better gender-related issues and challenges encountered in neurosurgery.

Methods: An electronic survey aimed at both women and men practicing neurosurgery was sent via social networks and neurosurgical societies and responses were collected anonymously.

Results: Preliminary results consisted of 168 responses ($n = 168$) with 118 men (70.2%) and 50 women (29.8) participating. 75% agreed with the statement that all people are equal and gender does not matter and 72.4% thought that men and women had the same leadership competences. Men and women were considered to have equal surgical skills by 78% (with 19.6% stating that men were the better surgeons) and equal teaching abilities by 81% of the participants. 29.8% considered that women had better bedside manners and more empathy and 4.2% considered that men were better in that regard. 89 subjects (53%) said to have experienced gender discrimination during their practice, mainly by patient or patient's family and by colleagues. Work-life balance was rated 4 out of 5 (1: low score. 5: best score) by 35.1% and 3 out of 5 by 26.2%. 78% of women thought they needed to work harder than their male colleagues to achieve the same goal while only 20% of the men answered positively when asked the same question.

Conclusion: The collected data suggest that although the majority of questioned people views gender-related topics in the practice of neurosurgery to be mainly irrelevant, there are still divergent ideas and perceptions regarding the matter.

O29

Parent Artery-Initiated and Stent-Mediated Neointima Formation in a Rat Saccular Side Wall Model

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Aims: In contrast to clipping, which promotes an immediate physical barrier of blood flow into aneurysms, endovascular treatments (coiling, stenting) rely on biological processes, namely thrombus organization and neointima formation. This study aimed to clarify whether endothelial cells covering the endoluminal layer of the neointima primarily derive from the adjacent, healthy vessel wall, are recruited from circulating progenitor cells or derive from the aneurysm wall. Furthermore, the amount of endothelial cells in the thrombus was analyzed regarding the potential role of endothelial clefts as main reason for aneurysm recurrence.

Methods: Aneurysms were sutured end-to-side on the abdominal aorta of male Lewis rats and treated with coil- (n = 16) or stent-embolization (n = 15). Fifteen decellularized wild-type aneurysms were sutured in recipient rats, in 16 cases vital aneurysms on wild-type rats. CM-Dil Dye, a fluorescent lipophilic cell tracer, was injected in the clamped aorta prior to aneurysm suture, in order to mark initial endothelial cells in the parent artery to track their proliferation during follow-up. Follow-ups were performed on either day 7 or 21 after aneurysm treatment. All aneurysms were analyzed for growth, thrombus formation and recurrences. After macroscopical assessment, histological evaluation followed via white-light and fluorescence microscopy with cell count for specific regions-of-interest (aneurysm wall, intraluminal thrombus, parent artery and neointima).

Results: During follow-up, no aneurysm ruptured. Aneurysms demonstrated macroscopic residual perfusion in 12/16 (75%) animals treated with coil embolization and in 1/15 (7%) with stent. Cell count showed a similar distribution of CM-Dil+ cells for either coil- or stent-treatment in the aneurysm wall (11.1% vs. 11.25%). However, the amount of CM-Dil+ cells in the thrombus (25.3% vs. 32.15%, p = 0.26) and neointima (36% vs. 43.83%, p = 0.28) was decreased in coiled vs. stented aneurysms.

Conclusions: Coil-treated aneurysms showed worse healing patterns compared to stent-treatment. Cell migration forming a neointima in stent-treated aneurysms is mainly dependent from the adjacent vessel, as shown by CM-Dil Dye application. Therefore, a cell-rich parent artery might be crucial. Continuous endothelial lining along the parent artery's lumen via stents might be substantial for complete aneurysm healing after endovascular procedures.

O30

Lumen- versus Wall-Oriented Treatment Strategies for Intracranial Aneurysms—A Systematic Review of Suggested Therapeutical Concepts in Preclinical Studies

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Introduction: The development of effective and elegant treatment strategies for intracranial aneurysms has been and continues to be a major interest in neurosurgical research. Initial concepts -based on a rather physical-mechanistic aneurysm understanding-focused on occlusion of the intra-aneurysmal blood flow (so called lumen-oriented therapies). However, gradually better understanding of an aneurysm as a diseased vessel and deeper knowledge in vessel wall biology shifted therapeutical concepts towards the putative role of the aneurysm wall (so called wall-oriented therapies). This study aims to identify and categorize all strategies that have been suggested for treatment of intracranial aneurysms.

Methods: A systematic literature search was conducted using the Medline database. All original publications which proposed a novel treatment strategy for intracranial aneurysms that have been published until 1 January 2021 were included. Studies were dichotomized between lumen- and wall-oriented strategies. Furthermore, both strategies were themselves categorized in groups summarizing similar treatment approaches

Results: Of 5278 studies identified to screen, 636 met with the inclusion criteria. Of these 399 (63%) presented a lumen-oriented strategy and 237 (37%) a wall-oriented strategy. Lumen-oriented strategies can be subdivided in (1) enhanced intraluminal healing, (2) enhanced intraluminal filling, (3) bridging the intraluminal space and (4) alternative concepts. Wall-oriented strategies can be subdivided in (1) stimulation of proliferative response, (2) prevention of aneurysm wall cell injury, (3) inhibition of inflammation and oxidative stress and (4) inhibition of extracellular matrix degradation.

Conclusion: This systematic review provides a comprehensive overview over suggested treatment strategies for intracranial aneurysms. Overall, lumen-oriented strategies numerically dominate over wall-oriented strategies. In view of the plethora of suggested preclinical treatment strategies only a small minority ever translated into clinically applicable concepts.

O31

Incidence and Outcome of Periinterventional Vasospasm during Endovascular or Microsurgical Treatment of Unruptured Intracranial Aneurysms

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Background: Periinterventional vasospasms (PIVS) is associated with high risk of delayed cerebral vasospasm (DCVS), delayed cerebral ischemia (DCI), and poor outcome after aneurysmal subarachnoid hemorrhage. However, their incidence and clinical significance in the treatment of unruptured intracranial aneurysm remains unclear.

Methods: A consecutive series of 205 patients that underwent UIA treatment by means of endovascular coil embolization (n = 96) or microsurgical clipping (n = 109) was assessed for the occurrence of PIVS. In all cases PIVS were detected in intraoperative/periinterventional DSA. Severity of PIVS, association of PIVS with development of DCVS, and neurological outcome were analyzed.

Results: Intraoperative PIVS was present in n = 14/109 (13%) patients with microsurgical clipping. Of these, caliber irregularities were mild (n = 11), moderate (n = 4) and severe (n = 3). In endovascularly treated patients, 6/96 (6%) developed PIVS, which were either mild (n = 3) or moderate (n = 3). None of the patients developed DCVS or persisting neurological deficits. Management included immediate aggressive blood pressure control and application of spasmolytics immediately upon detection in all cases.

Conclusion: This series revealed a relatively high overall incidence of PIVS at 10%. No association of PIVS with development of DCVS, DCI, or poor outcome was detected. In contrast to ruptured intracranial aneurysms, the phenomenon of PIVS in unruptured intracranial aneurysms seems to be benign without consequences for the patient.

O32

Endoscopic Surgery for Spontaneous Supratentorial Intracerebral Haemorrhage: A Systematic Review and Meta-Analysis

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Introduction: Therapeutic options of spontaneous supratentorial intracerebral haemorrhage (SSICH) are limited and consist of either best medical treatment (BMT) or surgical hematoma evacuation. The treatment methods and choice of surgical technique are debated, and so far, no clear advantage of endoscopic surgery (ES) compared to conventional craniotomy (CC) or BMT was shown. The aim of this systematic review and meta-analysis was to investigate the differences in outcome, morbidity, and mortality between ES and CC or BMT.

Methods: We searched systematically the Embase and PubMed databases for randomized controlled trials (RCT) comparing ES to CC and BMT. The primary outcome was favourable clinical outcome after 6 months, secondary outcomes were morbidity and mortality rates. The fixed effects model was used if low heterogeneity was present, otherwise a random effects model was applied. For the primary outcome, the leave-one-out method was used.

Results: We screened 932 articles of which 7 were eligible for the qualitative and quantitative analysis with a total of 312 subjects in the control (216 for CC and 96 for BMT) and 279 in the treatment group (ES). Compared to BMT, ES showed a significantly higher rate of favourable outcome (RR 1.93, 95%CI [1.12;3.33], $p = 0.02$) and a significantly lower mortality rate (RR 0.63, 95%CI [0.44;0.90], $p = 0.01$). There was no significant difference concerning the favourable outcome and mortality rates when ES was compared to CC (RR 2.13, 95%CI [0.01;737], $p = 0.35$; RR 0.42, 95%CI [0.17;1.05], $p = 0.06$). Furthermore, ES showed a significantly lower morbidity rate (RR 0.41, 95%CI [0.29;0.58], $p < 0.01$), and infection rate (RR 0.33, 95%CI [0.20;0.54], $p < 0.01$) as opposed to CC. Duration of surgery was significantly lower for ES compared to CC (SMD -3.17 , 95%CI $[-5.17; -1.18]$, $p = 0.01$).

Conclusion: ES seems to lead to significantly higher rates of favourable outcome and lower mortality rates compared to BMT. Further, ES shows reduced time of surgery and lower complication rates as opposed to CC. Therefore, ES seems to be a promising approach in the treatment of SSICH and should be the focus of well-designed prospective trials investigating the treatment of SSICH.

O33

The Value of 3-dimensional Models for Preoperative Clip Selection in Aneurysm Surgeries: A Pilot Study

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Objective: Due to the increasing scarcity of intracranial aneurysm (IA) clipping, its treatment can be challenging despite modern imaging data. In this preliminary study, we aimed at evaluating the accuracy of patient-specific 3-dimensional (3D) printed models to select the best clip configuration for unruptured IA (UIA) treatment.

Methods: In this prospective trial, a hollow, semi-elastic 3D model of the patient's neurovascular anatomy was generated from conventional computed tomography angiography (CTA) and 3D rotational angiography (3D-RA). A standardized questionnaire was used to evaluate the accuracy of the 3D model and conventional neuroimaging with regard to the intraoperative findings by means of correct clip selection, depiction of parent vessels, and adjacent perforators.

Results: In eleven consecutive patients, 13 UIAs were clipped. Patients' mean age was 61 years (range, 39–78 years). The 3D models allowed adequate depiction of the IAs, parent vessels and adjacent perforators $< 1\text{mm}$ in all patients. Intraoperative clip application was correct in ten (77%) UIAs when preoperatively selected with the 3D models, compared to 2 (15%) UIAs when selected with conventional imaging ($p = 0.01$). When using the 3D models, fine adjustments were necessary in two (15%) UIAs, where the aneurysm size was slightly underestimated. In one (8%) patient, serial clipping became necessary due to IA rupture. Intraoperative 3D-RA revealed complete aneurysm obliteration in all but one (8%) patient. No postoperative ischemia or neurological sequelae were noted.

Conclusions: Our preliminary experience indicates that the novel 3D model allows for adequate haptic feedback, optimal selection of the surgical approach, best clip configuration with regard to the intraoperative findings, and completeness of occlusion in the majority of patients. The 3D model might become a valuable planning tool to attain complete UIA obliteration.

O34

SpectoVR as a Novel 3D Virtual Reality Planning Software in Aneurysm SurgeryL. Greuter ¹, D. Croci ², P. Cattin ³, M. Psychogios ⁴, D.W. Zumofen ⁵, J. Soleman ¹ and R. Guzman ¹¹ University Hospital Basel/University of Basel, Switzerland² Clinical Neurosciences Center, University of Utah, Salt Lake City USA;³ University of Basel, Switzerland⁴ Division of Neuroradiology, University Hospital Basel, Switzerland⁵ Maimonides Medical Centre, Neurosurgery, New York, USA

Background: The surgical treatment of ruptured and unruptured intracranial aneurysms is challenging and requires years of training. With a reduced number of surgical cases in the endovascular era of aneurysm treatment alternative forms of training need to be explored. New technologies such as 3-dimensional (3D) Virtual reality (VR) enable novel possibilities to improve the anatomical understanding and the surgical planning. Specto-VR is such a 3D VR software, which allows full immersion patient specific image visualization and interaction with the reconstructed model. We aim to describe our experience with SpectoVR for planning elective aneurysm surgery.

Methods: Surgical planning with Specto-VR was performed routinely since 2019 in all patients undergoing aneurysm clipping at our institution. Specto-VR allows for direct import from the Radiology PACS system and doesn't require any prior manipulation of the CT-Angiography or DINA CT. The main surgeon and the assistant discussed all cases interactively prior surgery. Aneurysm location, morphology, size, and anatomy of parent arteries were analysed in the VR environment. Intraoperative images were recorded and postoperatively compared with the 3D-VR images.

Results: Forty-five cases (33 female, Avg Age 58 ± 9) were included in the analysis. DINA CT scan data seemed to be superior compared to CT-angiography based 3D reconstructions. The average time of technical preparation was 10 min. Aneurysm size and morphology, the bifurcating branches and major perforators were well visualized. Placement of the virtual patient's head in a surgical position and the virtual craniotomy resulted in an excellent understanding of the surgical orientation. The ability to virtually observe the aneurysm at high magnification from different angles, significantly enhanced the understanding of the neurovascular anatomy. In the surgeon's impression (senior and junior) it resulted in a subjective "déjà vu" in the operating room. Postoperative debriefing confirmed a good correlation of the surgical site with the VR model.

Conclusion: VR could play a significant role in surgical teaching and planning for aneurysm clipping as it allows a realistic 3D reconstruction in a full-immersive virtual environment of aneurysm morphology and adjacent branches. Further studies are needed to assess its function and standardized integration into vascular surgery teaching and planning, and patient outcome.

O35

Value of Three-Dimensional Digital Subtraction Angiography for Detection and Classification of Intracranial Aneurysm Remnants after ClippingS. Marbacher ¹, M. Halter ¹, D.R. Vogt ², J.C. Kienzler ³, C.T.J. Magyar ⁴, S. Wanderer ³, J. Anon ³, M. Diepers ³, L. Remonda ³ and J. Fandino ³¹ Kantonsspital Aarau, Switzerland² Department of Clinical Research, Clinical Trial Unit, University of Basel and University Hospital Basel, Switzerland³ Kantonsspital Aarau, Switzerland⁴ Kantonsspital Aarau, Switzerland

Background: The current gold standard for evaluation of the surgical result after intracranial aneurysm (IA) clipping is two-dimensional (2D) digital subtraction angiography (DSA). While there is evidence that postoperative 3D-DSA is clearly superior to 2D-DSA, especially for small (<2 mm) clipped IA remnants, there is a lack of data on intraoperative comparison.

Objective: This study compares the diagnostic yield of detection of IA remnants in intra- and postoperative 3D-DSA, categorizes the remnants based on 3D-DSA findings, and examines associations between missed 2D-DSA remnants and IA characteristics.

Methods: In this analysis of prospectively collected data, we evaluated 232 clipped IAs that were examined with intraoperative or postoperative 3D-DSA. Variables analyzed included patient demographics, IA and remnant distinguishing characteristics, and 2D- and 3D-DSA findings. Remnants detected by 2D-DSA were compared with those detected by intraoperative and postoperative 3D DSA. Maximal IA remnant size detected by 3D-DSA was measured using a 3-point scale of 2-mm increments.

Results: Although 3D-DSA detected all clipped IA remnants, 2D-DSA missed 30.4% (7 of 23) and 38.9% (14 of 36) clipped IA remnants in intraoperative and postoperative imaging, respectively (95% confidence interval [CI]: 30 [12, 49]%; p-value 0.023 and 39 [23, 55]%; p-value = < 0.001), and more often missed grade 1 (<2 mm) clipped remnants (Odds Ratio [95% CI]: 4.3 [1.6, 12.7], p-value 0.005). Our findings remain inconclusive about the effects of multiple clips or aneurysm location when detecting remnants with 2D-DSA.

Conclusion: The results corroborate previous findings that, compared with 2D-DSA, 3D-DSA achieves a better diagnostic yield postoperatively in the evaluation of clipped IA and suggest its superiority when used intraoperatively. Our method to grade 3D-DSA remnants based on the maximal remnant size proved to be simple and practical. Small IA remnants seemed to have a higher risk to be missed in 2D-DSA. We advocate the routine use of either intraoperative or postoperative 3D-DSA as a baseline for lifelong follow-up of clipped IA.

O36

The Herniation WFNS Scale Improves Prediction of Outcome in Poor-Grade Aneu-Rysmal Subarachnoid Haemorrhage Patients—An International Prospective Multi-Centre Study

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Aims: Good outcomes are seen in up to 50% of patients with World Federation of Neurosurgical Societies (WFNS) grade V subarachnoid haemorrhage (SAH). Therefore, the usefulness of the current WFNS grading system for identifying the worst scenarios for clinical studies and for making treatment decisions is limited. We previously modified the WFNS scale by requiring “positive” signs of brainstem dysfunction to assign grade V. This study aimed to validate the new herniation WFNS grading system in an independent prospective cohort.

Methods: We conducted an international prospective multicentre study in poor-grade aSAH patients comparing the WFNS classification with a modified version – the herniation WFNS scale (hWFNS). Here, only patients that showed “positive” signs of brainstem dysfunction (posturing, anisocoric or bilateral dilated pupils) were assigned hWFNS grade V. Outcome was assessed by modified Rankin Scale score 6 months after haemorrhage. The primary endpoint was the difference in specificity of the WFNS and hWFNS grading with respect to poor outcomes 6 months after haemorrhage.

Results: Of the 250 patients included, 237 reached the primary endpoint. Comparing the WFNS and hWFNS scale after neurological resuscitation, the specificity increased from 0.19 (WFNS) to 0.93 (hWFNS) (McNemar, $p < 0.001$), and the positive predictive value from 61.9 to 88.3 ((weighted) generalized score statistic, $p < 0.001$). For mortality, the specificity increased from 0.21 to 0.94 (McNemar, $p < 0.001$), and the positive predictive value from 0.51 to 0.87 ((weighted) generalized score statistic, $p < 0.001$).

Conclusion: The identification of objective “positive” signs of brainstem dysfunction significantly improves the specificity and positive predictive value with respect to poor outcome in grade V patients. Therefore, a simple modification – presence of brainstem signs is required for grade V – should be added to the WFNS classification.

O37

Does the Discontinuation Time of Antiplatelet or Anticoagulation Treatment Affect Hemorrhagic Complications in Patients Undergoing Craniotomy for Neurovascular Lesions?

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Background: The number of patients treated with platelet inhibitors (PI) and/or anticoagulants (AC) in neurosurgery is increasing. The aim of this study was to analyse the effect of PI/AC discontinuation time on hemorrhagic events after craniotomy for neurovascular pathologies.

Methods: The 30-day postoperative bleeding rates were retrospectively compared between short (≤ 5 days) and long (> 5 days) discontinuation time of PI/AC before and after surgery. Kaplan-Meier survival analysis comparing time to postoperative bleeding and the effect of PI/AC discontinuation time on bleeding rates were analysed. Potential risk factors for postoperative bleeding were further analysed in uni- and multivariate analysis.

Results: Out of 215 consecutive patients undergoing craniotomy for neurovascular lesions between January 2009 and April 2019, 23.3% were treated with PI/AC. Of these 36% ($n = 18$) and 20.8% ($n = 10$) were included in the short pre- and postoperative discontinuation group, respectively. Bleeding rates were comparable between the pre- and postoperative short and long discontinuation groups (preoperative 11.1% vs. 10%, $p = 0.659$; postoperative 0% vs. 13.2%, $p = 0.566$). In-hospital mortality rates and time to bleed of the groups were comparable as well. Similarly, the rate for thromboembolic events was not significantly affected by the pre- or postoperative discontinuation time of PI/AC. After multivariate analysis preoperative bleeding of the lesion was significantly associated with postoperative bleeding.

Conclusions: Patients with short discontinuation time of PI/AC treatment undergoing craniotomy for the treatment of neurovascular lesions do not appear to have increased rates of postoperative bleeding.

O38

Biologically Effective Dose (BED) Predicts Obliteration of Unruptured Arteriovenous Malformations Treated by First Intention Gamma Knife Radiosurgery in a Series of 149 Consecutive Cases

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Introduction: Arteriovenous malformations (AVMs) present no pathological tissue and radiation dose is confined in a clear-targeted volume. Here, we retrospectively evaluate the role of biologically effective dose (BED) after Gamma Knife radiosurgery (GKR) for brain AVMs.

Methods: Were enrolled 149 consecutive cases of unruptured AVMs treated by first intention GKR in Lille University Hospital, France. The mean follow-up was 52.9 months (median 48, 12–154). Primary outcome was obliteration and secondary outcome was complication appearance. The marginal dose was 24 Gy in a vast majority of cases (n = 115, 77.2%; range 18–25 Gy). The mean BED was 220.1 Gy^{2.45} (median 229.9, range 106.7–246.8). The mean beam on time was 32.3 min (median 30.8, range 9–138.7). The Virginia score was 0 in 29 (19.5%), 1 in 62 (41.6%), 2 in 41 (29.5%), 3 in 18 (12.1%), 4 in 0 (0%) patients, respectively. The mean Pollock-Flickinger score was 1.11 (median 1.52, range 0.4–2.9). A uni- (for obliteration and complication appearance) and multivariate (for obliteration only) analysis was performed.

Results: 104 (69.8%) AVMs were obliterated at last follow-up. The strongest predictor for obliteration was BED (p = 0.03). A radiosurgical obliteration score is proposed, derived from a fitted multivariable model: $(0.018 * \text{BED}) + (1.58 * \text{V12}) + (-0.013689 * \text{beam on time}) + (0.021 * \text{age}) - 4.38$. The area under the ROC curve was 74.38 and after internal validation using bootstrap methods was 70.88. Twenty-eight (18.8%) patients developed complications after GKR, of whom transient radiological in 20 (13.4%). Predictors for complication appearance were: higher prescription isodose volume (p = 0.0005) and 12 Gy isodose line volume (V12, p = 0.001), higher Pollock-Flickinger (p = 0.001) and Virginia scores (p = 0.003) and lower beam-on time (p = 0.03).

Conclusions: Biologically effective dose was the strongest predictor of obliteration of unruptured AVMs after first intention GKR. A radiosurgical score comprising the BED is proposed. The V12 appears as a predictor for both efficacy and toxicity. Beam-on time was illustrated as statistically significant for both obliteration and complication appearance. The exact threshold remains to be established by further studies.

O39

A Deep Brain-Computer Interface Allows Parkinson Patients to Control Pathological Oscillations and Quicken Movements through Neurofeedback

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Parkinsonian motor symptoms are linked to pathologically increased beta-oscillations in the basal ganglia. While pharmacological treatment and deep brain stimulation (DBS) reduce these pathological oscillations concomitantly with improving motor performance, we set out to explore neurofeedback as an endogenous modulatory method.

We implemented deep brain electrical neurofeedback to provide real-time visual neurofeedback of pathological subthalamic oscillations measured through implanted DBS electrodes. All 8 patients volitionally controlled ongoing beta-oscillatory activity within minutes of training.

During a single one-hour training session, the reduction of beta-oscillatory activity became gradually stronger and accelerated hand movements. Lastly, endogenous control over deep brain activity was possible even after removing visual neurofeedback, suggesting that neurofeedback-acquired strategies were retained in the short-term. We observed a similar motor improvement when the learnt mental strategies were applied 2 days later.

Further improvement of deep brain neurofeedback might benefit Parkinson patients by improving symptom control, even in the absence of real-time neurofeedback.

O40

European Multicentre Identification of a Probabilistic Stimulation Sweetspot for Essential Tremor

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Background: Deep Brain Stimulation (DBS) is an established therapy for medication-refractory Essential Tremor (ET). Since 1992, different targeting strategies have been suggested for both thalamic and subthalamic targets by different groups based either on stereotactic coordinates, anatomical landmarks or a combination of both. After almost 30 years of DBS for ET, predictors of outcome and the optimal stimulation site remains controversially discussed as an open question.

Objective: The objective of this study was to collect clinical and neuroimaging data of a large cohort of patients with DBS for ET from different European centers to identify predictors of outcome and construct a probabilistic stimulation map in order to determine an optimal stimulation site.

Methods: This study enrolled 119 ET patients treated chronically with unilateral or bilateral DBS operated at five different European DBS centres for retrospective analysis of data on baseline covariates, pre- and postoperative clinical tremor scores (12-month) as well as individual imaging data to obtain individual electrode positions and stimulation volumes. We used multiple regression analysis to estimate predictors of tremor reduction. We calculated a stimulation map using voxel-wise statistical analysis and performed a connectivity analysis to evaluate the role of involved circuits in the response to DBS.

Results: The mean tremor reduction per patient across all centers was 59.3% (55.7–62.9%, 95% CI). Preoperative tremor severity was the only baseline clinical characteristic that was significantly associated with outcome ($r^2 = 0.05$, $p = 0.03$). We identified an area of optimal stimulation that extended from the posterior part of the PSA to the Vim and coincided with the area of highest likelihood to contain the dentato-rubro-thalamic-tract (DRTT). The anatomical location of stimulation was the overall best predictor. The area associated to a significantly better clinical response tends to connect robustly to the primary motor cortex, whereas the area inducing a poor clinical outcome connects to the supplementary motor area.

Conclusions: Our multicentre ET probabilistic stimulation map identified an area of optimal stimulation along the course of the DRTT. This target may be used to guide surgical planning and for computer-assisted planning and programming of deep brain stimulation in the future.

O41

Surgical Treatment and Outcome of Posterior Fossa Arachnoid Cysts in Infants

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Objective: The aim of this cohort study is to describe and analyze our surgical treatment and outcome of posterior fossa arachnoid cysts (PFAC) in infants.

Methods: Patients presenting with PFAC at infancy or prenatally, between the years 2000 and 2019, and who were surgically treated before the age of 2 years old, were included in this study. Patient data was retrospectively collected; baseline characteristics and surgical variables are presented. Factors related to revision surgery were analyzed through uni- and multivariate analysis.

Results: We included 35 patients, of whom 54.3% were male. In 23 patients (65.7%) the cyst was diagnosed prenatally. Surgery was typically recommended after a mean cyst follow-up time of 3.4 ± 3.9 months, with a mean age at surgery of 6.1 ± 5.1 months. In 54.3% (n = 19), surgery was performed before the age of 5 months. The PFAC was treated neuroendoscopically in 57.1% of the patients, 28.6% underwent open cyst procedures, 5.7% were treated with a shunt, and 8.6% underwent a combined procedure. Additional surgery was required in 31.4% (n = 11; mean 2.36 ± 2.11 surgeries/patient). At last follow up (61.40 ± 55.33 months), no mortality or permanent morbidity was seen; radiological improvement was apparent in 91.4%. Patients treated before the age of 5 months (p = 0.09) and presenting before surgery with a stable cyst size throughout pre-op monitoring (p = 0.08), showed a trend towards higher revision rates after surgical treatment.

Conclusion: PFAC of infancy may require surgical treatment before the age of 5 months. Navigated endoscopy is a valid surgical option. Overall mortality or permanent morbidity is rare. Additional surgery is required in up to 30% of the patients; young age and preoperatively stable cysts might be risk factors for revision surgery.

O42

Differences in Postoperative Quality of Life in Young, Early Elderly, and Late Elderly Patients Undergoing Surgical Treatment for Degenerative Cervical Myelopathy

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Aim: Cervical spondylotic myelopathy (CSM) is a common progressive spine disorder affecting predominantly the middle-aged and elderly populations. With the continuously increasing life expectancy, the incidence of CSM is expected to rise further. The outcomes of elderly patients undergoing CSM surgery and especially their quality of life (QOL) postoperatively remains unpredictable. The aim of this study was to describe baseline differences and validated postoperative patient-reported outcome (PRO) measures in elderly patients undergoing CSM surgery using a prospectively collected, multi-institutional, neurosurgery-specific dataset.

Methods: The NeuroPoint Quality Outcomes Database (QOD) was queried for CSM patients treated surgically from January 2016 to December 2018. Data from the 14 highest-volume cervical QOD sites were included. Patients were divided into three groups: young (<65 years old), early elderly (65–74 years), and late elderly (> 75 years). Demographic and PRO measures (Neck Disability Index (NDI), modified Japanese Orthopaedic Association score (mJOA), EuroQol (EQ)-5D score, EQ-5D visual analogue scale (VAS)) were compared among the groups at baseline and 3 and 12 months postoperatively.

Results: A total of 1151 patients in the cervical QOD register underwent surgical treatment for CSM: 691 patients (60%) in the young, 331 patients (28.7%) in the early elderly, and 129 (11.2%) in the late elderly groups, respectively. At baseline, younger patients presented with worse NDI (p < 0.001) and lower baseline EQ-5D VAS (p = 0.004) and EQ-5D (p < 0.001) scores. No differences among age groups were found in the mJOA. An improvement of all QOL scores was noted in all age groups. On unadjusted analysis at 3 months, younger patients had greater improvement in arm pain, NDI, and EQ-5D VAS compared with late elderly. At 12 months, the same changes were seen, but on adjusted analysis, there were no difference on PROs between the age groups.

Conclusions: Our results indicate that elderly patients undergoing CSM surgery achieved equal QOL outcomes to younger patients at 12-month follow-up.

O43

The Need for Overcorrection—Evaluation of Computer-Assisted Virtually Planned Fronto-Orbital Advancement Using Postoperative 3D-Photography

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Background: The relapse rate after fronto-orbital advancement (FOA) seems to be high, however, to date objective measurement techniques of outcome do not exist. The aim of this study was to assess in an objective manner, the outcome of computer assisted design (CAD) and manufacturing (CAM) of individualized 3D printed templates for FOA correction of craniosynostosis, using postoperative 3D-photography.

Methods: We included all patients undergoing FOA between the years 2014 and 2020.

As of 2016 we routinely planned an additional “overcorrection” of 3mm to the FOA correction. The virtually planned supraorbital (SA) angle for FOA correction was compared to the measured postoperative SA based on postoperative 3D photographs. The primary outcome was achieved FOA correction based on these measurements. Secondary outcomes included comparison between outcomes with and without “overcorrection”, time of surgery, blood loss, and morbidity.

Results: Short term follow-up (± 9 months) for the follow-up cohort (14 patients) showed a delta of 12° between the planned and achieved SA. Long-term follow-up (mean 23 months) for 8 patients showed stagnant SA without significant increase in relapse. Postsurgical SA after an additionally planned overcorrection showed a mean delta of 11° as opposed to 14° without overcorrection. Peri- and postoperative complication rate for the whole cohort ($n = 36$) was low, mean intraoperative blood loss was 128mL (± 60) with a mean transfused red blood cell volume of 133mL (± 67 mL).

Conclusion: Postoperative measurements of the applied FOA based on 3D photographs is a feasible and objective method to assess the surgical results after FOA. The delta between the FOA correction using CAD/CAM and the achieved correction can be analyzed based on postoperative 3D photographs. In the future, the calculation of the amount of “overcorrection” needed for the affected side(s) to avoid relapse after FOA might be possible with the aid of these techniques.

O44

Open versus Laparoscopic Ventriculoperitoneal Shunt Placement in Children: An International Survey of Practice

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Objective: Ventriculoperitoneal shunt (VPS) surgery is the preferred treatment for hydrocephalus in children and adults, making it one of the most common procedures in neurosurgery. Patients and especially children being treated with a VPS require several revisions during their lifetime with a revision rate of around 30%. As opposed to adults, in children, only few studies exist assessing the outcome after distal laparoscopic VPS placement and the current practice in the pediatric population remains ambiguous. This international survey aims to investigate the current daily practice concerning shunt placement techniques in children.

Material and Methods: An online questionnaire investigating the different techniques used to place the distal catheter in pediatric VPS surgery was distributed internationally. All results were analyzed using descriptive statistics.

Results: A total of 145 responses were obtained. Mini-laparotomy was reported to be the preferred technique ($n = 108$, 74.4%) for distal shunt placement in children, while

standard laparoscopic placement was only used by 3.4% (n = 5) of all respondents. The remaining respondents (n = 32, 22.2%) use a trocar to place the VPS intraperitoneally. Most of the participants (n = 112, 79.4%) use the same methods for distal VPS placement in children and adults. No significant differences between different geographical regions or different seniority of respondents were observed. A majority of respondents (n = 84, 57.9%) concur, that further studies to investigate distal shunt placement techniques in children are necessary.

Conclusion: This international survey shows that laparotomy is the most frequently used technique for distal VPS placement in children all over the world. No regional differences were observed. However, over half of all respondents agree that further studies investigating shunt placement techniques are necessary.

O45

Mortality and Outcome in Patients Older Than 80 Years of Age Undergoing Burr-Hole Drainage of Chronic Subdural Hematoma

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Objective/Aim: Chronic subdural hematoma is frequently seen within the elderly population and neurosurgeons are confronted with patients older than 80 years presenting with symptomatic chronic subdural hematoma. However, data on surgical outcome are scarce. The aim of this study is to analyze the mortality and outcome after burr-hole drainage in patients older than 80 years.

Methods: This is a single-center retrospective study including patients who underwent burr-hole drainage of chronic subdural hematoma between the years 2016 and 2019. The cohort was divided into 3 age groups (80–84 years; 85–89 years; >90 years). Primary outcome was 30-day and overall mortality, whereas secondary outcome measures were recurrence rates, postoperative bleeding rates, and outcome measured by the modified ranking scale. Uni- and multivariate analysis was conducted to assess for potential risk factors for mortality, recurrence and postoperative bleeding rates.

Results: In total, 107 patients with a mean age of 85.5 ± 3.9 years were included. Mortality rate was less than 10% in each group, showing no significant difference between them ($P = 0.455$). No significant difference in recurrence and postoperative bleeding rates was seen ($P = 0.491$ and $P = 0.532$). Modified Ranking scale score differed significantly at release, whereas at follow-up no difference was seen. After uni- and multivariate analysis, age was not correlated with higher recurrence, postoperative bleeding, or mortality rates. Preoperative midline shift was found to be an independent risk factor for recurrence.

Conclusions: In patients older than 80 years undergoing burr-hole drainage for chronic subdural hematoma, age was not directly correlated with higher recurrence, postoperative bleeding, or mortality rates.

O46

Cerebrospinal Fluid Hemoglobin Drives Subarachnoid Hemorrhage-Related Secondary Brain Injury

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Background: Secondary brain injury after aneurysmal subarachnoid hemorrhage (SAH-SBI) is a significant contributor to poor outcomes in patients after rupture of an intracranial aneurysm. The lack of diagnostic biomarkers and novel drug targets represent an unmet

need. Prior experimental evidence has suggested cell-free hemoglobin in the cerebrospinal fluid (CSF-Hb) as a pathophysiological driver of SAH-SBI. The aim of this study was to investigate the clinical and pathophysiological association between CSF-Hb and SAH-SBI. **Methods:** We prospectively enrolled 47 consecutive patients and collected daily CSF-samples within 14 days after aneurysm rupture. Spectrophotometry and LC-MS/MS proteomics served to analyze the temporal changes in the CSF proteome. The clinical association between CSF-Hb and SAH-SBI was assessed using a generalized additive model and receiver operating characteristic analysis. To further investigate the dose-response between CSF-Hb and SAH-SBI as well as the therapeutic potential of specific Hb-scavenger proteins, we explored the vasoconstrictive and lipid peroxidation activities of Hb ex-vivo.

Results: There was very strong clinical evidence for a positive association between CSF-Hb and SAH-SBI. The diagnostic accuracy of CSF-Hb for SAH-SBI markedly exceeded that of established methods (area under the curve: 0.89 [0.85–0.92]). Temporal LC-MS/MS CSF proteomics demonstrated that erythrolysis accompanied by an adaptive macrophage response are the two dominant biological processes occurring in the CSF space after aneurysm rupture. The ex-vivo experiments on the vasoconstrictive and oxidative potential of Hb revealed critical inflection points overlapping CSF-Hb concentration thresholds in patients with SAH-SBI. Selective Hb depletion and in-solution neutralization by the Hb-scavenger haptoglobin or the heme-scavenger hemopexin efficiently attenuated the vasoconstrictive and lipid peroxidation activities of CSF-Hb in patient CSF.

Conclusion: Collectively, the clinical association between high CSF-Hb levels and SAH-SBI, the underlying pathophysiological rationale, and the favorable effects of haptoglobin and hemopexin in ex-vivo experiments position CSF-Hb as a highly attractive biomarker and potential drug target.

047

Management of Patients Undergoing Elective Craniotomy under Antiplatelet or Anticoagulation Therapy: An International Survey of Practice

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Background: There is increasing evidence suggesting that neurosurgery can be performed safely under antiplatelet (AP) medication. However, the literature is scarce concerning AP and anticoagulation (AC) medication in the perioperative phase of craniotomy. The aim of this international survey was to investigate the current practice among neurosurgeons regarding their perioperative management of AP and AC medication.

Methods: We distributed an online survey to neurosurgeons worldwide with questions concerning their perioperative practice with AP and AC medication in patients undergoing craniotomy. Descriptive statistics were performed.

Results: A total of 130 replies were registered. The majority of responders practice neurosurgery in Europe (79%) or high-income countries (79%). Responders reported in 58.9% and 48.8% to have institutional guidelines for the perioperative management of AP and AC medication, respectively. Preoperative interruption time of aspirin (ASA), Clopidogrel, vitamin K antagonist (VKA) and direct oral anticoagulants (DOAC) were reported very heterogeneously. No significant differences concerning ASA management were recorded between the different continents, while significant differences were observed for VKA and DOACs. Around half of all responders considered ASA safe to be continued or resumed within 3 days for bypass (55%) or vascular (49%) surgery. Three quarters of the responders (74%) did not consider AC safe to be continued or resumed early (within 3 days) for any kind of craniotomy. ASA was considered to have the lowest risk of bleeding. Nearly all responders (93%) agreed that more evidence is needed concerning AP and AC management in neurosurgery.

Conclusion: Worldwide, the perioperative management of AP and AC medication is very heterogeneous among neurosurgeons. Interventional trials are needed to further elucidate this clinically important question.

O48

Sustained Reduction of External Ventricular Drain-Associated Infection after Introduction of a Chlorhexidine Containing Dressing—A “Before-and-After” Study over a 10-Year Period

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Background: Dressings containing chlorhexidine (CHX) lower the incidence of external ventricular drain (EVD)-associated infections (EVDAs). In a previous prospective randomized trial (RCT) at the University Hospital Basel (NCT02078830), a significant reduction in bacterial cutaneous and catheter colonization was detected [1]. However, the study was underpowered to demonstrate an effect on the incidence of EVDaI.

Methods: Retrospective (2009–2013) and prospective (2014–2018) review of patients undergoing silver-coated EVD-insertion at the University Hospital Basel. The control group consisted of patients from January 2009 to October 2013, where the CHX-dressings were not in use. The study group consisted of patients between February 2016 and December 2018, where CHX-dressing was standard of care. Comparisons were made using the Chi-squared test. Primary endpoint was the diagnosis of EVDaI. Statistical significance was set at $p \leq 0.05$.

Results: 261 out of 362 (72.1%) patients were eligible for analysis. 79 out of 261 (30.3%) were assigned to the control group, 55 out of 261 (21.1%) to the RCT-group and 127 out of 261 (48.7%) to the study group. During the whole study period, 155 out of 261 (59.4%) received a CHX-dressing while 106 out of 261 (40.6%) did not. The rate of EVDaI were substantially lower after the introduction of the CHX-dressing and reached significance ($p = 0.019$). The incidence of EVDaI per year and 100 persons decreased strongly (3.4 vs. 2.16) over time and the prevalence (16 vs. 7 per 100 persons) more than halved, respectively. Overall, 13 out of 155 (8.4%) in the CHX compared to 20 out of 106 (18.9%) in the Non-CHX-group developed EVDaI ($p = 0.012$).

Conclusion: CHX-containing dressings as a standard of care for the exit site of EVD effectively reduce the occurrence of EVDaI.

O49

Intended Near-Total Removal of Koos Grade IV Vestibular Schwannomas: Long Term Results in a Single Center Cohort

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Introduction: A treatment paradigm characterized by intended near-total removal (INTR) of large vestibular schwannomas followed by “wait-and-scan” was associated with good clinical results and low tumor progression rates in the short mean follow-up [1]. This strategy needs a confirmation in a longer term.

Methods: We report on the clinical and MRI follow-up of our previous series of 44 consecutive unselected cases operated at our institution between January 2009 and December 2015. These patients had consented on the prospective monitoring of their clinical course and of the tumor volume at the time of first surgery.

Results: The F/U (mean) was 1.7 years (median 1.3, range 0.4–5.9) in the published series and 4.4 years by the end of June 2019 (median 4.1 years, range 1.3–8). The mean postoperative volume was 1.3 cm³ immediately after surgery, 1.0 cm³ at 1.8 years, and 1.1 cm³ (0.4 [0.0–8.0]) after 4.4 years of F/U. Twelve (27%) out of 44 tumor remnants

remained stable ($\leq 25\%$ change in volume), 24 (55%) showed a volumetric regression ($>25\%$ decrease in volume), and 8 (18%) demonstrated a volumetric progression ($>25\%$ increase in volume) at last F/U. Hence, there was one single additional volumetric progression after 4.4 years compared to 1.8 years. Although the number of progressions according to the volumetric criteria was 8, 12 patients (27%) had received stereotactic radiosurgery (SRS) by the time of last F/U due to any increase of tumor volume interpreted as a progression. SRS was performed 2.5 years after surgery (mean). When compared to the 1.7-year follow-up, four times more patients were additionally treated. Five (41%) of these tumor remnants showed a real volumetric progression after a mean of 1.6 years (1.9 [0.5–2.3]), while 7 (58%) demonstrated a post-actinic pseudoprogession with consecutive regression of the tumor remnant within a mean time of 0.9 years (0.6 [0.4–3.0]) and 1.8 (1.2 [0.5–5.6]) respectively. Hence, the overall control-rate of tumor remnants was 39 (89%). The facial outcome remained unchanged at 4.4 years as compared to 1.8 years: H&B I-II in 86%, HB III in 9%, and HB IV-VI in 2.3% of the patients, respectively. Ipsilateral hearing preservation (CPT-AMA loss $< 50\%$) dropped from 34% preoperatively to 18%, and to 14% after 1.8 years, and 4.4 years F/U.

Conclusions: INTR offers an excellent or good facial nerve outcome in 94% of patients with an 89% rate of tumor control after a mean F/U of 4.4 years after surgery.

O50

ZEISS CONVIVO in Bern—First Steps with Confocal Laser Endomicroscopy during Brain Tumor Surgery

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Aims: Confocal laser endomicroscopy (CLE) in combination with sodium fluorescein (FNa) as a contrast agent has emerged as a novel technology for intra-operative decision-making in brain tumor surgery. Currently, we systematically evaluate the ZEISS CONVIVO device for its use in brain tumor surgery. The main aim of this device is to distinguish tumor from non-tumor cells helping the surgeon to decide about extent of resection in the area of the tumor margin.

Methods: We systematically collect CONVIVO images in a continuous series of patients at our center both (i) intra-operative as well as (ii) post-operative in an ex-vivo setting.

(i) The CONVIVO device is a mobile unit developed for intra-operative use. Following a standardized process, we inject FNa (5 mg/Kg BW) shortly before imaging. Several spots within the tumor are imaged and correlating biopsies obtained for histological analysis, enabling us to compare CLE based diagnosis and frozen section diagnosis with definitive histology. In addition, we collect images and specimen from the edge of the resection cavity to assess the tumor margin. (ii) We use part of the specimen for ex-vivo CLE analysis prior to histological analysis. We irrigate it with FNa (0.1% solution) and image in an ex-vivo setting using the same device. We use these images to compare CLE-based diagnosis with histology without limits of the in-vivo setting (i.e., motion artefacts).

Results: Motion artefacts due to brain pulsation or shaking hands, blood and inappropriate timing and dosage of FNa injection initially made imaging challenging. We were able to produce high-quality images after testing different versions of image processing with clear identification of cell clusters after a short learning period (< 20 patients). We observed, that the accuracy of the CLE based diagnosis seems dependent on image quality, but not on image quantity. Moreover, the experience of surgeon and neuropathologist seems essential for accurate results. For the in-vivo method, we included 78 patients until today. For the ex-vivo method, we included > 100 patients for our analysis. We are currently setting up

a comparative analysis (CLE versus histopathology) performed by blinded pathologists. Further results are ready for report in summer 2021.

Conclusion: CONVIVO CLE produces high quality images of cell clusters both in-vivo and ex-vivo. The potential of CLE to distinguish tumor versus non-tumor cells is currently being evaluated in a series of tests.

O51

Combined Use of Intraoperative MRI and Awake Tailored Microsurgical Resection to Respect Functional Neural Networks: Preliminary Experience

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Introduction: The combined use of intraoperative MRI (IoMRI) and awake surgery aims at a tailored microsurgical resection to respect functional neural networks (mainly the language and motor ones). IoMRI has been classically considered to increase the extent of resection (EOR) for gliomas, allowing to also reducing neurological deficits. Here, we evaluate our preliminary results with the combined technique of awake microsurgical resection and IoMRI for primary brain tumors (gliomas, metastasis) and epilepsy (cortical dysplasia, non lesional, cavernomas).

Material and Methods: Eighteen cases were treated with this approach in Lille University Hospital, France, starting November 2016 and until End May 2020. Our approach was the commonly used “asleep awake asleep” (AAA). The exact anatomical location was insular (with various extensions, frontal, temporal or fronto-temporal) in 8 (44.4%), parietal in 3 (16.7%), fronto-opercular in 4 (22.2%), Rolandic in two (11.1%), supplementary motor area (SMA) in one (5.6%).

Results: The mean overall follow-up period was 15.8 months (median 12, range 3–36). The mean age was 38.4 years (median 37.1, range 20.8–66.9). The mean surgical duration was 4.1 h (median 4.2, range 2.6–6.4). The mean duration of IoMRI was 28.8 min (median 25, range 13–55). Overall, 61% (11/18) of cases underwent further resection, while 39% (7/18) cases had no additional resection after IoMRI. The mean preoperative and postoperative tumor volumes for primary brain tumors were 34.7 cc (median 10.7, range 0.534–130.25) and 3.5 cc (median 0.5, range 0–17.4), respectively. The most common locations of tumor remnant were posterior (5/9) or anterior (2/9) insular and at the proximity with the motor strip (1/9) or language areas (e.g., Broca, 1/9). Reasons for stopping further resection in seven patients were: no remnant in 3 cases, cortical stimulation approaching eloquent areas in 3 cases and non-lesional epilepsy in one.

Conclusion: Intraoperative MRI and awake microsurgical resection is feasible with extensive planning and multidisciplinary collaboration. Based on the up-to-date literature and also our preliminary results such an approach seems promising. These two methods can be considered complementary and synergic rather than competitive, striving at improving patient oncological outcomes and quality of life.

P01

Endoscopic and Endoscopically-Assisted Resection of Intra- and Extraventricular Lesions Using a Neuroendoscopic Ultrasonic Aspirator

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Background: The development of minimal invasive neuroendoscopy has advanced in recent years. Introduction of the neuroendoscopic ultrasonic aspirator (NUA) broadened the treatment spectrum of neuroendoscopy. We aim to describe our experience with the use of NUA for the resection of intra- and extraventricular lesions.

Methods: Consecutive retrospective case series of adult and pediatric patients undergoing resection of a lesion with a NUA (Endoscopic Neurosurgical Pen, Söring GmbH, Quickborn, Germany) between January 2019 and April 2020. Data was retrospectively collected and presented in a descriptive manner.

Results: Nine patients between the age of 0.5 and 73 years, underwent surgery using NUA and were included in this study. In five patients, an endoscopic assisted (EA) resection of the lesion was undertaken, while in four patients, the lesion was removed purely endoscopically (PE). In 8 cases (88.9%), gross/near total resection was achieved. The average blood loss was 141.1 ± 84.6 mL (range 50–300 mL). The mean surgery time was 178.8 ± 68.1 min (range 82–300 min). Transient morbidity was seen in five patients (55.6%), while permanent morbidity or mortality did not occur.

Conclusion: NUA seems to be a feasible, safe, and valuable tool for the resection of intra-, and extraventricular lesions in selected cases. The type, size, consistency, and vascularization of the lesion limit at times the purely endoscopic use of NUA. Further experience and research are needed before clear recommendations can be made concerning the ideal indications for purely endoscopic resection of intraventricular lesions using NUA.

P02

Sellar Teratoma in a Child—Case Report and Review of the Literature

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Background: Intracranial teratomas represent a rare phenomenon, accounting for approximately 0.5% of all intracranial tumors. Characteristic symptoms are neurological defects, including visual disturbances, hypopituitarism, and diabetes insipidus. Yet, diagnosis can be challenging due to similar radiological features in both teratomas and craniopharyngiomas. Surgery is the recommended treatment for mature teratomas and is associated with a good prognosis.

Case Description: We describe the case of a 10-year-old girl presenting with newly diagnosed growth retardation, fatigue, cephalgia and bilateral hemianopia. Laboratory analysis confirmed central hypothyroidism and hypercortisolism. Cranial magnetic resonance imaging showed a cystic space-occupying lesion in the sellar and suprasellar compartment with compression of the optic chiasm suggestive of craniopharyngioma. An endoscopic transnasal transsphenoidal near-total tumor resection with decompression of the optic chiasm was performed. During postoperative recovery the patient developed transient diabetes insipidus. Bilateral hemianopia remained unchanged. Histopathology revealed conspicuous areas of skin with formation of hairs and squamous epithelia, compatible with a mature teratoma.

Review: Tumors originating from the sella can be reached either endoscopically via a transsphenoidal approach, neuroendoscopically via the ventricles or by open pterional craniotomy, depending on the tumor extension and individual case. In infants, transsphenoidal access may be more challenging due to incomplete pneumatization of the sphenoid sinus and is limited for suprachiasmatic or lateral tumor extensions, given the proximity to the chiasm or carotid arteries. Following neuroendoscopic tumor cyst fenestration via the 3rd ventricle, an Ommaya reservoir may be left in situ for puncture in case of tumor cyst recurrence. It is of paramount importance not to injure the hypothalamus during surgery. Therefore, subtotal resection followed by proton beam therapy is often aimed for.

Conclusions: We present an extremely rare case of pediatric sellar teratoma originating from the pituitary gland. Surgical approaches vary, although radical neurosurgical tumor excision remains the recommended treatment for mature teratomas. However, adjacent structures, especially the hypothalamus, must be preserved even at the cost of partial resection.

P03

Image-Guided Supratentorial External Ventricular Drain for Temporary Cerebrospinal Fluid Diversion during Retrosigmoid Craniotomy for Large Cerebellopontine Angle Lesions

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Introduction: During retrosigmoid craniotomy for large cerebello-pontine angle (CPA) lesions, the surgeon commonly encounters cerebellar herniation upon durotomy. Thus, cerebellar contusions and cortical bleeding potentially occur during the surgical exposition. Standard methods of obtaining adequate cerebellar relaxation are anesthesiological management, temporary cerebrospinal fluid (CSF) diversion with a lumbar drain and the microsurgical release of CSF from the subarachnoid cisterns. The aim of this study is to report a temporary CSF-diversion method using an image-guided external ventricular drain (EVD).

Methods: After a retrosigmoid craniotomy, an EVD was inserted into the ipsilateral occipital horn of the lateral ventricle via the Keen's point using a sterile image guidance probe as stylet. Temporary CSF-diversion was performed to the point where the posterior fossa dura was visibly pulsatile. Assessment of the surgeon's observation, pre- and post-operative computed-tomography and magnetic-resonance imaging (MRI) were used for outcome assessment.

Results: 47 out of 88 consecutive cases were eligible for analysis, consisting of 33 cranial nerve schwannomas, 13 meningiomas and 1 case of CPA PNET. 13 out of 47 patients (28%) suffered from preoperative hydrocephalus, none of which received a preoperative permanent CSF-diversion. No failed cannulations were recorded, with 44 (94%) correct placed EVDs within the first and 3 (6%) within a second attempt. The operating surgeons consistently reported a relaxed surgical field without cerebellar herniation through the dural opening. In 6 (13%) patients, postoperative imaging revealed evidence of an EVD-track bleeding, associated with intraventricular hemorrhage (IVH) in two (4%). An isolated IVH was found in another two (4%) cases. In 37 patients (79%), the closed EVD was removed within 48 h after surgery. 10 out of 47 patients (21%) needed prolonged EVD-treatment because of postoperative hydrocephalus, five of which (11%) eventually needed a permanent CSF-diversion. In follow-up MRI, supratentorial cortical scars were seen in 13 out of 47 cases (28%), 5 (11%) of which were associated with a postoperative hemorrhagic event. None of the evaluated patients demonstrated radiological signs of upward herniation.

Conclusion: The method described above efficiently allows for a relaxed surgical field during the retrosigmoid approach. However, there is an inherent risk for supratentorial hemorrhagic complications.

P04

Secondary Dopamine-Agonist-Resistant Prolactinoma?—A Case Report

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We present a case of a 45-year-old patient with initial manifestation of visual disturbances and hypopituitarism in the year 2007. A CT scan showed a cystic pituitary adenoma of a size of $2.7 \times 2.2 \times 2$ cm and compression of the optic chiasm. The prolactin level was highly elevated and a therapy with dopamine agonists has started. Prolactin levels subsequently have normalized and a follow up MR scan more than one year later showed

a markedly decreased size of the pituitary tumor of $0.9 \times 0.7 \times 0.6$ cm. The visual acuity on the right eye remained severely impaired, however symptoms of hypopituitarism have alleviated. There was no routine follow up until 2019. A new MRI scan showed a progress to $1.7 \times 1.5 \times 1.2$ cm with a new compression of the optic chiasm despite continuing treatment of dopamine agonists. The prolactin levels were not elevated. The patients underwent surgery by an endoscopic transnasal resection. Histological workup showed immunostaining for FSH (70%) and LH (10%), but none for TSH, ACTH and prolactin. Thus providing an explanation for the secondary non-response to dopamine agonists. In conclusion, this patient apparently suffered of two different types of pituitary tumors. A thorough clinical follow up is also for medically treated prolactinomas essential.

P05

Longer Survival of Glioblastoma Complicated by Bacterial Infections after Surgery: What Is Known Today

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Objective/Aim: Glioblastoma is the most common primary brain tumor in adults with the worst overall survival. Post-craniotomy intracranial infections are not infrequent after surgery, however their impact on overall survival of glioblastoma patients remains unclear. Here we report the case of an unusual longer survival of a glioblastoma patient affected by multiple infections and review the literature on this topic.

Methods: PubMed, Embase and Cochrane search engines were reviewed for papers describing outcome of patients suffering from glioblastoma and associated cerebral infections.

Results: Four papers accounting a total of 29 patients met the eligibility criteria. Staphylococcus aureus and Staphylococcus epidermidis resulted the most common bacteria causing post-craniotomy intracranial infections in brain tumor patients. The overall median survival rate was 18 months $\pm$ 18.12 when adding all 29 patients. Only one study described a significant higher survival rate for the infected group.

Conclusions: Glioblastoma is the most frequent malignant brain tumor with a very poor outcome/survival. In the literature few cases described an exceptional longer survival often associated with a postoperative infection. To date, the pathophysiology behind this longer survival remains unclear, but it seems that Staphylococcus species could have an influence on the progression of this aggressive brain tumor.

P06

Intracranial Teratoma Mimicking a Meningioma: A Case Report with 18 Years Follow-Up

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Background and Importance: Intracranial teratomas are rare neoplasms representing only 0.5% of primary intracranial tumors. Due to their heterogeneous presentation, the diagnostic approach remains difficult, sometimes leading to misdiagnoses. In our case, we followed a misinterpreted teratoma for 18 years, assuming the intracranial tumor is a meningioma.

Clinical Presentation: A 68-year-old female patient presented in 2002 with complex partial seizures with gustatory aura and facial hypesthesia. MRI imaging of the brain demonstrated an intracranial mass, arising from the lateral wall of the left cavernous sinus. As the MRI scans did not show any signs of malignancy and the tumor was considered to be a

meningioma, only antiepileptic therapy and follow-up MRI were initiated. We did not observe any growth on follow-up studies for 12 years. Further MRIs in 2019 and 2020 showed tumor progression, already displacing intracranial structures. Therefore, surgical removal was then indicated and performed in September 2020. Against our expectations, the tumor consisted of a fluid and debris filled arachnoid membrane without typical features of a meningioma. Amongst other things, microscopic assessment revealed the presence of squamous epithelium and hair. Three months after surgery, the patient was doing well and follow-up MRI of the neuroaxis did not show any tumor.

Conclusion: Intracranial teratomas are rare neoplasms usually occurring in children. Given their rarity, only a limited number of case reports and studies have been reported. The clinical presentation of these tumors, including imaging features, is heterogeneous. Thus, diagnostic approach remains difficult, necessitating interdisciplinary management to aid those who may be affected by this pathology in the future.

Keywords: Central nervous system neoplasms, Intracranial teratoma, Meningioma, Cavernous sinus, Case report.

P07

The Behavior of 5-ALA in Primary and Histological Subtypes of Brain Metastases: A Systematic Review and Metaanalysis of the Current Literature

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Background: While routine use of 5-Aminolevulinic acid (5-ALA) fluorescence has become a well-established standard in glioma surgery, its role in the resection of brain metastasis remains controversially discussed, due to inconsistency and heterogeneity of fluorescence. This review investigates the different expressions of 5-ALA fluorescence in various types of metastases and analyses the possible link between fluorescence and primary tumor type.

Methods: We conducted a systematic review using PubMed/medline database according to PRISMA guidelines. All original publications published until February 2021 were screened. Inclusion criteria were: (1) documentation of intra-operative 5-ALA behavior in brain metastases, (2) publication in English, (3) >1 patient included and (4) description of subtypes of primary tumors. A meta-analysis of the selected studies was performed.

Results: Out of $n = 44$ studies screened, $n = 12$ studies met the inclusion criteria, comprising $n = 534$ patients. 5-ALA fluorescence positivity was described in 264/534 of the cases (49%). Primary tumor could be determined in 476/534 patients, whereas 58 patients suffered from a cancer of unknown primary (CUP). Lung carcinoma was the most frequently reported primary tumor ($n = 237$) with 5-ALA+ in $n = 120/237$ (50.6%); followed by mamma carcinoma ($n = 75$) with 5-ALA+ in $n = 42/75$ (56%); gastro-intestinal cancer ($n = 54$) with 5-ALA+ in $n = 24/54$ (44%); urogenital ($n = 52$) with 5-ALA+ in $n = 23/52$ (55%); and other cancer groups ($n = 34$), with 5-ALA+ in $n = 21/34$ (62%).

Conclusion: Brain metastases show a positive fluorescence in only 49% of the cases. There is no correlation between the presence of fluorescence and the primary tumor type, with a range of 5-ALA+ reported between 38–62%. Based on this literature review, the use of 5-ALA for surgery of brain metastasis is questionable. To support gross total resection of metastatic lesions, future studies should focus on the improvement of fluorescence expression and/or detection, and the exploration of alternative imaging techniques.

P08

Intraoperative MRI for the Microsurgical Resection of Meningiomas Close to Eloquent Areas or Dural Sinuses

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Introduction: Meningiomas are the most commonly encountered nonglial primary intracranial tumors. In this case series, we report on the usefulness of intraoperative MRI (iMRI) during microsurgical resection of meningiomas located close to eloquent areas.

Methods: Six patients benefited from such approach. We illustrate a seventh case, for which iMRI was initially scheduled but finally not performed due to complete microsurgical resection.

Results: The mean follow-up period after surgery was 3.3 years (median 3.2, range 2.1–4.6). Five patients had no postoperative neurological deficit, of whom 2 with preoperative motor deficit completely recovered (patients #5 and #6). One patient with preoperative left inferior limb deficit partially recovered (patient #6). The mean interval between surgery and radiation therapy was 15.8 months (median 16.9, range 1.4–40.5). Additional radiation therapy was required in 5 cases after surgery. The mean follow-up period after radiation was 2.1 years (median 1.9, range 1–3.5). At last follow-up, all tumors were controlled. Intraoperative MRI was particularly helpful to: (i) decide additional tumor resection according to iMRI findings during surgical procedure; (ii) evaluate the residual tumor volume at the end of the surgery; (iii) judge the need of further radiation and in particular also the feasibility of single fraction radiosurgery.

Conclusion: This case series showed that iMRI during microsurgical resection of meningiomas was highly useful to preserve neurological function and thus quality of life. It further helped to estimate whether the residual volume was compatible with further stereotactic radiosurgery.

P09

The Spectrum and Prevalence of MRI Pathologies of Patients Undergoing Surgery for Degenerative Cervical Myelopathy: Preliminary Analysis of an Ongoing Prospective Study

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Aims: Multiple studies have attempted to better delineate diagnostic and predictive factors of Degenerative Cervical Myelopathy (DCM). However, it is clear that such research will depend on the understanding of the heterogeneity of this population. Using an ongoing prospective study, we report a preliminary finding of a large set of MRI findings present preoperatively in patients undergoing surgical treatment for DCM.

Methods: All eligible DCM patients were enrolled into our institutional prospective protocol. MRIs were reviewed for the presence of types of pathologies, the level of highest compression, the number of levels involved in compression or touching the spinal cord, T2 hyperintensity (including the presence of skip lesions), the maximum canal compromise and maximum spinal cord compression based on sagittal imaging.

Results: 56 patients were included. The average number of compressed levels was 2.3. The most common level of maximum compression was C5-6 (36%), followed by C4-5 (30%). C5-6 and C4-5 were also most commonly implicated in cord compression presenting in 70% and 62.5%, respectively. T2 hyperintensity was observed in 75% (n = 42) and vertical skip lesions was observed in 8.9% (n = 5). Specific pathologies included: Multilevel degeneration (spondylosis) 75%, single disc herniation 21.4%, OPLL 14%, ligamentum flavum hypertrophy/bulging 39.3%, Spondylolisthesis 33.9%, Klippel-Feil Syndrome 3.57%, Modic changes 33.93%, Cord-Canal mismatch (congenital stenosis) 14%, Hyperostosis of ALL (DISH) 10.7%. The average sagittal canal compromise at the most stenotic level was 48.3% (26.3%-75%) and the average maximum spinal cord compression was 34.1% (7.1%-68%).

Conclusion: DCM patients present with a wide range of imaging findings and pathologies. Notably, many pathologies rarely reported amongst DCM patients are also commonly found, including DISH and Modic changes. This research confirms that future studies

assessing surgical outcomes should bear in mind that these varying features may impact disease severity, surgical-decision making and quality of life assessments.

P10

Intradural Extraarachnoid Sutureless Technique Combined with Laminoplasty for Indirect Repair of Ventral Dural Defects in Spontaneous Intracranial Hypotension: Technical Note and Case Series

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Background: There is a significant variance in surgical treatment strategies of ventral cerebrospinal fluid (CSF) leaks causing spontaneous intracranial hypotension (SIH). Posterior approaches might represent a preferable alternative to the more invasive anterior and lateral routes, as long as the spinal cord is not exposed to harmful manipulation. The aim of this technical note is to report and illustrate a new surgical technique using an intradural extraarachnoid sutureless technique via laminoplasty for indirect repair of ventral CSF leaks causing intractable SIH symptoms.

Methods: The surgical technique is described in a step by step fashion. Between May 2018 and May 2020, five patients with ventral spinal CSF leaks were operated on, utilizing this technique. All dural defects were located at the level of the thoracic spine. A retrospective review on demographic and radiological findings, symptoms, outcome, and follow up was performed.

Results: The intra- and postoperative course was uneventful in all patients with no surgery related complications. Three patients recovered completely at discharge, while neurological symptoms significantly improved in two patients. A postoperative MRI of the spine was obtained for all patients, demonstrating regressive signs of CSF leak.

Conclusion: Based on the presented case series this intradural extraarachnoid sutureless technique combined with laminoplasty seems to be a safe and effective option for indirect repair of ventral dural defects in SIH. In our opinion, it represents a valid alternative to traditional more aggressive approaches.

P11

The Role of Interleukin-6 in Spinal Cord Injury: A Systematic Review

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Introduction: Traumatic spinal cord injuries (SCI) are devastating events that result in significant impairment to an individual's functional ability. The use of IV methylprednisolone sodium succinate (MPSS) to prevent secondary inflammatory response and improve outcome after SCI is controversial. Interleukins have been described as key players in the inflammation cascade after neuronal injury; however, their role in SCI and their possible inhibition has not been widely studied. The aim of this study is to perform a systematic review of clinical studies that evaluated CSF and serum IL-6 levels in humans after acute traumatic SCIs and their relations with functional outcome.

Methods: We conducted two systematic literature searches using the PubMed database to identify clinical studies evaluating the role of IL-6 after SCIs. Suitable articles were selected based on predefined eligibility criteria following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: A total of 7 clinical articles were included in the systematic review. In all the studies in which IL-6 was measured in CSF, serum and post-mortem tissue biopsy showed

an increased expression of IL-6 after SCI. No clinical study analyzing the direct inhibition of IL-6 after SCI could be found. All 4 studies that correlated CSF concentrations of IL-6 with functional outcome measures showed a positive correlation between IL-6 and worse outcomes. No clinical study analyzing the direct inhibition of IL-6 after SCI could be found. **Conclusion:** IL-6 plays a fundamental role in the inflammatory response after traumatic spinal cord injury and directly correlate with worse outcome. The direct inhibition of IL-6 may represent a promising therapeutic approach to improve the outcome after SCI.

P12

A Novel Trackable Device to Perform Lumbar MIS TLIF with Augmented Reality Surgical Navigation: Technical Note

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Aim: Although minimally invasive (MIS) and percutaneous transforaminal (TLIF) approaches have been gaining popularity over the last years, surgeons often rely excessively on radiographic guidance, to compensate for the limited visualization of the anatomical structures and to achieve acceptable accuracy, especially in obese patients.

The aim of the present work is to describe the initial experience of the workflow for a MIS-TLIF procedure, using a new 3D augmented reality navigation integrated with intra-operative imaging, and to assess the capacity of this system to avoid some common problems encountered in obese patient surgery.

Methods: We performed a TLIF surgery at L4 L5 level in a morbidly obese lady in a hybrid OR equipped with a robotic ceiling mounted C-arm system, controlled by a module placed on the patient's bedside and a wireless foot pedal (Allura FlexMove, Philips Healthcare, Best, the Netherlands). The C-arm was used to perform 2D X-ray imaging and 3D cone beam computed tomography (CBCT) (XperCT, Philips, Best, The Netherlands). A navigation software was used to automatically create a 3D model of the spine based on the CBCT data, plan trajectories for providing guidance for pedicle screw placements, as well as to verify accuracy of the actual screw placement. We recorded the total procedure time, the time for individual workflow steps, radiation exposure to staff and patient and final accuracy based on Gertzbein grading.

Results: The whole procedure took about 4 h, the average time to place a screw was 7 min 10 s. The cumulative fluoroscopy time was 23 s. The total patient dose was 11.7 mSv: 0.9 mSv due to fluoroscopy and 10.8 due to CBCT. All screws were correctly placed in the first attempt with no requirement for intra-operative revisions. No post-operative infections or complications were noted. Patient's postoperative course was uneventful, and she was dismissed home on 5th postoperative day.

Conclusions: 3D augmented navigation system when used during MIS-TLIF could improve the accuracy of pedicle screw placement without need for invasive reference frames at a lower radiation dose, even in obese patients. The surgeon benefits from a streamlined workflow as a result of a good integration between different components of the system, i.e., intra-operative 3D image acquisition, real-time navigation and 2D real-time imaging.

P13

Intraoperative CT Navigated Postero-Lateral Muscle Sparing Thoracotomy to Remove a Median Calcified Thoracic Disc Herniation

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Aims: Thoracic disc herniation (TDH) is a rare condition, accounting only for 0.1 to 3% of all spinal disc herniation. Surgical treatment is indicated in patients with progressive neurological symptoms, with radiological signs of myelopathy or refractory pain. The thoracic spine anterior surgical approach (TSA) is normally preferred to the complete removal and decompression of the spinal cord in case of calcified TDH. TSA is considered highly invasive if performed through open thoracotomy compared to thoracoscopy. However, the 2D and narrow endoscopic visualization could reduce the safeness during spinal cord decompression, especially in calcified TDH. We present a less invasive open TSA approached based on intraoperative CT (i-CT) navigation and postero-lateral muscle sparing thoracotomy (MST) to treat a case of median calcified TDH in 57-year-old patient with clinical and radiological myelopathy.

Method: A CT and MRI scans revealed a median calcified T8-9 TDH in a 57-year-old man presenting with ataxia slowly progressive after a fall 3 months earlier. The indication of TSA was given.

The patient was positioned on right lateral side. I-CT scan (AIRO[®]) was acquired and the skin incision and surgical trajectory was planned based on i-CT navigation. MST, which is based on blunt dissection of the latissimus dorsi muscle, and a small osteotomy (ca. 6cm) of the rib were performed. The left lung was deflated to visualize the posterior pleura, the spinal column under it. The T8-9 level was identify using i-CT navigation and a small opening of the pleura was performed. Under microscope the calcified TDH was drilled, checking the remaining distance to spinal cord on i-CT navigation until only a flat layer was left on spinal cord dura which was gently removed with dissectors. The rib bone was positioned in the corpectomy space and a titanium plate was fixed over it, planning the fixing-screws' trajectories with i-CT navigation. A final i-CT scan showed the correct position of rib and plate.

Results: No intraoperative nor postoperative complications occurred. A thoracic drainage was removed at day 2 and at day 4 morphin-pump was stopped. The patient showed an immediate improvement of pain and walk.

Conclusion: I-CT navigated postero-lateral MST is an optimal surgical option in case of median calcified TDH which combine safeness and precision with less invasiveness.

P14

Title: Full-Endoscopic Resection of a Recurrent Posterior Longitudinal Ligament Cyst: Technical Note

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Background: Posterior longitudinal ligament (PLL) cysts are very rare lesions, and do not usually recur. Microscopic resection is commonly performed. We describe a case of recurrent PLL cyst, which benefitted from a full endoscopic resection.

Methods: We used the 25° endoscope of the RiwoSpine[®] set for interlaminar approach. Step-by-step description of the surgical technique is presented.

Results: Clinical evolution was favourable. One month after surgery, patient remained pain-free, and postoperative MRI showed complete resection of the cyst.

Conclusion: We believe that endoscopy is a safe and feasible approach for PLL cysts, also for unusual recurrent cases.

P15

Title: Spinal Fractures in Alpine Winter Sports: Comparison of Two Seasons in a Swiss Trauma Center 30 Years Apart

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Background and importance: Winter sports are causing a significant number of spine injuries in Switzerland. However, the number of patients, mechanism, presentation, diagnosis and treatment of spinal fractures may have evolved significantly over the last decades. Our hypothesis was that there may be an increase of spinal fractures in winter sports over the last 30 years.

Methods: We compared prospective case-series of winter sports related spinal fractures of two seasons 30 years apart (1989–1990 and 2019–2020) in a single institution (Sion Cantonal Hospital, Switzerland). History, clinical presentation, radiological features, treatment and surgical results were retrospectively collected. Two illustrative cases in each season are described.

Results: There were 6 patients in 1989–1990 (4 males, 2 females) and 25 patients (18 males, 7 females) in 2019–2020. Mean age was 31.8 ± 20.6 years old in 1989 and 32.1 ± 15.9 years old in 2019. A neurological deficit was present on admission in 5 of 6 patients in 1989 (83.3%), but only in 3 of 25 patients in 2019 (12.0%). Spine x-rays were performed in 5 of 6 patients in 1989 (83.3%) versus 20 of 25 patients (80%) in 2019. All patients benefitted from a CT-scan in 2019, but only 4 of 6 (66.7%) in 1989. MRI was not available in 1989, but nearly half (12/25, 48%) of patients benefitted from an MRI in 2019. Surgical management was performed in 3/6 patients (50%) versus 15/25 patients (60%). Percutaneous kypho- or vertebroplasty was the most common surgical treatment in 2019 (7 patients, 28%) versus posterior instrumentation with or without decompression in 1989 (3/3, 50%).

Conclusion: There was four times more spine fractures diagnosed in our trauma center in 2019/2020 compared to 1989/1990. However, the proportion of patients with neurological disturbances has decreased. Lumbar compression fractures type AO spine A1-3 accounted for the majority of the cases, and were diagnosed with MRI STIR sequences.

P16

Safety and Efficacy of Stand-Alone Anterior Lumbar Interbody Fusion in L5-S1 Isthmic Spondylolisthesis

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Aims: Surgical management of isthmic spondylolisthesis is controversial and reports on anterior approaches in the literature are scarce. In our study we evaluate the safety and efficacy of stand-alone anterior lumbar interbody fusion (ALIF) in patients with symptomatic L5-S1 isthmic spondylolisthesis.

Methods: All adult patients with isthmic spondylolisthesis of the lumbosacral junction treated in a single institution between 2008 and 2019 with stand-alone ALIF were screened. A titan cage was inserted at L5-S1 with vertebral anchoring screws. Prospectively collected clinical and surgical data as well as radiographic parameters were analyzed retrospectively.

Results: 34 patients (19 men, 15 women, mean age 52.5 ± 11.5 years) were included for final analysis. Mean follow-up (FU) was $2.7 (\pm 2.4)$ years. 91.2% (n = 31) of patients had a low-grade spondylolisthesis and 8.8% (n = 3) grade III according to Meyerding classification. The mean pelvic incidence was $65 (\pm 9)^\circ$. Mean COMI and ODI scores improved significantly from $6.9 (\pm 1.5)$ and $35.5 (\pm 13.0)$ to $2.0 (\pm 2.5)$ and $10.2 (\pm 13.0)$, respectively after one year, and to $1.7 (\pm 2.5)$ and $8.2 (\pm 9.6)$, respectively, after two years. The COMI and ODI scores improved in 86.4% and 80%, respectively of patients, after one year and 92.9% of patients after two years by at least the minimal clinically important change scores of 2.2 points and 12.9 points. Preoperatively, mean VAS values for back and leg pain measured $5.3 (\pm 2.5)$ and $6.8 (\pm 2.3)$, and improved significantly to $1.9 (\pm 1.8)$ and $1.7 (\pm 2.5)$, at one year, and to $1.6 (\pm 2.3)$ and $1.2 (\pm 1.5)$ at two years FU, respectively. No intraoperative complications were recorded. The reoperation rate was 8.8% (n = 3).

Conclusion: Patient reported outcomes after stand-alone ALIF for symptomatic isthmic spondylolisthesis showed clinically important improvement after one and two years. Stand-alone ALIF is an effective and safe surgical treatment option for low-grade isthmic spondylolisthesis.

P17

Intra-Aneurysmal Contrast Agent Stasis during Intraoperative Digital Subtraction Angiography: A Predictor of Thrombosis and Long-Term Occlusion of Intracranial Aneurysm Remnant after Clipping?

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Background: Routine use of intraoperative digital subtraction angiography (iDSA) leads to increased detection of intracranial aneurysm (IA) remnants after microsurgical clipping. Spontaneous thrombosis of IA remnants after clipping is considered a rare phenomenon. We analyse iDSA characteristics to find predictors for IA remnant thrombosis.

Methods: Treated aneurysms with intraoperative detection of an IA remnant after clipping were identified and subdivided into remnants undergoing spontaneous thrombosis and remnants with long-term patency and/or remnant growth. Angiographic features of iDSA were analysed and compared between the two groups. In addition, we performed a systematic review of the literature to identify similar cases of spontaneous IA remnant thrombosis.

Results: Out of 22 remnant aneurysms few cases underwent a spontaneous thrombosis and long-term occlusion. In all thrombosed cases ($n = 4$) iDSA revealed stasis of the contrast agent within the IA remnant until the late venous phase (mean 6.75 ± 0.4 sec.). By contrast, in all cases with patent long-term IA remnant ($n = 18$) iDSA demonstrated early wash-out without stasis of contrast agent. In the literature we found 13 cases with spontaneous regression of an IA remnant.

Conclusion: Spontaneous thrombosis of IA remnants after clipping is a rare phenomenon. Contrast stasis in IA remnants during iDSA seems to predict long-term IA occlusion and therefore clip correction manoeuvres may not be warranted in these cases.

P18

Combined Microsurgical and Endovascular Intracranial Aneurysm Treatment—Literature Review and Interdisciplinary Experience with a True Hybrid Approach

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Background: Most intracranial aneurysms (IA)s can effectively be treated with microsurgical clipping, endovascular coil embolization, or a staged combined approach. In selected cases however, simultaneous treatment in the hybrid operation room may be favorable. So far only few cases of such true hybrid approaches have been described in the literature. This study analyses indication for and benefits of a true hybrid approach that combines simultaneous endovascular and microsurgical interventions in cerebrovascular aneurysm surgery.

Methods: All patients that underwent a hybrid procedure for IA treatment in our institution between 2010–2020 were included. Demographic characteristics, neurological symptoms, pre-interventional treatments, pre- and peri-interventional angiographic findings, and postoperative clinical and radiologic findings are analyzed. Results are discussed in the light of the literature on true hybrid procedures for IA treatment.

Results: We identified seven IAs ($n = 5$ ruptured, $n = 2$ unruptured) that were treated in a true hybrid approach. Of these, in four emergency situations aneurysm coiling and concomitant decompressive craniectomy was performed. Furthermore, in one patient presenting with acute subarachnoid hemorrhage, three IAs were detected but it remained

unclear which one to be the source of the bleeding. Consequently, two IAs were clipped (anterior cerebral and anterior choroidal artery) and a third IA (PICA) was coiled in the same session. In a different patient undergoing elective clipping of an MCA aneurysm, intraoperative angiography revealed a remnant on the IA fundus. Repositioning of the clip was considered risky because of distinctive adhesions with the M2-segment. Instead, complete coiling of the remnant was performed in the same session. Lastly, in the situation of an elective MCA clipping a contralateral recurrent media aneurysm treated in an earlier session was re-coiled.

Conclusion: Overall, the need for a true hybrid approach for IA treatment is rare and limited to selective cases. In our experience, the true hybrid approach has been most valuable in the emergency setting of ruptured IAs. Furthermore, a true hybrid approach may also be considered in patients with multiple aneurysms in different vascular territories.

P19

Inter- and Intraobserver Agreement of Two- and Three-Dimensional Digital Subtraction Angiography Classifications for Detecting Remnants after Intracranial Aneurysm Clipping

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Background: A growing body of evidence suggests that three-dimensional digital subtraction angiography (3D-DSA) is superior to 2D-DSA in the detection of remnants after intracranial aneurysm (IA) clipping. Recently, a simple and practical quantitative scale measuring maximal remnant dimension on 3D-DSA has been proposed. The aim of this study is to validate inter- and intra-observer agreement of this newly established 3D-DSA score and compare it to a commonly used 2D-DSA scale (Sindou scale) for clipped IA remnant categorization.

Methods: Forty-three patients with clipped IAs and various remnant sizes who underwent both pre- as well as intra- or postoperative DSA between 2012 and 2018 were selected for our study. Six blinded raters classified the clipped IA remnants at two different time points. Inter- and intra-observer agreement for both grading schemes were calculated by using kappa (κ) statistics.

Results: For interobserver agreement, the 2D-DSA yielded a κ -value of 0.225 (p-value = 0.000, 95%-CI [0.185; 0.265]) for the first and a κ -value of 0.368 (p-value = 0.000, 95%-CI [0.328; 0.408]) for the second time point. The κ -values for the 3D-DSA score were 0.700 (p-value = 0.000, 95%-CI [0.654; 0.745]) and 0.776 (p-value = 0.000, 95%-CI [0.729; 0.822]), respectively. Intraobserver agreement demonstrated κ -values between 0.139 and 0.512 for the 2D-DSA and κ -values between 0.487 and 0.813 for the 3D-DSA score.

Conclusions: Whereas the inter- and intra-observer agreements were only minimal or weak for the 2D-DSA score, they were moderate or strong for the 3D-DSA categorization. These results suggest the simple and practical 3D-DSA categorization may yield a more reliable categorization of clipped IA remnants as baseline for lifelong follow-up. Prospective validation of this new classification system is needed.

P20

“SEP for CLIP”: New Frontiers of Intra-Operative Neurophysiology in Brain Aneurysm Surgery

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Aims: Vascular neurosurgery carries a high risk of neurological sequelae due to possible cortical and subcortical ischemia; for this reason, the use of sensitive and reliable tools, able to monitor the cerebral blood supply and prevent ischemic insult, is mandatory. Somatosensory evoked potentials (SSEP) provide real-time information on cortical blood supply and amplitude reductions greater than 50% are considered an alarm (1). But is this parameter sufficiently sensitive to ischemic damage? To answer this question, we analyzed the SEP signal from a new point of view, namely that of its shape fluctuations during operation. Our goal was to compare the SEP “morphology”, considered as a representation of a specific neuronal network, with the SEP “amplitude”, in terms of sensitivity to a pre-ischemic and reversible state, during brain aneurysm surgery.

Methods: This work included 23 patients undergoing clipping of an unruptured MCA aneurysm and represents the second step of a previous pilot study based on a population of 16 patients (2). We distinguished a BASELINE phase from a RISK phase, which contains the temporary closure of the middle cerebral artery, when needed. We considered 4 measures: SEP Amplitude (N20 peak-to-peak), SEP Morphology Delta (difference between each individual SEP and the baseline SEP), SEP Morphology Correlation coefficient (used to quantify the strength of the relationship between 2 variables) and SEP Morphology Fréchet Distance (measure of similarity between 2 curves). We then applied a filter derived from GARCH (generalized-autoregressive conditional heteroskedasticity, used to estimate relevant trends in fluctuating signals) financial model (3) to each of them.

Results: An analysis of variance showed a significant SEP Index effect with different behavior of the 4 indices GARCH during the RISK phase. While the Correlation coefficient GARCH index did not differ from the trend of Amplitude GARCH, Delta GARCH and Fréchet GARCH indices remained within the “normal range” at BASELINE, but exceeded this threshold of 80% and 83% respectively during the RISK phase, compared to Amplitude GARCH which did it of 67% only.

Conclusions: This study confirms that SEP Morphology, as a measurement derived from the networking nature of the brain, is more sensitive to blood flow reduction than Amplitude and is likely able to detect structural cortical alterations while still reversible.

P21

Segmental Agenesis of the Internal Carotid Artery: Embryologic and Angiographic Correlation with a Revised Classification

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Background: Internal carotid artery (ICA) agenesis is a very rare anatomical variant, with an estimated prevalence inferior to 0.01%. It can involve different segments of the ICA, with consequent regression of the segments proximal to the vascular insult. The flow distal to the involved segment can be supplied by different forms of compensation. Many authors along history described cases of ICA agenesis and proposed their own classifications for this variant basing on different criteria. However, none of these allows to include and classify all the cases described in literature.

Method: We revised all the cases of ICA agenesis described in literature, as well as the previous proposed classifications. We also made a detailed review of the steps of ICA embryological development.

Results: We identified four different types of flow compensation for ICA agenesis: through the Circle of Willis, the persistency of an embryological artery, an arterio-arterial anastomosis

sis and internal-external carotid artery anastomoses (rete mirabile). Each type also differs for the ICA embryological segment involved by the vascular insult and for the stage when the insult happens.

Conclusion: After description and comprehensive analysis of the ICA embryology, different types of segmental agenesis, and previous classifications, we propose a new and more comprehensive classification for ICA agenesis that allows to include all the cases described in literature.

P22

Clipping and Exclusion of a Multiple Shunts Thoracic Pial Arteriovenous Fistula: How I Do It

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Aims: Thoracic pial arteriovenous fistulas (pAVFs) are rare vascular malformations. They usually consist in a single dilated pial radiculomedullary artery connected directly to an enlarged draining medullary vein. Multiple shunts thoracic pAVFs are even rarer entities, that can progress to a myelopathy and demand a complex surgery approach.

Methods: We illustrate our radiological assessment with micro catheterization and our surgical technique to identify and exclude a multiple shunt thoracic pAVF. The success of our treatment is permitted by an appropriate pre-operative planning supported with an extent angiography. Such an exam gives us a deep understanding of the unique fistula's anatomy. We also discuss an intraoperative video of the clipping, that shows step by step our surgical technique.

Conclusions: Double injection and micro catheterization in pre-operative angiography are helpful in identifying all the fistula's feeders and planning an efficacious surgery. The three fundamental pillars of our surgical approach are: removal of the vertebral pedicle that results in exposure of the dorsal and ventral vessels, use of indocyanine green and microdoppler.

P23

Early Minimally Invasive Image Guided Endoscopic Evacuation of Intracerebral Haemorrhage (Eminent-ICH): Study Protocol for a Prospective Randomized Trial

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Background: Spontaneous supratentorial intracerebral haemorrhage (SSICH) is a devastating disease affecting more than 5 million people worldwide. Treatment for SSICH aims to reduce the hematoma volume, however to this date an established surgical treatment is largely lacking. Minimally invasive endoscopic surgery (ES) seems to provide improved functional outcome and mortality rates compared to the best medical treatment (BMT), yet the exact treatment window is still discussed. With this randomized controlled trial, we aim to demonstrate that early (<24 h) conducted minimally invasive ES is superior to BMT.

Methods: In this multi-centre randomised controlled trial we aim to enrol 300 patients with SSICH across Switzerland over the duration of 3 years. Patients will be randomised in a 1:1 fashion to either early (<24 h) minimally invasive ES or BMT with an overall observation period of 6 months. The primary endpoints will be favourable outcome defined as a modified Rankin scale < 3 and hematoma reduction to <15 mL, while secondary outcomes will be relative reduction in hematoma volume, focal neurological deficits, temporal evolution of biomarkers for secondary brain damage, morbidity, and mortality rates. The study design and the study procedures will be tested in a pilot trial including 10 patients prior to commencing with the RCT. The surgical technique will be unified for all included centres.

Significance: SSICH is a devastating cerebrovascular disease currently lacking a sufficiently effective surgical treatment. The aim of the proposed work is to compare the current gold standard, BMT, against ES for the treatment of SSICH. It analyses whether early ES might lead to improved functional outcome and mortality rates and be a valid alternative in the treatment of SSICH. Swiss stroke centres interested in collaborating on this project are encouraged to contact us.

P24

Endoscopic Evacuation of Acute Subdural Hematoma in the Elderly—A Systematic Review

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Introduction: Acute subdural hematoma (ASDH) is one of the most common brain injuries and carries a high mortality. Gold standard treatment is a surgical evacuation of the hematoma using a large craniotomy. However, some reports in the literature show that an endoscopic hematoma removal via a mini- craniotomy is also feasible. Especially in older patients, in which large craniotomies are accompanied with a high morbidity, endoscopic surgery was shown to have a good clinical outcome. The aim of this systematic review is to evaluate the clinical outcome and morbidity of endoscopic subdural hematoma evacuation. **Methods:** We performed a systematic search in the databases PubMed and Embase using a search string with a combination of the keywords “ASDH” and “Endoscopic surgery”. We included randomized controlled trials, prospective and retrospective cohort studies as well as case series with more than 5 patients. All included studies were rated using the Newcastle-Ottawa Scale. Primary outcome is hematoma evacuation rate and secondary outcomes were clinical outcome, craniotomy size, morbidity and mortality.

Results: Out of 97 studies screened, we included seven studies for our qualitative analysis with a total of 95 patients. All studies included only patients older than 70 years with a mean GCS of 10 (± 2 , range). In all seven studies, a hematoma evacuation rate of over 80% was achieved. Postoperative GCS was improved in all studies with a mean improvement of 2.9 points (± 1.6). There was no consistent evaluation of functional outcome, while five studies reported a mean mRS of 3.1 (± 1.4) postoperatively. Overall surgical mortality was low (5%), and no study described surgery-induced mortality. Postoperative infection rate was 2%, rebleeding rate 4% while seizures occurred in 9%. Mean duration of surgery was mean 87.3 min; ± 13 min. The size of the mini-craniotomy was 3cm diameter in all studies.

Conclusion: This systematic review of the literature shows that endoscopic evacuation of ASDH is feasible and safe in elderly patients with a low postoperative morbidity and mortality rates.

P25

Quality of Life in Patients with Unruptured Intracranial Aneurysms. A Single Centre Cohort Study

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Introduction: Treatment recommendations for unruptured intracranial aneurysms (UIA) is challenging due to the incompletely elucidated UIAs natural history and the morbidity associated with treatment. The awareness of being diagnosed with an UIA can be associated with a feeling of anxiety and psychosocial distress. The impact of treatment on a patients' health perception and quality of life should be considered when advising individual patients.

Objective: The aim of this study was to compare the quality of life (QoL) in patients diagnosed with one or more UIAs, before and after treatment.

Material and Methods: Analysis of demographic and clinical data as well as results of the validated 15D quality of life questionnaire (15D QoL) of a prospective database with $n = 198$ consecutive patients diagnosed with UIA. A mean QoL 15D score difference of at least 0.015 was considered to be clinically relevant. Patients were categorised into different groups, depending on their treatment and their pre- or postoperative status at the time of completion of the questionnaire. Comparison was performed by standard descriptive statistics analysis.

Results: Conservatively treated patients (QoL 15D score 0.9025) had similar mean quality of life scores as preoperative patients (0.9057). There was no clinically relevant nor statistically significant difference between preoperative and postoperative mean 15D QoL scores (preoperative 0.9057 vs. postoperative 0.9063). There was a trend to improvement in the postoperative QoL scores over time. After an initial transient reduction (0.8809), QoL scores returned to and exceeded preoperative levels in the long term (0.9106, after one to three years after treatment and 0.9446, after more than three years after treatment). In the microsurgical clipping group, postoperative patients (0.8885) experienced a decrease in quality of life compared to preoperative patients (0.9176), while patients after endovascular coiling showed increased quality of life scores (preoperative 0.8972 vs. postoperative 0.9426). However, these differences did not reach a statistical significance and the lengths of follow-up differed between the two groups (mean FU: 371 days for surgery vs. 1371 days for endovascular treatment).

Conclusions: Intervention for UIA is not associated with a worsening of QoL. QoL in treated patients improves over time.

P26

Measurement of the Middle Cerebral Artery Pressure during Superficial Temporal Artery to Middle Cerebral Artery Bypass Surgery: A Preliminary Study

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Objective: Measurement of the middle cerebral artery (MCA) pressure during superficial temporal artery (STA) to MCA bypass surgery for chronic cerebrovascular occlusive disease (COD) may be used to evaluate cerebral perfusion. In this study, we sought to determine the changes of distal MCA pressure during bypass surgery.

Methods: Following STA-MCA anastomosis, the second branch of the STA was connected to an arterial line, while a temporary clip was placed on the proximal main trunk of the STA, allowing for baseline measurement of distal MCA pressure. The radial artery (RA) pressure was measured simultaneously. Subsequently, the temporary clip was removed to measure the post-anastomosis terminal MCA pressure.

Results: Between 2019–2021, the mean arterial pressure (MAP) in the terminal MCA was monitored during ten revascularization procedures performed in 3 women and 5 men. Median age was 64 years (range, 17–75 years). Six patients suffered from atheromatous carotid occlusion, 2 patients from moyamoya vasculopathy. The baseline mean ($\pm$ SD) distal MCA MAP was 34 ± 13 mmHg, which corresponded to 41% of the measured RA pressure. Following opening of the bypass, the intraoperative distal STA/MCA MAP increased significantly to 71 ± 11 mmHg, corresponding to 88% of the respective RA pressure ($p < 0.001$).

Conclusions: The actual measurements suggest surprisingly low baseline MCA pressure values in patients with COD and a significant increase of perfusion pressure in the MCA territory following STA-MCA bypass surgery. Pressure monitoring might indicate conditions at risk for postoperative hyperperfusion and hemorrhage. Thus, MCA pressure measurement might become a valuable tool in the assessment of the intraoperative cerebral perfusion status.

P27

Effect of Transcutaneous Stimulation (TENS) on Pain and the Consumption of Analgesics in the Postoperative Period of Decompression Surgery with Lumbar Fixation

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Background: TENS is a non-invasive stimulation technique that has proven to be effective in postoperative root pain, particularly in visceral and orthopedic surgery. In neurosurgery, few studies have been carried out in this context, whereas TENS has already been accepted as one of the first-line treatment in the conservative management of lumbosciatalgia. In this study, we are analysing the effect of transcutaneous stimulation on postoperative pain and postoperative consumption of analgesics in patients having undergone lumbar decompressive surgery followed by fixation.

Methods: We are prospectively recruiting patients undergoing lumbar decompressive surgery followed by fixation in our department. Patients will be divided into a "TENS", experimental group and a control group (who did not receive TENS treatment) and both groups will be compared for NRS score, total use of analgesics and recovery of autonomy after surgery (ODI and TUG test).

Results: A preliminary analysis with the first ten patients is ongoing. The study will be finished in summer 2021.

Conclusions: These preliminary data will hopefully confirm the usefulness of TENS in reducing postoperative pain, resulting in decreased analgesics use and increased recovery of autonomy.

P28

Electromagnetic Navigated Percutaneous Radiofrequency Thermocoagulation under General Anesthesia in the Treatment of Trigeminal Neuralgia: Technical NoteA. Simonin ¹, E. Pralong ², M. Roulet ² and J. Fournier ¹¹ H pital de Sion, CHVR² CHUV Centre Hospitalier Universitaire Vaudois, Switzerland

Introduction: Percutaneous radiofrequency trigeminal rhizotomy (RF-TR) is considered as a common treatment for patients with trigeminal neuralgia (TN), but it is usually done under local anesthesia, and under guidance of fluoroscopy. The procedure may be painful for the patient, and precise localization of the RF needle is often difficult to achieve.

Methods: A 78-year-old female patient presented with a left V2-3 trigeminal neuralgia. We used a non-invasive electromagnetic navigation (AxiEMTMElectromagnetic StealthStation, Medtronic) with a Passive Catheter Introducer (PCI) placed in a 16 Gauge IV Catheter Needle. They were introduced together using coronal, axial, sagittal, and guidance views on the Stealth Station with preoperative CT-scan fused with MRI.

Under general anesthesia, Bipolar subdermal recording electrodes were positioned at the emergence of V1, V2 and V3 trigeminal nerve branches. Bipolar subdermal electrodes were also positioned in the temporalis and masseter muscles. Corticobulbar motor evoked potentials (CMEP) were elicited by transcranial electrical stimulation through corkscrew scalp electrodes placed on Cz and C4 derivations (10–20 EEG System). Recordings were performed during catheter needle advancement to trigeminal nerve. Electro Neurography (ENG) of the spontaneous activity of trigeminal nerve branches and triggered ENG (TEG) recorded during electrical stimulation through the catheter needle.

Results: Spontaneous ENG activity was observed during V2 or V3 approach. Trigeminal triggered ENG was observed during catheter stimulation on V2 and V3 derivation only. CMEP remained constant during the whole surgery. There was an immediate relief of the symptomatology after the surgery. At discharge from our department, the patient described a mild hypoesthesia of the mandibular region, that disappeared after 1 month. At 1-year follow-up, there was no recurrence of the symptoms.

Conclusion: Electromagnetic navigated trigeminal rhizotomy, performed under general anesthesia with neuromonitoring was a non-invasive, safe, painless and efficient procedure for trigeminal neuralgia.

P29

Preclinical and Clinical Role of Interleukin-6 in the Development of Delayed Cerebral Vasospasm and Neuronal Cell Death after Subarachnoid Hemorrhage: Towards a Potential Target Therapy?

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Aim: Delayed cerebral vasospasm (DCVS), early brain injury (EBI), and delayed cerebral ischemia (DCI) are devastating complications after aneurysmal subarachnoid hemorrhage (SAH). Interleukin (IL)-6 seems to be one of the key interleukins in the setting of the inflammatory response after SAH, and a growing body of preclinical and clinical studies described a strong correlation between IL-6, EBI, DCVS, DCI, and worse outcome. The aim of this study was to systematically review preclinical and clinical studies that evaluated systemic and cerebral IL-6 levels after SAH and their relation to DCVS, neuronal cell death, and DCI.

Methods: We conducted two systematic literature searches using the PubMed database to identify preclinical and clinical studies evaluating the role of IL-6 after SAH. Suitable articles were selected based on predefined eligibility criteria following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

Results: A total of 61 and 30 preclinical and clinical articles, respectively, were included in the systematic reviews. Of the preclinical studies in which IL-6 was measured in cerebrospinal fluid (CSF), parenchyma, and systemically, 100%, 94.4%, and 81.3%, respectively, showed an increased expression of IL-6 after SAH. Preclinical results were mirrored by clinical findings in which elevated levels of IL-6 in CSF and plasma were found after SAH, correlating with the occurrence of DCVS, DCI, and worse outcome. Only two preclinical studies analyzed the direct inhibition of IL-6, which resulted in a decrease of DCVS and neuronal cell death.

Conclusion: IL-6 plays a fundamental role in the onset of DCVS and DCI after SAH in preclinical animal models and clinical studies. Its inhibition might be a possible therapeutic approach to improve the outcome of SAH patients.

P30

Anatomical Variations of the Common Carotid Arteries and Neck Structures of the New Zealand White Rabbit and Its Implication for the Development of Preclinical Vascular Models: A Cadaver Study

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Background: Rabbit aneurysm models involving neck arteries are of growing interest for the study of human intracranial aneurysms. To improve existing models and minimize mortality and morbidity, a better understanding of the vascular and neck anatomy is needed. This study aims to describe the anatomical variations regarding carotid arteries and the structures at risk during dissection and vascular surgeries.

Method: A necropsy was performed on ten cadaver collected from ongoing laboratory studies. The origin of the right common carotid artery (RCCA) was localized measuring its distance laterally and caudally to the manubrium sterni. The origin of the left CCA and its distance relative to the RCCA was measured. A neck dissection was performed to describe anatomical structures at risk. Precautious measures and single steps of dissection were systematically documented in all animals.

Results: Ten female New Zealand White Rabbits with a mean weight of 4.0 ± 0.3 kg and mean age of 25 ± 5 weeks were included. The RCCA origin was located 9.6 ± 1.2 mm laterally and 10.1 ± 3.3 mm caudally to the manubrium. In all the rabbits the LCCA originated from the right side, from the brachiocephalic trunk and about 6.2–3.1 mm proximally to the RCCA origin. They were no cases with LCCA originating from the left subclavian artery or from the aorta. The trachea, jugular vein and laryngeal nerve are the main structures at risk during surgeries in this field.

Conclusion: In the given species with similar weight and age, we found only few anatomical variations. The data shown helps to localize both CCAs and their origin to guide surgical approach to these structures. Attention has to be paid to the trachea, jugular vein and laryngeal nerves in order to reduce morbidity and mortality. This study can help researchers optimizing their dissection procedures in order to improve or develop new preclinical aneurysm models.

P31

Creation of Two Saccular Elastase Digested Aneurysms with Different Hemodynamics in One Rabbit

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The development of preclinical animal models with hemodynamic, morphologic, and histologic characteristics close to human intracranial aneurysms plays a key role for our understanding of the pathophysiological processes and the development and testing of new therapeutic strategies. This study aims to describe a new rabbit aneurysm model that allows to create two elastase-digested saccular aneurysms with different hemodynamic conditions within in the same animal.

Five female New Zealand white rabbits with a mean weight of $4.0 (\pm 0.3)$ kg and mean age of $25 (\pm 5)$ weeks underwent microsurgical stump and bifurcation aneurysm creation. One aneurysm (stump) was created by right common carotid artery (CCA) exposure at

its origin at the brachiocephalic trunk. A temporary clip was applied at the CCA origin and another 2 cm above. This segment was treated with a local injection of 100 U Elastase for 20 min. A second aneurysm (bifurcation) was created by suturing an elastase treated arterial pouch into the end-to-side anastomosis of the right CCA to left CCA. Patency was controlled by fluorescence angiography immediately after creation.

The average duration of surgery was 221 min. Creation of two aneurysms in the same animal was successful in all rabbits without complication. All aneurysms were patent immediately after surgery except for one bifurcation aneurysm which showed an extreme tissue reaction due to elastase incubation and an immediate intraluminal thrombosis. We observed no mortality during surgery and up to one-month follow up. Morbidity was limited to a transient vestibular syndrome (one rabbit), which recovered spontaneously within one day.

We demonstrate for the first time the feasibility of creating a two-aneurysm rabbit model with stump and bifurcation hemodynamic characteristics and highly degenerated wall conditions. This model allows to study the natural course and potential treatment strategies on the basis of aneurysm biology under consideration of different flow conditions.

P32

Mixed-Reality Head-Mounted Display in Cranial Neurosurgery: A Proof-of-Concept Study

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Objective: Mixed-reality (MR) head-mounted displays (HMD) offer virtual augmentations registered with real objects, allowing for direct patient-centered lesion visualization and manipulation. In this proof-of-concept study, we aimed at evaluating the application of HMD as an adjunct to standard neuronavigation (SN) in the planning of treatment for patients undergoing neurovascular and tumor surgeries.

Methods: A 3D hologram of the patient's anatomy was generated from conventional CT scan, MRI, and/or 3D rotational angiography (3D-RA), and integrated into the HMD (Magic Leap One) (Brainlab, Feldkirchen, Germany). The participating surgeons completed a standardized questionnaire, which evaluated the application of HMD compared to SN, to detail the visualization benefits and limitations of the 3D hologram.

Results: Eight consecutive patients with neurovascular ($n = 4$) or tumor pathologies ($n = 4$) were selected for MR. The mean ($\pm$ SD) setup time was significantly longer for HMD than SN (8.3 ± 1.5 min vs. 4.8 ± 1.3 min; $p < 0.001$), independent of the pathology applied (i.e., tumor: 8.0 ± 2.0 vs. 4.3 ± 1.3 , $p = 0.02$, and vascular: 8.7 ± 0.9 vs. 5.4 ± 1.1 ; $p < 0.001$). Surgeons wearing the HMD succeeded in moving the 3D hologram from respective operators' angles and identifying the shape and configuration of the lesion. The MR device was superior to SN with regard to treatment planning on account of its improved spatial awareness. Both SN and MR were rated as equally effective in providing navigation guidance. The depiction of bony involvement and small aneurysm perforators by the 3D hologram was rated as poor.

Conclusions: Our initial experience in this proof-of-concept study indicates that a 3D hologram with MR techniques represents an adjunct to SN in that it provides spatial awareness. The current method is limited in its representation of small perforators in neurovascular pathologies and bony involvement in tumors. The significant longer setup time being noted for HMD doesn't impair the surgical workflow, but might be shortened with greater experience with MR HMD. Further development is necessary to improve the clinical applicability of the MR HMD.

P33

Pros and Cons of Interhemispheric Transcallosal Approach for Thalamic Lesions Illustrated by Two Clinical Cases with 2-D Surgical Videos

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Objective: The aim of our report is to show the surgical indications and pros and cons of the interhemispheric transcallosal approach via the illustration of two clinical cases with didactic surgical videos. Surgical details and possible surgical difficulties are also explained through these illustrative cases.

Introduction: Interhemispheric transcallosal approach is an effective and useful surgical access for tumours of the lateral and third ventricles, it also allows an excellent surgical corridor for well-defined and small lesions in the thalamic region.

Observations: The first case reported is a left thalamic glioblastoma resected via an interhemispheric posterior transcallosal approach. In this video, you would appreciate difficulties of this approach and the need to re-operate the patient by trans-parietal approach to complete the tumor resection. The second case illustrated is a left thalamic cavernoma associated with acute hematoma operated via an interhemispheric anterior transcallosal approach. In this case, the approach was well-chosen and allows a complete resection of the lesion.

Conclusion: The size and the texture of the thalamic lesion are one of the key points to consider before to perform this surgical approach. The interhemispheric transcallosal approach is a versatile and useful surgical access for tumors in lateral and third ventricle, it also proves to be an excellent surgical corridor for well-defined and small lesions in thalamic region.

P34

Intraoperative Ultrasound Guided Compared to Stereotactic Navigated Ventriculoperitoneal Shunt Placement: Study Protocol for a Randomized Controlled StudyS. Leu ¹, F. Halbeisen ¹, L. Mariani ² and J. Soleman ²¹ Universitätsspital Basel² Universität Basel & Universitätsspital Basel, Switzerland

Aims: Ventriculoperitoneal shunt (VPS) placement is one of the most frequent neurosurgical procedures and the operation is performed in a highly standardized manner under maintenance of highest infection precautions. Short operation times are important since longer duration of surgery can increase the risk for VPS complications, especially infections. The position of the proximal ventricular catheter influences shunt functioning and survival. With freehand placement rates of malpositioned VPS are still high. Several navigation techniques for improvement of shunt placement have been developed. Studies comparing these techniques are sparse. The aim of this study is to prospectively compare ultrasound (US) guided to stereotactic navigated shunt placement using optical tracking with the focus on operation time and efficiency.

Methods: In this prospective randomized, single-centre, partially-blinded study we will include all patients undergoing VPS placement in our clinic. The patients will be randomized into two groups, one group undergoing US guided (US-G) and the other group stereotactic navigated VPS placement using optical tracking. The primary outcome will be the surgical intervention time. This time span consists of the surgical preparation time together with the operation time and is given in minutes. Secondary outcomes will be accuracy of catheter positioning, VPS dysfunction and need for revision surgery, total operation and anaesthesia times, amount of intraoperative ventricular puncture attempts as well as complications, any morbidity and mortality.

Results: The study started recruitment in February 2020 and until now 38 patients were included. 17 patients completed follow up of 6 months.

Conclusion: To date, there is no prospective data available comparing these two navigation techniques. A randomized controlled study is urgently needed in order to provide class I evidence for the best possible surgical technique of this frequent surgery.

P35

Open versus Laparoscopic Distal Ventriculoperitoneal Shunt Placement in Children: A Systematic Review and Meta-Analysis

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Objective: Ventriculoperitoneal shunt (VPS) surgery for treating hydrocephalus is one of the most common procedures in pediatric neurosurgery. However, the revision rate of VPS remains high ranging between 32–67% of which a third is due to distal revisions. VPS revision surgery significantly reduces the quality of life in the affected children and creates a socioeconomic burden. Traditionally, distal VPS placement has been achieved by mini-laparotomy in children and adults. However, in adults several studies showed that a lower rate of distal dysfunction is achieved using laparoscopic insertion. In children, the literature is scarce regarding this topic. The aim of this systematic review and meta-analysis was to compare open vs. laparoscopic distal VPS placement in children regarding complications.

Methods: Pubmed and Embase databases were searched using a systematic search strategy to identify studies comparing open vs. laparoscopic distal VPS placement up to April 2021. Two independent researchers assessed the studies for inclusion and quality. Primary outcome measure was distal revision surgery. For the meta-analysis, a fixed effects model was used if low heterogeneity ($I^2 < 50\%$) was present, otherwise a random effects model was applied.

Results: Out of 108 studies screened, we included 7 articles for qualitative analysis of which 2 studies were included for the meta-analysis. For the quantitative analysis, 133 children, with a mean age of 4.94 (± 3.69) years, received laparoscopic and 269 children, with a mean age of 2.50 (± 0.00) years, received open distal VPS placement. Distal revision rate was 6.1% vs. 4.3% for laparoscopic vs. open distal VPS placement, without a significant difference between the two methods (RR 1.16, 95% CI [0.48–2.79], $I^2 = 50\%$, $z = 0.32$, $p = 0.74$). The overall revision rate was 26.2% vs. 28.6%, without any significant difference (RR 0.88 95% CI [0.61–1.26], $I^2 = 21\%$, $z = -0.68$, $p = 0.49$). A similar duration of surgery was observed for laparoscopic vs. open VPS placement (64.5 min vs. 68 min, SMD -0.14 , 95% CI $[-1.57-1.30]$, $I^2 = 98\%$, $z = -0.19$, $p = 0.85$).

Conclusion: Only few studies were retrieved comparing laparoscopic versus open distal VPS placement in children. This meta-analysis did not find any significant difference between these two methods regarding distal and overall revision rate. Therefore, both methods seem to be warranted in children.

P36

Endoscopic Third Ventriculostomy Compared to Ventriculoperitoneal Shunt as Treatment for Idiopathic Normal Pressure Hydrocephalus: A Systematic Review and Meta-Analysis

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Aim: The traditional treatment for idiopathic normal pressure hydrocephalus (iNPH) is the insertion of a ventriculoperitoneal shunt (VPS). However, VPS has an overall revision rate of around 20%. Recently, some studies examined endoscopic third ventriculostomy (ETV) for the treatment of iNPH with controversial results. The aim of this systematic review and meta-analysis was to compare ETV to VPS regarding outcome and complications for the treatment of iNPH.

Methods: We searched Medline, Embase and Scopus using a search string with the keywords “ETV”, “VPS” and “iNPH”. Two independent researchers assessed the search results for studies comparing ETV vs. VPS in iNPH. Studies describing the treatment of hydrocephalus due to other etiologies (e.g., post-hemorrhagic, post-infectious) were excluded. We included randomized controlled trials, retro- and prospective cohort studies but excluded technical or case reports. Primary outcome was failure of cerebrospinal fluid (CSF) diversion method, while secondary endpoints were clinical outcome and complications.

Results: Out of 208 screened studies, 4 were included for our quantitative analysis including one RCT and three cohort studies. One study did not clearly distinguish between the complications of ETV and VPS treatment and was detected as an outlier, which is why we excluded it from further analysis. No statistically significant difference concerning failure of CSF diversion method was found comparing ETV vs. VPS (27.5% vs. 30.9%, RR1.40, 95% CI [0.97–2.03], I² = 0%, z = 3.89, p = 0.06). ETV showed a significantly lower complication rate compared to VPS (7.5% vs. 51.1%, RR 0.2480, 95% CI [0.08–0.76], I² = 22.6%, z = −2.43, p = 0.0151), however, the revision rate was not significantly different between the two methods (17.5% vs. 33.2%, RR 0.86, 95% CI [0.47–1.57], I² = 0%, z = −0.49, p = 0.6). No statistically significant difference, between the methods was observed for the rate of post-operative infection (0% vs. 1.0%, RR 0.09, 95% CI [0.001–7.50], I² = 0, z = −1.06, p = 0.28). No pooled outcome was possible for clinical outcome.

Conclusion: ETV shows a similar failure rate compared to VPS in iNPH but a significantly lower complication rate. However, the data available is scarce with only one RCT investigating this important matter. Further well-designed trials are necessary to investigate the clinical outcome of ETV in iNPH.

P37

Intracranial Neuroendoscopy in Children and Adults: A Comparative Analysis

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Background: Intracranial neuroendoscopy has evolved to be an essential adjunct in neurosurgery and is used across all age groups for various indications. Studies comparing the use of neuroendoscopic procedures in children and adults are scarce. Our study aims to compare indications, functional outcomes, and postoperative complications of the two age groups and identify predictive factors associated with poor functional outcomes.

Methods: We will retrospectively analyze and compare data of consecutive patients dichotomized into two cohorts: pediatric (<18 years) and adults (>18 years) in whom intracranial neuroendoscopy has been performed between January 2010 and June 2020. Potential risk factors for poor functional outcome will be analyzed in uni- and multivariate analysis.

Results: Of 146 patients who underwent intracranial neuroendoscopic surgery, 58.2% (n = 85) and 41.8% (n = 61) were adults and children, respectively. We will analyze the data from the two different cohorts and compare baseline characteristics, functional outcome, and complication rates. We will also present risk factors associated with poor functional outcomes.

Conclusion: We will conclude for which indication in the two cohorts neuroendoscopic surgery is safe and which risk factors are associated with a poor functional outcome. In addition, conclusions based on the difference in outcome between the two age groups will be drawn.

P38

Neurocognitive Outcome in Patients Receiving Neuroendoscopy

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Introduction: Neuroendoscopic surgery (NES) has been widely acknowledged as a treatment option for multiple intraventricular and cystic pathologies. This minimally invasive approach shows an overall reduced morbidity compared to craniotomy, however, carries the risk for neurocognitive complications caused by an injury to the fornix, hypothalamus, and other structures adjacent to the ventricular system. Neurocognitive deficits are rarely reported in a systematic matter after NES but occur in up to 2% of the cases. The aim of this study is to assess the subjective neurocognitive outcome in patients who underwent NES for various pathologies.

Methods: We conducted a retrospective cohort-study in patients receiving NES at our institute from 2010–2021 regarding subjective neurocognitive outcome, quality of life and patient satisfactions after NES assessed by a telephone questionnaire. The primary outcome was the subjective neurocognitive outcome after endoscopic surgery. Secondary outcomes were the return-to-work rate, subjective quality of life and satisfaction with the surgery. Descriptive and comparative statistics were conducted for all outcome parameters.

Results: Of 92 patients screened, 51 patients with a mean age of 48.59 ± 18.22 agreed to participate in the study and were included in the final analysis. The most common symptom upon admission was headache (52.9%), which was more common in younger patients ($p < 0.001$). Hydrocephalus was the most common indication for surgery (54.9%) with a mean duration of surgery of 63 ± 44 min. Subjective memory skills improved in 31.4%, subjective numerical skills in 13.7% and subjective association skills in 15.7%. Normalisation of any skill impairment was observed in 31.4%. Pre-operative rate of occupation was 58.8% and return-to-work rate was 45.1% after surgery while the subjective quality of life improved in 62.7%. Patient's satisfaction was good as 74.5% would undergo the surgery again and 60.8% would recommend it.

Conclusion: Based on the observations made in this study, it appeared that subjective skill improvement could be achieved by endoscopic surgery, while in some patients subjective deficits were seen, yet these were mostly of transient nature. Subjective quality of life was good, and the surgery was well accepted by the patients and their relatives. However, further well-designed trials and neuropsychological testing are warranted to determine the exact effect of NES on neurocognitive outcome.

P39

Suboccipital Retrosigmoid Approach for Cerebello-Pontine Angle Pathologies: Is the Park-Bench Position Necessary?

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Aim: Suboccipital retrosigmoid approach (SRA) is a workhorse craniotomy to diverse cerebellopontine angle (CPA) pathologies, such as microvascular decompression, or tumor resection. The park-bench position is considered as the gold-standard in order to avoid the limitations of supine and sitting position, namely neck pain and air embolism respectively. However, it may be time consuming and demands trained personnel, which can be problematic in urgent situations and/or in intermediate non-tertiary institutions.

Methods: We propose a modified prone position as an alternative positioning during SRA. Patient is positioned in a prone position with the ipsilateral shoulder supported on a 30° gel rest. The head is immobilized on a 3-point head-clamp, rotated 30° towards the ipsilateral shoulder and flexed 20° towards the floor. The upper extremities lay next to the trunk.

Results: Eighty-one patients were operated by the senior author since 2014 for various pathologies of CPA. Of them, 51 cases of microvascular decompressions, namely 44 cases of trigeminal neuralgia, 6 for hemi-facial spasms and 1 for glossopharyngeal neuralgia. Twenty-nine tumor cases; 19 vestibular schwannomas, 6 meningiomas, 3 epidermoid cysts and 1 ependymoma. Lastly, one patient had SRA for a traumatic lateral hemispheric cerebellar hematoma. Satisfactory exposure was achieved between the trigeminal impression until the condylar fossa with unobstructed view of all critical neurovascular structures of the CPA, including cranial nerves V, VII-VIII and IX-XI complexes as well superior cerebellar, anterior inferior cerebellar and posterior inferior cerebellar arteries. All procedures were completed according to the pre-operative plan and none was terminated due to limited exposure. Contrary to park-bench position, the ipsilateral shoulder does not interfere with surgeons' gestures offering additional comfort. None of our patients experienced any decubitus ulcers neither post-operative neck or shoulder pain.

Conclusions: The modified prone position described in this work is safe, easy and fast. Due to its simplicity, it can be advantageous for institutions without dedicated personnel for neurosurgical operating rooms. Moreover, it can be ideal for urgent situations. In addition, it offers comfort to the surgeon since the ipsilateral shoulder lays far from the operating field. Lastly but most importantly, access to all neurovascular structures in CPA remains comparable to park-bench position.

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Surgical Treatment of Epilepsy in Children with Sturge-Weber Syndrome with Focus on Focal lesionectomy: A Case-Based Review

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Background: Sturge-Weber Syndrome (SWS) is a rare neurocutaneous disorder presenting mostly with a facial port wine stain and leptomeningeal angiomas. Young patients present often with epilepsy and psychomotor deficits. Symptom control is the focus of SWS treatment, since a causal therapy does not exist. Generally, epilepsy is treated pharmacologically, while in some cases of intractable epilepsy, surgery might be a curative option.

Case presentation: We describe a case of a boy presenting with epilepsy at the age of 8 months. He was diagnosed with SWS type III, while in the course of the disease he developed an intractable focal epilepsy with complex partial seizures. On magnetic resonance imaging a leptomeningeal angiomas in the right parieto-occipital region was seen. After stage I evaluation of the epilepsy, the seizure origin was regionally correlated to the leptomeningeal angiomas and therefore surgical resection of the lesion was recommended. At the age of two years we performed a right-sided parieto-occipital craniotomy and a focal lesionectomy sparing the affected postcentral gyrus. Postoperatively, no complications occurred, while at 2-year follow-up the patient is seizure-free, the antiepileptic drugs were reduced, and he continued his favorable development.

Conclusion: Based on the limited literature available, it seems that lesionectomy leads to lower seizure control rates and higher risk for repeat surgery, while morbidity rates are lower than after hemispherectomy. However, focal lesionectomy remains a valid alternative to hemispherectomy in SWS patients with a clearly depicted epileptogenic area, since repeat lesionectomy in case of recurrent epilepsy shows good seizure control and low surgical morbidity.

Conflicts of Interest: All abstracts & information are published as submitted by the authors and are not the responsibility of the CTN Journal (Clinical and Translational Neuroscience) or the meeting organizer.