

The 18th Korea-Japan Joint Conference on  
Surgery for Cerebral Stroke

# Abstracts

PL-1

## **A tapestry of my surgical experience with anterior choroidal arteries and associated aneurysms**

Jaechan PARK

Department of Neurosurgery, Kyungpook National University, Daegu, ROK

Like a tapestry, woven thread by thread with warp and weft, this presentation brings together the surgical experiences with anterior choroidal arteries (AChAs) and associated aneurysms that I have accumulated over a lifetime. First, to minimize the risk of AChA insufficiency in AChA aneurysm surgery, the detailed surgical techniques for ascertaining the location of the AChA and its branches posterior to the aneurysm, clip application within the safety zone, and verification of the AChA blood flow after aneurysm clipping are discussed. In particular, the various positions of a segment of an AChA behind the aneurysm and its first perforating branch are discussed. Second, a case of the blood blister-like aneurysm (BBA) with a rupture point close to the AChA origin is presented. Surgical techniques for common BBAs, including trapping the lesion of an internal carotid artery with or without bypass procedures and encircling techniques (encircling clip placement or clip placement on wrapping material), are not appropriate for such BBA. The method of direct repair of the rupture point using microsuturing and additional tangential clipping of the lesion is presented. Third, cases of infundibular widening of a duplicate, minor AChA which is not visible in any angiographic evaluation is presented. Such aneurysms or aneurysm mimics emitting an angiographically invisible, minor AChA, resembling a typical AChA aneurysm, require particular caution on the part of the interventionist.

## Perspective of Cerebrovascular Surgery and Role of Japanese Society of Surgery for Cerebral Stroke

Satoshi KURODA

Professor and Chairman, Department of Neurosurgery, University of Toyama Graduate School of Medicine and Pharmaceutical Sciences, Toyama, Japan

Recently, advancements in cerebrovascular endovascular therapy and associated devices have offered patients the benefits of minimally invasive procedures and shorter hospital stays, enabling young neurosurgeons to acquire technical skills more rapidly. This brings great benefits to patients, and also to neurosurgery in Japan, where the majority of endovascular procedures are performed by neurosurgeons. However, as the scope of endovascular therapy expands, the opportunities for open surgery have diminished; consequently, it is undeniable that the hurdles for young neurosurgeons to acquire these skills have risen. Yet, not all cerebrovascular diseases can be resolved through endovascular therapy alone, and young neurosurgeons are increasingly likely to encounter technically challenging cases. Amidst this landscape, the continuous training of neurosurgeons who possess a high level of proficiency is an urgent global challenge. Addressing this issue requires a deliberate, multi-layered approach. The Japanese Society of Surgery for Cerebral Stroke is committed to actively supporting these efforts. One such initiative is the Stroke Surgery Technical Certification System, launched in 2016, which aims to standardize surgical proficiency across the country while providing young neurosurgeons with clear goals for their training. We are also preparing to provide the society members the surgical videos by outstanding neurosurgeons and a database of large to giant, difficult-to-treat cerebral aneurysms (Japan Hard-to-Treat Aneurysm Database; J-HAND) on our website. Launched in 2019 in response to the decline in bypass surgeries performed abroad, the J-MOVA (Japan MicroOVascular Anastomosis training course) program invites young neurosurgeons from overseas to our high-volume institutions to learn bypass techniques and perioperative management. Furthermore, it is essential for us to take the lead in disseminating information to the world. We are currently conducting the "Benefits of STA-MCA Anastomosis in Japan" (BEST-Japan) study to report on the short- and long-term (5–10 years) clinical outcomes of STA-MCA bypass procedures in Japan.

S1-1

## **Beyond the operating room: AI-based risk prediction as an upstream enabler of elective aneurysm treatment**

Tackeun KIM

TALOS Corp., Seoul, ROK

Unruptured intracranial aneurysms are largely asymptomatic and difficult to detect until rupture produces catastrophic subarachnoid hemorrhage. Conventional screening depends on neuroimaging such as MRA, which is costly and impractical to apply indiscriminately across a general population, leaving high-risk individuals unidentified until an emergency presentation.

ANRISK addresses this gap through an AI-based solution that estimates individual aneurysm risk using routine health-checkup data alone, without any neuroimaging. By stratifying examinees and concentrating MRA on those most likely to benefit, ANRISK converts undirected mass screening into a targeted pathway that channels genuinely at-risk patients toward timely evaluation. Deployed across more than 60 institutions in Korea, the system analyzes approximately 250,000 records annually, contributing to earlier detection at population scale.

When adopted by a treating hospital, this upstream enrichment reshaped the downstream clinical profile. Per neurosurgeon per year, new-patient (first-visit) volume rose by 78%, reflecting a marked influx of newly identified aneurysm patients. The unruptured share of cerebral angiography increased from 89.2% to 97.1% ( $p=0.003$ ), and the unruptured share of aneurysm embolization increased from 53.3% to 65.2%. Elective embolization volume grew by 64%, indicating substantially expanded capacity for planned intervention.

These shifts represent more than improved hospital throughput. A rising unruptured, elective fraction means care is moving from emergency, rupture-driven treatment toward planned, patient-selected intervention—precisely the structural change that earlier risk stratification is intended to produce. For patients, this translates into treatment before rupture rather than after. ANRISK demonstrates that AI-based risk prediction, positioned upstream of the operating room, can simultaneously strengthen institutional practice and deliver definitive care to the patients who truly need it.

## **AI-driven AR navigation: Enhancing precision and workflow efficiency in emergency neurosurgery**

Hyun Jin HAN, Yong Bae KIM, Jung-jae KIM, Solbi KIM, Keun Young PARK

Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

**Background and Objectives:** Emergency neurosurgery is a life-saving procedure where intracranial pressure must be controlled within minutes. However, the traditional freehand method relies on blind insertion, leading to an optimal placement rate for External Ventricular Drainage (EVD) of only 72%. While traditional surgical navigation systems can improve accuracy, their complex setup and dependency on the operating room make them unsuitable for time-sensitive emergency bedside applications. This study aims to develop a standalone mobile navigation system to enhance surgical precision and workflow efficiency in emergency settings.

**Methods:** The system utilizes Transformer-based AI models to automatically segment the ventricles and intracranial hemorrhage (ICH) regions from non-contrast CT scans to extract 3D models. These models are registered in real-time onto the patient's head through a mobile AR system integrated with an EM tracking system. By inserting an EM sensor into the catheter tip, the system visualizes the insertion path and depth in real-time. Furthermore, the AI algorithm automatically calculates the optimal surgical trajectory based on anatomical landmarks such as Kocher's point. The system's effectiveness was validated through human-mimicking phantoms and fresh cadaver studies, comparing accuracy and procedure time between expert and novice users.

**Results:** Preliminary research using Post-Mortem CT (PMCT) data achieved a Dice Similarity Coefficient (DSC) of 98% for skin, 86% for bone, and 83% for hemorrhage. The system aims for over 90% accuracy in ventricle and hemorrhage segmentation and has reduced the real-time AR-EM registration time to under 20 seconds, ensuring immediate usability in emergencies. The final target for surgical instrument insertion and target distance error is set to less than 2.0 mm, meeting the FDA's clearance standards for surgical navigation systems.

**Conclusions:** This AI-driven mobile AR navigation system has the potential to shift the paradigm of emergency neurosurgery from blind procedures to guided precision.

S1-3

## **The Evolution of Real-Time AI Assistance in Neuroendovascular Therapy: From Detection to Decision Support**

Ryo AIURA<sup>1</sup>, Yoshikazu MATSUDA<sup>1</sup>, Yuma MIKI<sup>1</sup>, Akito OIWA<sup>1</sup>,  
Kenichi KONO<sup>2,3</sup>, Yoichi MOROFUJI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Showa Medical University Hospital, Shinagawa-ku, Tokyo, Japan,

<sup>2</sup>Department of Neurosurgery, Showa Medical University Fujigaoka Hospital, Yokohama, Kanagawa, Japan,

<sup>3</sup>iMed Technologies, Bunkyo-ku, Tokyo, Japan

In neuroendovascular therapy, operators must integrate diverse information, including device position, vascular anatomy, and the progression of embolic material, while making rapid decisions under continuously changing conditions. Simultaneous monitoring of multiple screens and devices imposes substantial cognitive burden and may increase the risk of overlooking critical findings. Artificial intelligence (AI) has therefore evolved beyond diagnostic imaging toward real-time procedural assistance.

The first stage of AI assistance is Detection, in which deep learning identifies vascular abnormalities and automatically detects and tracks guidewires and catheters on fluoroscopic images. The next stage, Notification, is represented by Neuro-Vascular Assist, which provides visual and auditory alerts when devices move outside the fluoroscopic field or predefined regions of interest. Favorable accuracy and clinical utility have been reported across carotid artery stenting, aneurysm coiling, liquid embolization, and mechanical thrombectomy, suggesting that AI may function as a “second eye.”

However, Detection and Notification alone do not directly support decisions based on vascular anatomy and procedural context. A newly developed AI overlay function superimposes feeders, drainers, and the progression of liquid embolic material on frontal and lateral views and alerts operators when embolic material reaches hazardous regions. This represents Cognitive Assistance, integrating intraoperative information to enhance situational awareness, and may advance toward Decision Support by facilitating actions such as interrupting injection or repositioning devices.

Real-time AI may also support education and technical assessment. Quantification of device displacement, movement velocity, manipulation smoothness, approaches to hazardous regions, and response times may enable objective performance evaluation. Comparing experienced and less-experienced operators could identify technical deficiencies, visualize critical decision points, and support standardized training. Rather than replacing operator judgment, AI may provide a platform for safer decision-making and transfer of technical expertise.

## The Neuro-AI Society (NAIS): Future Directions and Challenges

Fusao IKAWA

Department of Neurosurgery, Shimane Prefectural Central Hospital

Artificial intelligence (AI) is rapidly reshaping diagnosis, treatment selection, prognostication, and research and development across neurology and neurosurgery. Applications are expanding across a broad spectrum of disorders, including stroke, brain tumors, dementia, epilepsy, and diseases of the spine and spinal cord, and are being developed for medical image analysis, natural language processing, surgical assistance, telemedicine, and clinical decision support. In 2026, we established the Neuro-AI Society (NAIS) as a general incorporated association, with its inaugural annual meeting scheduled for October 30-31, 2027. In the years ahead, the Society is expected to serve as an interdisciplinary platform linking clinicians, researchers, industry, government, patients, and the public, and to promote the safe and effective integration of AI technologies into clinical practice.

Substantial challenges, however, remain. First, the standardization of medical data, rigorous quality control, privacy protection, and frameworks for interinstitutional collaboration are essential. Second, evaluation frameworks should emphasize not only performance but also explainability, fairness, reproducibility, and external validation. Third, AI should augment rather than replace clinical judgment; it must be integrated with specialists' expertise to support the best possible care for each patient. Additional priorities include training specialists in neurology and neurosurgery who can understand and use AI, cultivating professionals who bridge medicine and engineering, and addressing ethical, legal, and regulatory issues.

The J Neuro-AI Society (NAIS) should extend beyond showcasing new technologies. It should serve as a central hub that advances the full translational continuum: from AI development driven by unmet clinical needs, through validation in real-world clinical practice, to implementation in healthcare and society. The Society's future mission is to integrate the clinical neurosciences with AI to advance personalized and preventive medicine, reduce healthcare disparities, and create a new interdisciplinary field that contributes to health worldwide.

S2-1

## Clinical and Genetic Landscape of Pediatric Moyamoya Syndrome

Ji Hoon PHI, Sung Hyun KANG, Joo Whan KIM, Taehoon KIM, Seung-ki KIM

Seoul National University Children's Hospital, ROK

### Objective

Moyamoya syndrome refers to moyamoya vasculopathy associated with a well-defined disease or syndrome that may contribute to its pathogenesis. We aimed to characterize the spectrum and frequency of underlying diseases in pediatric moyamoya syndrome and investigate the prevalence of the RNF213 p.R4810K variant.

### Materials and Methods

We retrospectively reviewed 1,264 consecutive patients who underwent revascularization surgery for moyamoya vasculopathy between January 2001 and December 2023. After excluding 12 patients who did not meet angiographic diagnostic criteria, 1,252 patients were analyzed. Comorbidities diagnosed within six months of the initial diagnosis were recorded, with only the primary diagnosis considered in patients with multiple systemic disorders. Germline RNF213 p.R4810K genotyping was performed when available.

### Results

A total of 166 patients (13.3%) had at least one qualifying comorbidity. Genetic or chromosomal disorders were the largest category ( $n = 56$ , 33.7%), including neurofibromatosis type 1 (NF1,  $n = 36$ ), Down syndrome ( $n = 4$ ), polycystic kidney disease ( $n = 4$ ), and other rare syndromes ( $n = 12$ ). Autoimmune diseases were identified in 13 patients (7.8%), most commonly Kawasaki disease ( $n = 7$ ). Fifteen patients had isolated congenital heart disease, and nine had ocular anomalies, predominantly morning glory disc anomaly (MGDA,  $n = 6$ ). NF1 was associated with unilateral disease (39%,  $p < 0.001$ ) and posterior circulation involvement (36%,  $p = 0.037$ ). Among 84 genotyped patients, 47 (56.0%) carried the RNF213 p.R4810K variant.

### Conclusion

This large single-center cohort defines the clinical and genetic spectrum of pediatric moyamoya syndrome. We confirmed established disease associations, identified potential novel syndromic links, demonstrated distinct vascular phenotypes associated with specific comorbidities, and showed that the RNF213 p.R4810K variant is common among genetically tested patients. These findings refine the clinical spectrum of moyamoya syndrome and provide insight into the heterogeneous pathogenesis of moyamoya vasculopathy.

## Identification of Genetic Characteristics of Multiple Intracranial Aneurysms in the Korean Population

Jeong-Mee PARK<sup>1</sup>, Won-sang CHO<sup>2</sup>, Sung Ho LEE<sup>2</sup>, Jeong Eun KIM<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Seoul Metropolitan Government-Seoul National University Boramae Medical Center, Seoul, ROK, <sup>2</sup>Department of Neurosurgery, Seoul National University Hospital, Seoul National University College of Medicine, Seoul, ROK

**Background:** Intracranial aneurysm (IA) is a localized dilation of the cerebral arterial wall that can lead to subarachnoid hemorrhage. Although conventional clinical risk factors are well established, definitive evidence regarding significant genetic factors driving general IA susceptibility remains limited. Given that patients with multiple IAs (MIAs) likely harbor a stronger genetic predisposition than those with single lesions, contrasting these two phenotypes provides a strategic opportunity to uncover critical genetic drivers. Therefore, this study aimed to elucidate systemic germline variations underlying IA pathogenesis. **Methods:** Whole exome sequencing was performed on 200 Korean IA patients (100 single, 100 multiple) matched for age and sex. Comparative analyses were conducted using Fisher exact test ( $p < 0.05$ , fold change  $> 1$ ). Significant genes were examined by functional enrichment analysis with g:Profiler (g:SCS adjusted  $p < 0.05$ ). Sex stratified analyses assessed gender specific genomic features. **Results:** Comparative analysis revealed distinct germline variant distribution patterns. Variants in *SYNE2* and *TTN* were significantly enriched in the single aneurysm group, whereas the multiple aneurysm group demonstrated a significantly higher frequency of variants in *RNF213* and *THSD1*. Sex stratified analyses identified dimorphic genomic features; multiple lesion females uniquely exhibited variant enrichment in *LRP2* and *INTS1*, whereas multiple lesion males were characterized by variants in *DMBT1* and *ALG2*. **Conclusions:** IA multiplicity is driven by a genetically sensitized endotype, where distinct pathways modulate vascular vulnerability. While variants preserved in single lesions implicate localized mechanotransduction stability (*SYNE2*, *TTN*), susceptibility to multiple lesions involves systemic endothelial remodeling (*RNF213*, *THSD1*), alongside sex linked metabolic dysregulation specifically lipid transport in females (*LRP2*, *INTS1*) and metabolic stress in males (*DMBT1*, *ALG2*). Incorporating these multi axial genomic signatures establishes a strategic framework for future genotype informed risk prediction.

S2-3

## Identification of serine/threonine kinase 3 as a novel susceptibility locus for aneurysm rupture in the Korean population

Jin Pyeong JEON<sup>1,2</sup>, Eun Pyo HONG<sup>3</sup>, Ben GAASTRA<sup>4,5</sup>, Ian GALEA<sup>4</sup>

<sup>1</sup>Department of Neurosurgery, Hallym University College of Medicine, Chuncheon, ROK, <sup>2</sup>Department of Population and Quantitative Health Sciences, University of Massachusetts Chan Medical School, Worcester, MA 01655, USA, <sup>3</sup>Institute of New Frontier Research, Hallym University College of Medicine, Chuncheon, ROK, <sup>4</sup>Faculty of Medicine, University of Southampton, Southampton, SO17 1BJ, UK., <sup>5</sup>Department of Neurosurgery, Wessex Neurological Centre, University Hospital Southampton, Southampton, SO16 6YD, UK

Although genome-wide association studies (GWAS) have identified several susceptibility loci for intracranial aneurysm (IA) formation, the genetics of IA rupture remain inconclusive. There is substantial genetic heterogeneity across populations, and genetic studies of IA rupture in Asian cohorts are limited. We conducted a GWAS in Korean and non-Korean populations to identify genomic loci associated with IA rupture in adults, aiming to identify novel population-specific pathogenic mechanisms. A GWAS comparing individuals with ruptured and unruptured IA was performed within a Korean cohort. A second GWAS was performed incorporating European individuals identified from the UK Biobank (UKB). In silico functional annotation and pathway analyses were conducted for the identified variants and candidate genes reaching genome-wide or suggestive significance. In the Korean population (n = 600), one directly typed variant (rs2442015) in the serine/threonine-protein kinase 3 (STK3) gene at 8q22.2 showed a genome-wide significant association with IA rupture (odds ratio = 2.18, 95% confidence interval: 1.65-2.88; P = 4.51 x 10<sup>-8</sup>). Eight imputed variants in complete linkage disequilibrium at the same locus achieved the same threshold of significance. The nine STK3 variants were not significantly associated with IA rupture in the European UKB population (P > 0.1, n = 1,986). Functional analyses suggested that inhibition of STK3/4 may attenuate Hippo signaling, thereby promoting endothelial inflammation and aneurysmal instability. This study identified STK3 as a novel biologically plausible Korean-specific susceptibility locus for IA rupture and highlights the Hippo pathway as a potential molecular mechanism.

## Gene and Protein Expression Profiling of Programmed Cell Death and Autophagy Markers in Cerebral Arteriovenous Malformations

Kenji SHIMADA, Izumi YAMAGUCHI, Takeshi MIYAMOTO, Masaaki KORAI,  
Alfredo SHIMABUKU, Keiko T KITAZATO, Yasushi TAKAGI

The Department of Neurosurgery, University of Tokushima, Tokushima, Japan

**Background:** Cerebral arteriovenous malformations (cAVMs) are a major cause of intracranial hemorrhage in young adults. Recent genetic discoveries, such as somatic KRAS mutations, highlight endothelial dysregulation as a primary driver, yet downstream mechanisms leading to vessel instability remain poorly understood. We investigated the alterations of programmed cell death pathways and autophagy-related markers in human cAVM tissues.

**Methods:** Surgically resected human cAVM nidi (ruptured and unruptured) and normal brain controls were analyzed. Gene and protein expression of apoptosis/necroptosis markers (caspase-8, RIPK3, MLKL), inflammatory cytokines (IL-6, IL-8), and autophagy-related markers (including Beclin-1, p62, ATG5, and LC3-II) were evaluated using qPCR, Western blotting, proteome arrays, and immunohistochemistry. Expression patterns were correlated with hemorrhagic presentation and clinical severity.

**Results:** Gene and protein expression analyses revealed significantly elevated levels of caspase-8, RIPK3, MLKL, IL-6, and IL-8 in cAVM tissues compared to normal controls. High MLKL expression strongly correlated with hemorrhagic rupture and severe presentation, whereas caspase-8 was predominantly increased in unruptured, low-grade cases. Conversely, expression levels of autophagy-related markers, including p62 and LC3-II, were significantly decreased in cAVM tissues relative to controls.

**Conclusion:** Human cAVM tissues exhibit upregulation of apoptosis/necroptosis markers alongside downregulation of autophagy-related factors, with MLKL strongly associated with rupture. These reciprocal molecular alterations suggest a potential crosstalk between programmed cell death and autophagy impairment in cAVM pathogenesis, providing valuable insights for hemorrhagic risk assessment.

S2-5

## **A Novel MicroRNA-Mediated Ferroptosis Pathway in Early Brain Injury after Subarachnoid Hemorrhage**

Taichi IKEDO<sup>1</sup>, Ryotaro OTSUKA<sup>1</sup>, Takahiro HORIE<sup>2</sup>, Koh ONO<sup>2</sup>, Yoshiki ARAKAWA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kyoto University, Japan, <sup>2</sup>Department of Cardiovascular Medicine, Kyoto University

Early brain injury (EBI) is a major determinant of neurological outcome after subarachnoid hemorrhage (SAH), yet its molecular and genetic regulatory mechanisms remain poorly understood. Ferroptosis, an iron-dependent form of regulated cell death characterized by lipid peroxidation and iron accumulation, has emerged as a key contributor to EBI. We investigated a lipid metabolism-regulating microRNA to identify a novel molecular pathway underlying EBI after SAH.

Human cerebrospinal fluid (CSF) obtained during aneurysm surgery showed significantly higher miR-33a levels in patients with SAH than in those with unruptured intracranial aneurysms ( $p=0.036$ ), whereas miR-33b levels did not differ ( $p=0.57$ ). Based on these human molecular findings, we performed genetic loss-of-function analysis using miR-33a knockout (KO) mice subjected to experimental SAH.

miR-33a KO mice showed significantly improved survival compared with wild-type (WT) mice (91% vs. 33%,  $p<0.01$ ), together with reduced neuronal degeneration, brain edema, neurological deficits, and lipid peroxidation. Furthermore, Fe<sup>2+</sup> accumulation was reduced ( $12.3\pm0.4$  vs.  $18.5\pm3.6$  nmol/g), whereas ApoE levels were increased ( $53.0\pm1.9$  vs.  $34.6\pm0.6$  ng/g), suggesting that miR-33a regulates ferroptosis through coordinated control of lipid peroxidation and ApoE-associated iron homeostasis. Importantly, intrathecal administration of an miR-33a antisense oligonucleotide reproduced the protective phenotype, improving survival (85% vs. 46%,  $p=0.034$ ), brain edema, and neurological outcomes.

These findings identify miR-33a as a novel microRNA regulator of ferroptosis and EBI after SAH. The concordance between human molecular profiling and genetic loss-of-function experiments provides a translational framework linking genetic analysis to therapeutic development. Targeting miR-33a may enable biomarker-based risk stratification and nucleic acid therapeutics, providing a potential strategy for precision medicine in SAH.

## From Detection to Decision: AI Across the Neurointerventional Workflow

Wi-Sun RYU

Artificial Intelligence Research Center, JLK Inc., Seoul, ROK

Artificial intelligence has entered the neurointerventional workflow unevenly. At the detection end it is mature. Automated detection of large vessel occlusion, intracranial hemorrhage, and unruptured aneurysm now reaches accuracy sufficient for deployment, and multicenter workflow studies consistently report shortened door-in-door-out and door-to-puncture intervals. Yet performance is anatomically uneven, falling from proximal to distal occlusions, and positive predictive value does not transfer between settings whose pre-test probability differs several-fold. Almost all clinical impact evidence rests on before-after designs, so the benefit is measured in minutes, not outcomes.

At the decision end the problem changes character. Ischemic core is not a measurement but a prediction of tissue fate conditional on reperfusion. Every core volume is therefore conditional on the signal measured, the reference standard it was fitted against, and the interval between them. The familiar rCBF  $<30\%$  threshold was fitted to acute diffusion-weighted imaging; in a recanalized cohort the best matching threshold moved to  $<22\%$  against immediate post-procedural DWI and back to  $<30\%$  against follow-up DWI. Two software packages can agree on core volume with a concordance correlation of 0.96 while disagreeing on trial eligibility with kappa near 0.5, because disagreement migrates to the decision boundary.

This lecture argues that AI's contribution at the decision stage is resolution rather than verdict: grading tissue state by net water uptake, apparent diffusion coefficient tiers, and perfusion severity instead of a binary label, and making inter-modality discordance explicit so that it becomes a clinical question, not an error. Severity-resolved analyses show that identical labels, diffusion reversal or large core, split into opposite prognoses once graded. Detection can be automated; decision should be resolved, not replaced.

S3-2

## **AI-driven prehospital triage for intracerebral hemorrhage: Intergrating imaging-based detection and LLM guided initial management**

Jin Pyeong JEON<sup>1,2</sup>, Jaewoong KANG<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Hallym University College of Medicine, Chuncheon, ROK, <sup>2</sup>Department of Population and Quantitative Health Sciences, University of Massachusetts Chan Medical School, Worcester, MA 01655, USA,

<sup>3</sup>Department of Biomedical Informatics, Hallym University Sacred Heart Hospital, Chuncheon, ROK

Despite nationwide efforts to improve the quality of care for intracerebral hemorrhage (ICH) in Korea, regional disparities persist because of shortages of neurological specialists and inadequate medical infrastructure in rural areas. Since 2022, we have implemented two digital technologies such as an AI-based teleconsultation system and a SNS-based patient transfer coordination platform to support the early management of patients with various neurological conditions at rural hospitals and facilitate timely collaboration with regional hub hospitals. These two functions have subsequently been integrated into a single application-based platform that supports AI-assisted image assessment, specialist consultation, and patient transfer coordination. To expand the platform beyond diagnostic support and provide practical treatment guidance, we are also developing a LLM-based management algorithm for patients with ICH. In this presentation, I will describe the development of this integrated digital platform, its implementation in rural clinical settings, and our experience with its real-world application.

## **POLARIS: International Validation of a Machine Learning Model for Intracranial Aneurysm Rupture Prediction and Clinical Decision Support**

Soichiro FUJIMURA<sup>1,2</sup>, Takeshi YANAGISAWA<sup>2</sup>, Genki KUDO<sup>2</sup>,  
Hiroyuki TAKAO<sup>2</sup>, Toshihiro ISHIBASHI<sup>2</sup>, Shigeo YAMASHIRO<sup>3</sup>, Mervyn D. I. VERGOUWEN<sup>4</sup>,  
Gabriel J. E. RINKEL<sup>4</sup>, Aman B. PATEL<sup>5</sup>, Yuichi MURAYAMA<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, Tokyo University of Science, Japan, <sup>2</sup>Department of Neurosurgery, The Jikei University School of Medicine, Japan, <sup>3</sup>Division of Neurosurgery, Department of Cerebrovascular Medicine and Surgery, Saiseikai Kumamoto Hospital, <sup>4</sup>Department of Neurology and Neurosurgery, UMC Utrecht Brain Center, University Medical Center Utrecht, Utrecht University, <sup>5</sup>Department of Neurosurgery, Massachusetts General Hospital

### Background:

Preventive treatment decisions for unruptured intracranial aneurysms require balancing future rupture risk against treatment-related risk. However, existing risk scores alone may not adequately estimate individualized rupture risk across heterogeneous cases, particularly for small aneurysms. We developed POLARIS, a machine learning model integrating clinical and morphological features to predict rupture within 2 years, and evaluated its generalizability using international multicenter data.

### Methods:

Data collected between 2003 and 2022 were obtained from four institutions across Asia, North America, and Europe. Each aneurysm was characterized using 29 clinical and 18 morphological features. A LightGBM-based model was developed using the largest institutional dataset to estimate rupture risk within 2 years from baseline. The remaining three institutional datasets were used for external validation. Performance was assessed using sensitivity, specificity, and area under the receiver operating characteristic curve (AUROC).

### Results:

The development cohort included 2,750 patients with 3,312 unruptured intracranial aneurysms, of which 71 (2.1%) ruptured during a median follow-up of 8.5 years. The external validation cohort included 1,153 patients with 1,501 aneurysms, of which 48 (3.2%) ruptured over a median follow-up of 5.4 years. POLARIS achieved a sensitivity of 0.78, specificity of 0.82, and AUROC of 0.88 in the development cohort. In the external validation cohort, sensitivity was 0.90, specificity was 0.70, and AUROC was 0.88, demonstrating consistent discriminative performance across geographically and institutionally distinct populations. Predictive performance was also maintained for aneurysms smaller than 10 mm.

### Conclusion:

POLARIS demonstrated robust generalizability across international multicenter datasets and may support individualized treatment decisions for unruptured intracranial aneurysms. Further studies should compare the predictive performance of clinicians and AI and evaluate the impact of AI assistance on clinical decision-making.

S3-4

## Real-Time AI Assistance in Neurointervention

Kenichi KONO

iMed Technologies, Tokyo, Japan

Artificial intelligence (AI) in neurointerventional surgery has mainly been applied to pre-procedural diagnosis and postprocedural image analysis. In contrast, real-time analysis of fluoroscopic images has the potential to support operators at the moment when procedural risk arises. We have developed and clinically implemented a real-time AI platform, Neuro-Vascular Assist, that recognizes device and embolic-material behavior during neuroendovascular procedures and provides visual and auditory feedback. Its current functions include detection of guidewire movement outside the fluoroscopic field, visualization of liquid embolic material, and monitoring of coils and catheters.

Clinical studies in diagnostic cerebral angiography and therapeutic procedures have demonstrated the feasibility of real-time AI assistance and its ability to identify potentially hazardous procedural events. In middle meningeal artery embolization and other embolization procedures, AI-generated visualization can help operators recognize the distribution and movement of embolic material during injection. The frequency and pattern of AI notifications may also provide objective information related to technical proficiency, suggesting potential applications in training and quality improvement.

However, real-time AI remains an assistive technology. False-positive notifications, limited sensitivity for some events, variation among imaging systems and procedures, workflow integration, and automation bias must be carefully addressed. Prospective multicenter validation and assessment of AI interaction are therefore essential.

Future systems will integrate device tracking with vascular anatomy, procedural phase, and patient-specific risk to provide context-aware decision support. Further integration with robotic platforms may enable semi-autonomous navigation and safety control. This presentation will review our current clinical experience, and the pathway from event detection toward intelligent procedural assistance in neurointerventional surgery.

## **Toward Intelligent Neurointervention: AI for Stroke Triage, Aneurysm Risk Prediction, and Real-Time Hemodynamic Modeling**

Kunhee HAN<sup>1,5</sup>, Hyeong-Joong YI<sup>1</sup>, Sang Hyung LEE<sup>2,5</sup>, Jaiyoung RYU<sup>3,5</sup>,  
Simon SONG<sup>4,5</sup>, Kyu-Sun CHOI<sup>1,5</sup>

<sup>1</sup>Department of Neurosurgery, Hanyang University Medical Center, Hanyang University College of Medicine, Seoul, ROK, <sup>2</sup>Department of Neurosurgery, National Medical Center, ROK, <sup>3</sup>Department of Mechanical Engineering, Korea University, Seoul, ROK, <sup>4</sup>Department of Mechanical Convergence Engineering, Hanyang University, Seoul, ROK, <sup>5</sup>Center for Precision Medicine Platform Based-on Smart Hemo-Dynamic Index, Seoul, ROK

Artificial intelligence (AI) is rapidly transforming neurointerventional practice by enabling faster image interpretation, more objective risk assessment, and increasingly sophisticated patient-specific modeling. In acute ischemic stroke, AI-based systems can automatically detect large-vessel occlusion, quantify early ischemic changes, analyze perfusion imaging, and facilitate rapid communication within stroke networks. These applications illustrate the potential of AI to reduce delays in time-sensitive neurovascular care.

Beyond acute stroke, AI is increasingly being investigated for intracranial aneurysm assessment. Machine-learning and deep-learning models can integrate clinical variables, aneurysm morphology, radiomic features, and surrounding vascular anatomy to improve risk stratification beyond conventional scoring systems. However, most current models remain limited by retrospective datasets, variable external validation, and the distinction between classifying rupture status and truly predicting future aneurysm growth or rupture.

Hemodynamic modeling represents another important frontier. Computational fluid dynamics can provide detailed information on wall shear stress, flow patterns, and pressure, but its clinical application is constrained by computational cost, modeling assumptions, and limited patient-specific physiological data. Emerging approaches combining AI, physics-informed neural networks, graph-based models, and 4D flow imaging may enable rapid reconstruction of patient-specific cerebral hemodynamics and bring real-time simulation closer to the angiography suite.

The future of intelligent neurointervention will likely extend from automated detection to prediction, simulation, and procedural decision support. Integration of multimodal imaging, vascular geometry, hemodynamics, and clinical data may ultimately provide real-time, patient-specific augmentation of neurointerventional decision-making.

S4-1

## **EC-IC Bypass for Atherosclerotic Occlusive Disease: Defining Its Role in the Era of Precision Revascularization**

Tsuyoshi IZUMO, Yusuke EGASHIRA, Yukiko ENOMOTO, Hirofumi MATSUBARA,  
Hiroaki TAKEI, Kenji SHODA, Shoji YASUDA

Department of Neurosurgery, Gifu University Graduate School of Medicine, Gifu, Japan

Extracranial-intracranial (EC-IC) bypass offers an intuitive solution for symptomatic atherosclerotic internal carotid or middle cerebral artery occlusion: restoring flow to a hemodynamically threatened brain. Nevertheless, the international EC-IC Bypass Trial, the Carotid Occlusion Surgery Study (COSS), and, more recently, the Carotid and Middle Cerebral Artery Occlusion Surgery Study (CMOSS) failed to demonstrate an overall benefit of bypass over medical therapy. The central question is therefore no longer whether bypass can improve cerebral hemodynamics, but whether a sufficiently high-risk, surgically remediable phenotype can be identified before disabling stroke occurs.

Current evidence does not support routine bypass for all patients with symptomatic atherosclerotic occlusion. A selective role may remain, however, for carefully evaluated patients with recurrent ischemic events despite intensive medical therapy and objectively demonstrated severe hemodynamic compromise. This presentation reviews lessons from landmark trials and Japanese experience, emphasizing the influence of improved medical therapy, heterogeneity of ischemic mechanisms, limitations of single-time-point perfusion assessment, and perioperative complications on treatment effect.

A practical selection framework should integrate clinical recurrence and symptom pattern; infarct distribution and tissue viability; quantitative cerebral blood flow and cerebrovascular reserve; collateral pathways; donor-recipient anatomy; and institutional microsurgical outcomes. Treatment should be individualized through multidisciplinary assessment, with strict perioperative control of blood pressure, antithrombotic therapy, bypass flow, and hyperperfusion risk.

The future of EC-IC bypass depends on moving from a diagnosis-based indication to precision revascularization. Standardized multimodal hemodynamic imaging, longitudinal assessment, flow-demand matching, validated risk models, and prospective multicenter studies with contemporary medical controls are essential. EC-IC bypass should neither be broadly abandoned nor routinely applied; its value will be determined by selecting the right patient, at the right time, with the lowest possible procedural risk.

## Refining the Target: Who Benefits, and How We Would Know

Tae Keun JEE

Samsung Medical Center, Sungkyunkwan University School of Medicine, ROK

Four decades of randomized trials (the EC/IC Bypass Study, JET, COSS, and CMOSS) teach a consistent lesson: extracranial-intracranial (EC-IC) bypass for atherosclerotic occlusive disease failed not because revascularization is ineffective, but because the surgical target was not defined with sufficient precision. Unselected enrollment produced harm; strict hemodynamic selection produced benefit; and in the modern era, perioperative risk and improved medical therapy have narrowed the margin beyond what imprecise selection can overcome. Yet a reduction in ipsilateral stroke beyond the perioperative period has recurred across trials, suggesting the biological rationale for bypass remains intact.

Building on these lessons, this presentation examines bypass for atherosclerotic occlusive disease from three perspectives: identifying the patients who stand to benefit (risk enrichment), predicting and reducing perioperative risk, and choosing the operative strategy.

First, risk enrichment. Candidates are identified at the intersection of two axes: recurrent or progressive ischemic symptoms despite best medical treatment (failure of secondary prevention) and hemodynamic confirmation of misery perfusion in the territory of the occluded vessel.

Second, perioperative risk. Perioperative events eroded the late benefit in previous trials. Patient factors such as age are less biological ceilings on benefit than proxies for perioperative risk, which can be lowered through strict hemodynamic management, anesthetic and neurocritical care protocols, and an experienced surgical team. Timing is likewise a matter of risk management: early surgery may increase perioperative risk, yet unstable disease carries the opposing risk of recurrence while waiting, so the decision rests on weighing these risks rather than on days elapsed.

Third, operative strategy. Its principal elements (the selection of donor and recipient arteries and the choice between single- and multiple-pedicle bypass) influence operative time, technical difficulty, perioperative risk, and the degree of perfusion improvement.

Finally, we present findings from our institutional experience that may offer some insight into these questions.

S4-3

## **The Role of Bypass Surgery in Chronic and Acute Atherosclerotic Cerebral Ischemia**

**Akitsugu KAWASHIMA**

Department of Neurosurgery, St. Luke's International Hospital, Tokyo, Japan

**Background:** The role of extracranial-intracranial bypass surgery for atherosclerotic cerebral ischemia remains controversial because randomized trials have not demonstrated a clear overall benefit. However, selected patients with severe hemodynamic compromise may still benefit when perioperative risk is minimized.

**Methods:** We reviewed the current evidence and our institutional experience with bypass surgery for three clinical conditions: chronic anterior-circulation ischemia, acute ischemic stroke, and chronic vertebrobasilar insufficiency. In acute ischemic stroke, 17 consecutive patients with atherosclerotic internal carotid or middle cerebral artery stenosis or occlusion underwent superficial temporal artery-middle cerebral artery double bypass. Indications included clinical-diffusion-weighted imaging mismatch and fluctuating or progressive neurological deficits despite maximal medical therapy. For chronic posterior-circulation ischemia, 54 consecutive patients underwent 55 bypass procedures for recurrent vertebrobasilar insufficiency associated with vertebral or basilar artery stenosis or occlusion.

**Results:** In the acute ischemic stroke cohort, the mean interval from onset to surgery was 2.9 days. One patient developed chronic subdural hematoma, and one showed radiological hyperperfusion. Favorable functional outcome, defined as a modified Rankin Scale score of 0-2, increased from 5.9% preoperatively to 76.5% at 6 months. In the posterior-circulation cohort, early bypass patency was 100%. During a mean follow-up of 36 months, symptoms disappeared in 85.1% and improved in 6.6%. The postoperative stroke rate was 0.7% per person-year.

**Conclusions:** Bypass surgery may provide durable hemodynamic improvement in carefully selected patients with atherosclerotic cerebral ischemia. Its benefit depends on accurate patient selection, appropriate timing, and minimization of perioperative complications. Further prospective studies are required to refine selection criteria, particularly for acute ischemic stroke and posterior circulation ischemia.

## The last line of defense: EC-IC bypass for ICAD

Sungpil JOO, You Sub KIM, Tae Sun KIM

Chonnam National University Hospital, ROK

Extracranial-intracranial (EC-IC) bypass remains an important revascularization technique for management of complex cerebrovascular disease and intracranial arterial stenosis. Despite evolving endovascular techniques, the role of bypass for the purpose of flow replacement prior to planned vessel sacrifice remains relevant for treatment of complex and ICAD. The role of bypass for purposes of flow augmentation in the setting of cerebral ischemia is limited based on current data, but remains an important option for selected cases of athero-occlusive disease, in addition to a primary treatment for symptomatic moyamoya disease. An objective flow-based approach to EC-IC bypass can enhance decision-making in preoperative patient selection, intraoperative graft assessment, and postoperative follow-up.

S4-5

## **Surgical outcomes and indirect revascularization of low-flow bypass surgery in intracranial atherosclerotic steno-occlusive diseases**

Yuwhan CHUNG<sup>1</sup>, Won-sang CHO<sup>2</sup>, Jeong Eun KIM<sup>2</sup>, Kangmin KIM<sup>2</sup>, Hyun-seung KANG<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, CHA Bundang Medical Center, CHA University School of Medicine, ROK, <sup>2</sup>Department of Neurosurgery, Seoul National University Hospital, Seoul National University College of Medicine, Seoul, ROK

**Objective** The role of bypass surgery in intracranial atherosclerotic steno-occlusive disease (ICAD) remains controversial. We aimed to evaluate clinical, hemodynamic, and angiographic outcomes of low-flow bypass surgery for ICAD and to identify predictors of indirect revascularization and favorable clinical outcomes, comparing combined bypass with direct bypass alone.

**Methods** Among 799 patients who underwent low-flow bypass surgery at a single institution between 2003 and 2022, 245 patients met diagnostic criteria for ICAD. After exclusions, 215 patients were analyzed for overall clinical, hemodynamic, and angiographic outcomes, including cumulative stroke risk. Of these, 191 patients with available follow-up angiography were further analyzed to compare treatment outcomes between the two surgical techniques and to identify, via multivariable logistic regression, independent predictors of indirect revascularization and of favorable clinical outcome.

**Results** Clinical status improved significantly from admission to last follow-up. All strokes occurred in 12.1% of patients, with 2-year and 5-year cumulative stroke risks of 12.1% each; most events (84.6%) occurred within 30 postoperative days. Direct bypass patency was 96.3% at last angiographic follow-up, and hemodynamic status improved in all patients with available perfusion data. Further analysis revealed that the rate of indirect revascularization was significantly higher in the combined bypass group than in the direct bypass alone group (39.5% versus 17.2%,  $P = .022$ ). An additional analysis revealed that indirect revascularization (OR 5.508, 95% CI 1.003-30.245,  $P = .050$ ) was an independent predictor of favorable clinical outcomes.

**Conclusion** Low-flow bypass surgery showed acceptable treatment outcomes in the prevention of recurrent stroke. Indirect revascularization was more pronounced after combined bypass than direct bypass alone and was a significant predictor of favorable clinical outcomes. Further comparative studies are warranted to clarify the role of bypass surgery in ICAD.

## Contemporary Decision-Making for Carotid Revascularization in the CREST-2 Era

Masakazu OKAWA, Masakazu OKAWA

The department of Neurosurgery, National Cerebral and Cardiovascular Center, Osaka, Japan

### Background:

The optimal management of carotid artery stenosis has entered a new era following the publication of the CREST-2 trials, which reassessed the role of carotid revascularization in the context of contemporary intensive medical therapy. While carotid endarterectomy (CEA) and carotid artery stenting (CAS) remain established treatment options, advances in medical management have substantially reduced the risk of stroke, particularly among patients with asymptomatic disease. Recent CREST-2 data demonstrated a significant reduction in ipsilateral stroke with CAS plus intensive medical therapy compared with medical therapy alone, whereas the parallel CEA trial did not show a statistically significant benefit over medical therapy alone. These findings highlight the need for individualized treatment strategies rather than a procedure-centered approach.

### Methods

Our treatment algorithm prioritizes plaque characteristics and overall procedural risk. CEA remains the first-line revascularization strategy for lesions with a large plaque burden, extensive lipid-rich necrotic core, or morphologic features suggestive of embolic vulnerability. However, technological developments in CAS, including improved embolic protection devices, have enhanced procedural safety and expanded its applicability. Consequently, procedure selection is increasingly determined by factors beyond the carotid lesion itself, such as high cervical lesion location, hostile neck anatomy, prior irradiation, or unfavorable aortic arch pathology including shaggy aorta.

### Discussion and Future Perspectives:

The most important clinical question is no longer whether CEA or CAS is superior, but whether intervention is necessary at all. Given the continuing improvement of intensive medical therapy, indications for revascularization, particularly in asymptomatic patients, should be considered cautiously. Future research will likely focus on identifying biologically unstable plaques at high risk of stroke and developing strategies to prevent plaque destabilization. Precision-based risk stratification integrating imaging, biomarkers, and plaque biology may ultimately define the next generation of carotid artery disease management.

S5-2

## **CAS or CEA? How I Choose and Perform Carotid Revascularization as a Hybrid Vascular Neurosurgeon**

Jun Kyeong KO

Department of Neurosurgery, School of Medicine, Pusan National University, ROK

My treatment strategy for carotid artery stenosis has evolved through continuous clinical experience and reflection. In the early phase of my practice, I primarily adopted a carotid artery stenting (CAS)-first approach. During this period, I encountered several challenging cases, including thromboembolic complications and suboptimal angioplasty outcomes. These experiences led me to recognize the limitations of endovascular treatment and the important role of carotid endarterectomy (CEA).

Consequently, I devoted a significant period to learning and refining CEA techniques. I gained experience with various approaches, including patch angioplasty and awake CEA. However, during this phase, I also faced serious postoperative complications, such as carotid artery occlusion and postoperative neck hematoma. These events highlighted the technical complexity of CEA and the importance of careful patient selection and meticulous surgical execution.

Through these cumulative experiences, my treatment philosophy gradually matured. Currently, I maintain a CAS-first policy for most patients, reserving CEA for cases considered unfavorable for CAS based on anatomical features, plaque characteristics, or procedural risks. To assess the current role of CEA in my practice, I recently reviewed my surgical cases. Most were associated with heavily calcified plaques, which are challenging for endovascular intervention. This finding reflects a more selective and individualized treatment strategy.

In conclusion, my clinical journey has been shaped by both success and failure in CAS and CEA. These experiences have led to a balanced, patient-centered approach emphasizing appropriate case selection, technical refinement, and personalized decision-making.

## Is Carotid Shunting Truly Optional? Redefining Safety Standards in Carotid Endarterectomy

Taek Kyun NAM

Department of Neurosurgery, Chung-Ang University Hospital, Seoul, ROK

In the current endovascular era, carotid artery stenting (CAS) has become increasingly prevalent for the treatment of carotid artery stenosis, a trend particularly pronounced in South Korea and Japan. However, carotid endarterectomy (CEA) remains irreplaceable and indispensable in several clinical scenarios. This study aims to define the specific conditions under which CEA should be prioritized as first-line treatment and to share our surgical experience for performing CEA safely with carotid shunting.

We reviewed our institutional experience with CEA and identified clinical and anatomical scenarios in which CEA was favored over CAS. We also describe our technique of shunt insertion using a micropuncture kit to facilitate safe, atraumatic cannulation of the fragile internal carotid artery (ICA).

CEA was prioritized over CAS in the following scenarios: difficult vascular access, severe arterial tortuosity, near-occlusion, heavy calcification, contraindication to antiplatelet therapy, and vulnerable/unstable plaque morphology. Routine use of a carotid shunt was employed to prevent cerebral ischemia during cross-clamping. Utilizing a micropuncture kit for shunt insertion into the ICA reduced the risk of intimal injury and facilitated safe, atraumatic cannulation, contributing to consistent and reliable outcomes.

Even in the current endovascular-dominant era, CEA maintains its role as the gold-standard treatment through careful, anatomy- and risk-based patient selection. Routine carotid shunting, combined with micro-access techniques for safer shunt insertion, allows cerebrovascular surgeons to perform CEA safely and achieve optimal outcomes. The authors believe that routine use of carotid shunting is essential for surgical safety in CEA.

S5-4

## **Recirculation from common carotid artery to external carotid artery during carotid endarterectomy**

Tae-Sun KIM, You-sub KIM, Young-jun LEE, Sung-pil JOO

Department of Neurosurgery, Chonnam National University Hospital & Medical School, Gwang-Ju, ROK

**Background:** This study aimed to investigate the effect of recirculation from common carotid artery (CCA) to external carotid artery (ECA) flow on intraoperative cerebral perfusion during carotid endarterectomy (CEA).

**Methods:** We retrospectively reviewed 116 consecutive patients who underwent CEA between January 2023 and December 2025. Following exclusion of patients with incomplete intraoperative somatosensory evoked potential (SSEP) monitoring data, intraluminal shunting, or missing clinical data, 82 patients were included in the final analysis. Patients were divided into two groups based on intraoperative SSEP changes. Systemic arterial pressure was augmented by approximately 20% above baseline before carotid artery clamping in all patients. Recirculation of ECA flow was performed when SSEP changes persisted despite blood pressure augmentation.

**Results:** Intraoperative SSEP changes occurred in 22 patients (26.8%). Among them, recirculation from CCA to ECA flow was performed in 17 patients, and SSEP recovery was observed in all patients within  $4.0 \pm 1.1$  minutes. Notably, MAP did not increase following recirculation of ECA flow and instead showed a slight decrease ( $86.3 \pm 10.2$  vs.  $83.2 \pm 8.8$  mmHg,  $p=0.046$ ). In addition, recirculation of ECA flow was associated with an additional clamping time of  $8.1 \pm 4.1$  minutes.

**Conclusions:** Recirculation from CCA to ECA flow during CEA was associated with rapid recovery of intraoperative SSEP changes and provided an additional operative time window independent of systemic blood pressure changes. These findings suggest that ECA-mediated collateral circulation may contribute to the maintenance of cerebral perfusion during carotid artery clamping and support the potential role of ECA flow recirculation in the management of intraoperative cerebral ischemia during CEA.

## Investigations of Appropriate Surgical Strategy for Carotid Stenosis

Daina KASHIWAZAKI, Naoki AKIOKA, Emiko HORI, Satoshi KURODA

Department of Neurosurgery, University of Toyama, Toyama, Japan

### Introduction

To reduce morbidity, we conducted a rule carotid 8 in 2012. Over 12 years, our strategy had been improved in response to various issues. In this paper, we present current our strategy for carotid stenosis and its results.

### Materials and Methods

From April 2012 to December 2025, we performed 199 CEA and 204 CAS.

Our strategy recommends CEA and CAS for symptomatic and asymptomatic lesions, respectively. However, crossover of therapeutic options can be performed in patients at high surgical risk. Cerebral blood flow measurement by SPECT is mandatory before and after CEA, CAS. Over 12 years, there were 3 improvements in strategy, therefore, checking system coronary artery disease by CTA before surgery, and CEA for symptomatic mid carotid stenosis. Patients with carotid stenosis underwent CEA because of recurrent TIA or ischemic stroke despite prior antiplatelet therapy or were considered at high risk of further ischemic stroke

### Results

Of 403 patients, crossover was made in 18 patients. During 2 years follow up period, ipsilateral ischemic stroke was occurred in 2 patients with lacunar infarction. Staged angioplasty was performed for 10 patients. Preoperative screening identified severe, untreated coronary artery disease in 19 patients. who required PCI or CABG prior to CEA, CAS because they were considered at high risk for MI during CEA, CAS. Only one patient. developed acute coronary syndrome in postoperative period. CEA was performed for 31 patients with symptomatic mild carotid stenosis. Postoperative course was uneventful.

### Conclusion

Our result showed a management protocol for carotid artery stenosis needs to be established. Furthermore, continue to make appropriate improvement are mandatory to allow better results of CEA, CAS for carotid artery stenosis.

S5-6

## **Durable Long-Term Outcomes of Carotid Endarterectomy with Patch Graft Closure in the Era of Selective Revascularization**

Masaaki KORAI<sup>1</sup>, Toshiyuki OKAZAKI<sup>2</sup>, Masaaki UNO<sup>3</sup>,  
Yasuhisa KANEMATSU<sup>4</sup>, Junichiro SATOMI<sup>5</sup>, Izumi YAMAGUCHI<sup>1</sup>, Takeshi MIYAMOTO<sup>1</sup>,  
Kenji SHIMADA<sup>1</sup>, Yasushi TAKAGI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Tokushima University Graduate School of Biomedical Sciences, Tokushima, Tokushima, Japan, <sup>2</sup>Department of Neurosurgery, Shin-Yurigaoka General Hospital, Kawasaki, Kanagawa, Japan, <sup>3</sup>Faculty of Rehabilitation, Kawasaki University of Medical Welfare, Kurashiki, Okayama, Japan, <sup>4</sup>Department of Neurosurgery, Tokushima Prefectural Central Hospital, Tokushima, Tokushima, Japan, <sup>5</sup>Department of Neurosurgery, Kitajima Taoka Hospital, Itano, Tokushima, Japan

**Background:** In the contemporary era of intensive medical therapy, revascularization for carotid artery stenosis is no longer a default strategy, particularly for asymptomatic disease. However, intervention remains important in selected patients with symptomatic lesions or imaging features of plaque vulnerability.

**Objective:** To clarify the current value of carotid endarterectomy (CEA), we evaluated the long-term durability of CEA with patch graft closure and its role in selective, individualized revascularization.

**Methods:** We retrospectively analyzed 104 carotid lesions in 99 patients treated with CEA and patch graft closure between June 2000 and March 2013, with more than 3 years of follow-up. Mean postoperative follow-up was 130.0 months. Restenosis and symptomatic restenosis were assessed using Kaplan-Meier analysis.

**Results:** Cumulative restenosis rates were 4.6% at 120 months and 12.2% at 200 months. Symptomatic restenosis rates were 1.0% at 120 months and 1.9% at 200 months. Ipsilateral hemispheric cerebral infarction occurred in 8.6% (9/104), and all events were minor stroke. These findings demonstrate sustained long-term patency and a very low incidence of clinically significant restenosis after patch graft CEA.

**Conclusions:** Even in the era of selective revascularization and improving medical therapy, CEA with patch graft closure remains a highly durable treatment option. Its excellent long-term performance supports its continued central role in patients with acceptable surgical risk, particularly when plaque vulnerability favors endarterectomy over stenting. For hybrid vascular practice, durable CEA outcomes remain an essential benchmark for individualized treatment selection between CEA and carotid artery stenting.

## **Comparison of Bifrontal Craniotomy and Multiple Burr Hole Encephalogaleoperiosteal-synangiosis for Pediatric Moyamoya Disease: An Experience of 346 Patients**

Joo Whan KIM<sup>1</sup>, Ji Hoon PHI<sup>1</sup>, Ji Yeoun LEE<sup>2</sup>, Eun Jung KOH<sup>1</sup>, Kyung Hyun KIM<sup>1</sup>,  
Hee-soo KIM<sup>3</sup>, Seung-ki KIM<sup>1</sup>

<sup>1</sup>Division of Pediatric Neurosurgery, Seoul National University Children's Hospital, Seoul National University College of Medicine, ROK, <sup>2</sup>Neural Development and Anomaly Laboratory, Department of Anatomy and Cell Biology, Seoul National University College of Medicine, Seoul, ROK, <sup>3</sup>Division of Pediatric Anesthesiology and Pain Medicine, Seoul National University Children's Hospital, Seoul National University College of Medicine, ROK

### Background and objectives

Moyamoya disease (MMD) is a steno-occlusive disease treated with revascularization surgery. Craniotomy and multiple burr hole encephalogaleoperiosteal-synangiosis (EGPS) are used for revascularization of the anterior cerebral artery (ACA) territory. The aim of this study was to compare the clinical outcome between the two surgical methods in pediatric MMD patients.

### Methods

A retrospective review of MMD patients who underwent bifrontal indirect bypass surgery was performed. Clinical features, perioperative data, and angiographic, perfusion, and functional outcomes were compared between the two groups. Propensity score matching was performed to compare the perioperative characteristics and clinical outcomes.

### Results

A total of 346 patients were included in this study, 111 patients underwent bifrontal craniotomy EGPS, and 235 patients had bifrontal multiple burr hole EGPS. An insignificant higher rate of postoperative infarction (11.7% vs. 5.5%,  $p=0.072$ ) and more postoperative hemorrhage occurred in the craniotomy EGPS group (3.6% vs. 0%,  $p=0.004$ ). Of the 83 patients selected with propensity score matching for each group, the duration of operation was shorter ( $p<0.001$ ), and the amount of intraoperative bleeding was significantly less in the multiple burr hole EGPS group ( $p=0.008$ ). There was no difference in clinical outcomes between the two groups.

### Conclusion

Bifrontal multiple burr hole EGPS has benefits over craniotomy with shorter surgical time, less intraoperative bleeding, fewer postoperative complications, and comparable perfusion and functional outcomes. Multiple burr hole EGPS is a safe and effective method that might be considered for revascularization of the ACA territory in pediatric MMD patients.

S6-2

## The Role of Periventricular Anastomoses in Surgical Management of Moyamoya Disease

Eika HAMANO<sup>1</sup>, Takeshi FUNAKI<sup>2</sup>, Hiroharu KATAOKA<sup>1</sup>, Koki ONODERA<sup>1</sup>,  
Junichiro OCHIAI<sup>1</sup>, Kazuki KOMIYAMA<sup>1</sup>, Yu YAMAMOTO<sup>1</sup>, Takenori OGURA<sup>1</sup>, Hisae MORI<sup>1</sup>,  
Koji IIHARA<sup>1</sup>, Masakazu OKAWA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, National Cerebral and Cardiovascular Center, Osaka, Japan, <sup>2</sup>Department of Neurosurgery, Kyoto University Graduate School of Medicine, Kyoto, Japan

Revascularization surgery reduces the risk of recurrent hemorrhage in moyamoya disease. Recent studies have also improved our understanding of the vascular structures associated with hemorrhagic stroke. Nevertheless, despite successful revascularization, hemorrhage remains a major concern in patients with hemorrhagic moyamoya disease and may also occur during follow-up in those with initially non-hemorrhagic presentation. These observations underscore the importance of identifying abnormal collateral pathways associated with hemorrhage and optimizing surgical strategies for long-term hemorrhage prevention.

Periventricular anastomoses (PA) have emerged as clinically relevant hemorrhage-prone collateral pathways in moyamoya disease. In our longitudinal cohort of 111 patients with hemorrhagic moyamoya disease, we investigated whether postoperative persistence of Grade-2 PAs was associated with subsequent hemorrhage. During a median follow-up of 6.3 years, rebleeding occurred in 16 hemispheres of 15 patients. The presence of persistent Grade-2 PA was independently associated with rebleeding (adjusted hazard ratio, 4.11). Among the three subtypes, lenticulostriate anastomosis was the most common subtype associated with postoperative hemorrhagic event.

These findings provide a rationale for developing surgical strategies aimed at promoting regression of PA. However, surgical refinement alone is unlikely to eliminate hemorrhagic risk completely. More definitive prevention of hemorrhagic stroke will depend on further insights into the underlying disease mechanisms.

## Predictive Factors for Hemorrhagic and Ischemic Stroke After Combined Bypass for Adult Patients

Si Un LEE, Jehun JANG, Sang Hyo LEE, Jae Seung BANG

Department of Neurosurgery, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam-si, ROK

Combined bypass (CB) is widely performed for adult moyamoya disease (MMD); however, perioperative hemorrhagic and ischemic strokes remain important complications. We investigated whether quantitative preoperative hemodynamic parameters could identify patients at increased surgical risk and help optimize revascularization strategies.

First, we evaluated hemorrhagic cerebral hyperperfusion syndrome (hCHS) in 277 hemispheres with nonhemorrhagic adult MMD undergoing CB. hCHS occurred in 4.7% of hemispheres. Advanced age and a larger preoperative volume of Tmax greater than 6 seconds were independent predictors, with cutoff values of 43.5 years and 80.5 mL, respectively.

We subsequently investigated postoperative cerebral infarction (PostCI) in 276 hemispheres undergoing CB. PostCI occurred in 6.2%. Although PCA involvement and larger perfusion-delay volumes were associated with PostCI in univariable analyses, the volume of Tmax greater than 6 seconds was the only independent predictor, with a cutoff value of 59.5 mL. These findings suggested that extensive preoperative perfusion delay represents a common high-risk feature for both hemorrhagic and ischemic complications after CB.

Based on these observations, we further compared CB with indirect bypass (IB) in perfusion-defined high-risk hemispheres with a Tmax greater than 6 seconds volume of at least 59.5 mL. After overlap-weighted propensity score adjustment, angiographic revascularization and perfusion improvement were comparable between the two strategies, whereas postoperative stroke occurred less frequently after IB.

Quantitative assessment of preoperative perfusion delay may facilitate risk stratification and individualized surgical planning. In adult MMD with extensive hemodynamic compromise, IB may be considered a risk-adapted alternative to CB in carefully selected patients.

S6-4

## Hyperperfusion Syndrome: Refining Its Clinical Implications for Bypass Surgery in Adult Moyamoya Disease

Jeong Eun KIM<sup>1</sup>, Won-sang CHO<sup>1</sup>, Hyeon-seung KANG<sup>1</sup>, Kang Min KIM<sup>1</sup>, Jin Pyeong JEON<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Seoul National University College of Medicine, ROK,

<sup>2</sup>Department of Neurosurgery, Hallym University

Cerebral hyperperfusion syndrome (CHS) after revascularization for adult moyamoya disease has commonly been regarded as a direct consequence of abrupt flow augmentation. However, our institutional studies suggest a broader postoperative hemodynamic disorder. Serial SPECT demonstrated that transient regional hyperperfusion may correspond topographically to reversible neurological deterioration after superficial temporal artery-middle cerebral artery bypass and can also occur after indirect revascularization. Later adult combined-bypass cohorts reported symptomatic CHS in approximately 36%-49%, depending on the definition and cohort. These observations emphasize the need to distinguish radiographic hyperperfusion, symptomatic CHS, postoperative transient neurological dysfunction, infarction, and hemorrhage.

Risk is not determined by bypass flow alone. Recurrent predictors include impaired preoperative cerebrovascular reserve, particularly in the temporal cortex; surgery on the dominant hemisphere; poor baseline neurological status; higher platelet count; negative fluid balance; longer temporary occlusion; and lower intraoperative PaCO<sub>2</sub>. Physiological monitoring further demonstrated impaired dynamic cerebral autoregulation before and after surgery in patients developing CHS, while dynamic contrast-enhanced MRI suggested focal blood-brain barrier disruption accompanying transient perianastomotic cerebral blood flow elevation. Thus, chronically dilated microvasculature, impaired autoregulatory adaptation, endothelial vulnerability, and perioperative physiological stress may jointly determine clinical expression.

Preventive approaches based on isolated interventions have shown limited effects. Sevoflurane postconditioning did not reduce symptomatic CHS, and scalp nerve block shortened symptom duration without significantly reducing incidence. Therefore, the clinical goal should not be indiscriminate suppression of postoperative perfusion. Management should combine preoperative risk stratification, early symptom-triggered perfusion imaging, maintenance of euvolemia and normocapnia, and individualized blood pressure control that mitigates hyperperfusion while preserving perfusion in remote or contralateral compromised territories.

CHS should be interpreted as a dynamic neurovascular response rather than a binary flow complication. Refining its definition and mechanisms may improve perioperative decision-making and enhance the safety of bypass surgery.

## Lessons from Hemodynamic Complications and Strategies for Safer Revascularization in Moyamoya Disease

Atsushi KANOKE<sup>1,2</sup>, Hidenori ENDO<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Kohnan Hospital, Sendai, Japan, <sup>2</sup>Department of Neurosurgery, Tohoku University Graduate School of Medicine, Sendai, Japan

Surgical revascularization is the mainstay of treatment for symptomatic moyamoya disease. However, a patent bypass does not always guarantee an uncomplicated postoperative course. The immediate introduction of donor flow into a chronically hypoperfused and auto-regulation-impaired brain may produce diverse hemodynamic responses, ranging from local cerebral hyperperfusion to ischemia in adjacent, remote, or even contralateral territories.

This presentation reviews our practical strategy for combined revascularization, with particular emphasis on lessons learned from perioperative complications. Illustrative cases will demonstrate cerebral hyperperfusion syndrome, postoperative watershed shift, remote ischemia, and neurological deterioration associated with collateral flow redistribution. These events highlight the limitations of evaluating surgical success solely by bypass patency or focal flow augmentation.

Safe revascularization requires integration of the patient's symptoms, cerebral perfusion, vascular territory, and collateral architecture. Perioperative management should maintain individualized blood pressure targets, while avoiding both systemic hypoperfusion and excessive focal flow augmentation. Early postoperative neurological assessment and cerebral blood flow imaging are essential for distinguishing hyperperfusion from ischemic mechanisms, because their management may be fundamentally different.

Future complication avoidance may require a more physiology-based, flow-balanced approach to surgery. Potential strategies include selecting recipient arteries and bypass territories according to preoperative collateral dependence, tailoring the number and distribution of anastomoses, assessing intraoperative flow dynamics, and monitoring not only the bypassed cortex but also remote and contralateral territories. Revascularization surgery should therefore be designed not merely to add blood flow, but to reorganize cerebral circulation safely. Learning from hemodynamic complications may help refine surgical planning and perioperative care for more reliable outcomes in moyamoya disease.

S7-1

## Mechanical Thrombectomy: Current Landscape and Remaining Challenges

Tsuyoshi OHTA

Department of Neurosurgery, Kyoto University, Kyoto, Japan

Mechanical thrombectomy (MT) is established as standard care for acute ischemic stroke caused by proximal anterior circulation large vessel occlusion (LVO), on the basis of the HERMES pooled analysis of five randomized trials. Since then, eligibility has widened along three axes. Time: DAWN and DEFUSE-3 demonstrated benefit up to 24 hours in patients selected by clinical-imaging or perfusion mismatch. Core volume: RESCUE-Japan LIMIT, SELECT2, and ANGEL-ASPECT showed that patients with ASPECTS 3-5 or core volumes of 50-100 mL still gain functional benefit, albeit with more intracranial hemorrhage. Territory: ATTENTION and BAOCHE established MT within 24 hours as a reasonable option for basilar artery occlusion. In Japan, the 2019 Stroke and Cardiovascular Disease Control Act provided the legislative framework for making MT broadly available.

Substantial questions remain. Whether intravenous thrombolysis should precede MT is unresolved: SKIP, DIRECT-MT, and SWIFT-DIRECT reached discordant conclusions, and their non-inferiority margins were arguably wider than the minimal clinically important difference in stroke trials, raising concerns about assay sensitivity. For medium vessel occlusion, approximately 40% of medically treated patients reach mRS 0-1, and subgroup analysis of ESCAPE-MeVO suggests that any benefit may be confined to early presenters. Intracranial atherosclerotic disease, which underlies 30-50% of ischemic stroke in Asian populations, is associated with lower recanalization by stent retriever, frequent intraprocedural reocclusion, and longer procedures, and demands distinct rescue strategies; temporary dilation devices such as the TG Dilator are under evaluation. Optimal imaging selection, DWI versus CT perfusion or neither, also remains contested.

Expanding indications enlarge the pool of eligible but untreated patients. MT is cost-effective, with a mean incremental cost-effectiveness ratio of approximately US\$14,000 per QALY, yet access is uneven and many low-volume centers raise concerns about economic sustainability. Expanding eligibility demands both rigorous evidence and equitable systems of care, so that no eligible patient is left untreated.

## Building an Effective Stroke System of Care in Japan: Impact of a Prefecture-Wide Prehospital Triage Program

Yukiko ENOMOTO<sup>1,5</sup>, Takayuki NISHIWAKI<sup>1</sup>, Hirofumi MATSUBARA<sup>1</sup>, Tsuyoshi IZUMO<sup>1</sup>,  
Takahito MIYAKE<sup>2,5</sup>, Shinji OGURA<sup>3,5</sup>, Hideshi OKADA<sup>4,5</sup>

<sup>1</sup>Department of Neurosurgery, Gifu University Graduate School of Medicine, Japan,

<sup>2</sup>Advanced Critical Care Center, Gifu University Hospital, <sup>3</sup>Department of Emergency Medical Science, Asahi University,

<sup>4</sup>Department of Emergency and Disaster Medicine, Gifu University Graduate School of Medicine,

<sup>5</sup>Gifu Prefecture Medical Control Council

(Background) Timely identification of patients eligible for reperfusion therapy and appropriate hospital selection are essential for improving outcomes in acute ischemic stroke (AIS). Optimal triage should be adapted to local geographic characteristics and healthcare resources. We established a prefecture-wide stroke triage involving emergency medical services (EMS), all Primary Stroke Centers (PSCs), and the regional Medical Control Council, and evaluated its impact on acute stroke care.

(Methods) This multicenter observational study included consecutive EMS transports for suspected acute stroke occurring within 24 hours between October 2024 and September 2025. Patients were triaged using the Japan Stroke Society Large Vessel Occlusion Scale (JSS-LVO Scale). During Phase 1, patients meeting at least two points were preferentially transported to EVT-capable PSCs. During Phase 2, the threshold was changed to three points. EMS operational metrics, treatment data, and clinical outcomes were prospectively collected and analyzed.

(Results) Among 2,078 patients, 1,570 patients with confirmed stroke were analyzed, including 984 patients with ischemic stroke and 372 with LVO. Intravenous thrombolysis rates were similar between the two phases (7.0% vs. 7.9%). However, the rate of mechanical thrombectomy increased in phase 2 (8.8% vs. 11.7%,  $p < 0.05$ ). Favorable outcomes at discharge (mRS 0-2) were also more frequent during Phase 2 (33.3% vs. 37.7%,  $p = 0.05$ ). The protocol demonstrated excellent operational feasibility, with acceptance achieved on the first negotiation attempt in 96.5% of cases. Regional analyses suggested that local healthcare resources and geographic characteristics influenced protocol performance, highlighting the need for region-specific optimization.

(Conclusions) Implementation of a coordinated prefecture-wide prehospital stroke triage system was associated with improved access to mechanical thrombectomy and favorable patient outcomes while maintaining efficient EMS operations. Regional adaptation of stroke triage protocols may strengthen stroke systems of care and serve as a practical model for improving access to reperfusion therapies in regions with heterogeneous healthcare resources.

S7-3

## **Large Core Thrombectomy: What Should We Consider Before We Treat?**

**Wonsoo SON**

Department of Neurosurgery, Kyungpook National University Hospital, Daegu, ROK

The indication for endovascular thrombectomy (EVT) has expanded following several recent randomized controlled trials demonstrating its benefit in patients with large-core ischemic stroke. Although EVT improves functional outcomes in this population, considerable heterogeneity remains despite successful reperfusion. These findings have shifted the clinical focus from determining whether thrombectomy should be performed to identifying which patients are most likely to benefit from treatment.

Patient selection in large-core infarction requires integration of multiple clinical and imaging factors, including baseline neurological severity, infarct extent, time from symptom onset, collateral circulation, and the biological severity of ischemic tissue injury. Recent evidence suggests that conventional imaging parameters alone may not sufficiently characterize tissue status or predict individual outcomes after reperfusion.

Current evidence from randomized trials, contemporary guidelines, and observational studies supports a more comprehensive approach to patient selection beyond infarct size alone. Imaging biomarkers, including net water uptake (NWU), may provide incremental prognostic information beyond conventional imaging parameters and represent a promising tool for individualized risk stratification in patients with large-core infarction. Recent data regarding the prognostic significance of NWU following EVT will also be presented in the context of current evidence and future directions.

## **The role of direct stent angioplasty ("rescue stenting") in cerebral acute ischemic stroke**

Kuhyun YANG

Department of Neurological Surgery, Gangneung Asan Medical Center, University of Ulsan College of Medicine, ROK

Intracranial atherosclerotic stenosis (ICAS)-related large vessel occlusion (LVO), which is characterized by in situ thrombo-occlusion within the underlying stenosis of the cerebral artery, is a common cause of acute ischemic stroke (AIS) with LVO. ICAS is the underlying cause of AIS in 40% of Asian individuals, 30% of Black individuals, and 10% of White individuals. Accordingly, ICAS-related LVO accounts for approximately 18%–37% of AIS cases with LVO in East Asia and for approximately 10% of LVO cases in cohort studies from France and the United States. Hence, this is a crucial causative factor that should not be ignored.

As in embolic LVO, fast and successful recanalization by mechanical thrombectomy (MT) is the most important determinant of favorable outcomes in ICAS-related LVO. However, ICAS-related LVO is known to be a major cause of MT failure due to reocclusion because of platelet aggregation activated by the underlying inflamed plaque, the presence of a severe degree of stenosis, or a combination of both. Therefore, in an effort to overcome the reocclusion process after first-line MT failure in refractory cases of ICAS-related LVO, rescue modalities such as the administration of glycoprotein IIb/IIIa inhibitor and rescue stent (RS) with or without balloon angioplasty have shown potential effectiveness. Particularly, among these rescue modalities, RS effectively overcomes MT refractoriness, which is mostly caused by repeat reocclusion, achieving luminal gain and demonstrating the improved patency of the target vessel, leading to a good short-term outcome.

In the hyperacute period, the role of RS is to achieve successful recanalization after failed first-line MT for ICAS-related LVO. Given its permanent placement in the cerebral artery, RS needs to continue playing another life-long role beyond the hyperacute period by maintaining CBF, preventing stroke recurrence, and, consequently, ensuring a good outcome.

S7-5

## Urgent Bypass for Patients with Acute Ischemic Stroke

Si Un LEE, Jehun JANG, Sang Hyo LEE, Jae Seung BANG

Department of Neurosurgery, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam-si, ROK

Despite advances in endovascular treatment (EVT), some patients with acute ischemic stroke (AIS) continue to deteriorate because of persistent hemodynamic compromise, particularly in atherosclerotic major cerebral artery steno-occlusive disease. For patients who are ineligible for EVT or in whom endovascular revascularization fails, urgent extracranial-intracranial bypass may provide an alternative strategy for flow augmentation.

Recent studies since 2020 have further clarified its potential role. Kimura et al. reported favorable outcomes after urgent STA-MCA bypass in selected patients with progressing hemodynamic stroke and showed that higher preoperative NIHSS was associated with poor outcome, emphasizing the importance of intervention before severe neurological deterioration. Subsequent studies have suggested potential benefit in carefully selected patients with perfusion-diffusion mismatch or intracranial atherosclerosis-related large vessel occlusion after failed EVT, whereas more recent data indicate limited benefit in patients with severe deficits and extensive established infarction.

In our previous study of 41 patients undergoing urgent bypass under strict selection criteria, quantitative CTP analysis demonstrated a marked reduction in Tmax >6 s volume after surgery, with minimal infarction progression. These findings supported the concept that urgent bypass can rapidly improve cerebral hemodynamics when substantial salvageable tissue remains.

An illustrative case will be presented to demonstrate imaging-based patient selection, surgical strategy, and postoperative hemodynamic improvement.

Urgent bypass should not be considered a routine treatment for AIS. However, it may serve as a valuable rescue strategy in highly selected patients with a small infarct core, substantial salvageable tissue, and progressive hemodynamic deterioration despite maximal medical and endovascular treatment. Appropriate patient selection and timely intervention appear to be the key determinants of successful urgent revascularization.

## **Treatment Strategy of Unruptured Spetzler-Martin Grade III Arteriovenous Malformations: A Review of the Literature and Recommendation**

**Sang Weon LEE**

Department of Neurosurgery, School of Medicine, Pusan National University, Busan, ROK

### Background:

Optimal management of unruptured brain arteriovenous malformations (AVMs) remains controversial, particularly for Spetzler-Martin (SM) grade III lesions. These AVMs occupy an intermediate position between low- and high-grade lesions and represent a heterogeneous group with distinct anatomical configurations and treatment risks. Contemporary decision-making therefore requires individualized assessment beyond SM grade alone.

### Methods:

Recent literature on the natural history and management of unruptured SM grade III AVMs was reviewed. Particular attention was given to the four anatomical subtypes (S1E1V1, S2E0V1, S2E1V0, and S3E0V0), supplemented SM grading, hemorrhage-risk features, and outcomes of microsurgery, stereotactic radiosurgery (SRS), embolization, multimodality treatment, and observation.

### Results:

The risk-benefit profile of intervention varies substantially among SM grade III AVMs. Microsurgery offers immediate and durable obliteration and remains an important option for younger patients with favorable surgical anatomy and low supplemented SM grades. SRS is particularly valuable for compact AVMs of suitable volume in eloquent or deep locations, although delayed obliteration, latency-period hemorrhage, and radiation-related complications must be considered. Volume-staged SRS may expand treatment options for selected larger AVMs. Embolization is primarily used as an adjunct to microsurgery or SRS, while curative embolization is reserved for highly selected lesions with favorable angioarchitecture. Observation remains appropriate when the anticipated lifetime hemorrhage risk does not justify the procedural or delayed risks of intervention.

### Conclusions:

SM grade III alone is insufficient to determine treatment for an unruptured AVM. Management should integrate anatomical subtype, supplemented SM grade, patient age and life expectancy, hemorrhage-risk features, nidus morphology and volume, and modality-specific risks. The key clinical question is not simply whether an unruptured grade III AVM should be treated, but **\*\*which AVM should be treated, in which patient, and by which modality.\*\***

S8-2

## **Treatment Strategies for Spetzler-Martin Grade III Brain Arteriovenous Malformations: A Single-Center Experience**

Yushiro TAKE<sup>1</sup>, Mizuho IIZUKA<sup>1</sup>, Ryota SAITO<sup>1</sup>, Kazuaki KURIHARA<sup>1</sup>, Masaya NISHIKATA<sup>1</sup>,  
Haruka KUME<sup>1</sup>, Takuma MAEDA<sup>1</sup>, Akio TERANISHI<sup>1</sup>, Shinya KOHYAMA<sup>2</sup>,  
Takayuki HARA<sup>1</sup>, Hiroki KURITA<sup>1</sup>

<sup>1</sup>The Department of Cerebrovascular Surgery, Saitama Medical University, International Medical Center, Saitama, Japan,

<sup>2</sup>The Department of Intravascular Neurosurgery, Saitama Medical University, International Medical Center, Saitama, Japan

### Background

The optimal treatment of Spetzler-Martin (SM) grade III brain arteriovenous malformations (bAVMs) remains controversial because of their marked heterogeneity. We reviewed our treatment strategy and clinical outcomes, with a focus on SM grade III bAVMs.

### Methods

We retrospectively reviewed 261 consecutive patients with bAVMs treated between January 2011 and September 2023. Clinical characteristics, rupture status, SM grade, treatment modality, and functional outcomes were analyzed. Treatment strategies were determined by a multidisciplinary team based on lesion characteristics and patient factors.

### Results

Among 121 patients with unruptured bAVMs, 93 (76.8%) underwent intervention. Twenty-five patients had SM grade III bAVMs, of whom 21 (84.0%) underwent intervention. Microsurgical resection was performed in 16 patients (76.2%), stereotactic radiosurgery alone in 2 (9.5%), and combined endovascular embolization followed by stereotactic radiosurgery in 3 (14.3%). No patient underwent embolization alone. Complete resection was achieved in all patients who underwent microsurgical resection. Favorable functional outcomes (90-day modified Rankin Scale [mRS] score  $\leq 2$ ) were achieved in 95.5% of all surgically treated unruptured bAVMs and in all surgically treated SM grade III patients.

Among 140 patients with ruptured bAVMs, 130 (92.8%) underwent intervention. The SM grades were I in 30 patients, II in 46, III in 30, IV in 16, and V in 9. Among the 30 patients with SM grade III bAVMs, 29 (96.7%) underwent intervention, including 17 who underwent microsurgical resection. Favorable functional outcomes at discharge (mRS score  $\leq 2$ ) were achieved in 94 patients (72.3%).

### Conclusions

SM grade III bAVMs are a heterogeneous group requiring individualized treatment strategies. Careful patient selection and multimodal management can achieve favorable outcomes. Further refinement of treatment strategies for SM grade III bAVMs beyond the conventional SM grading system may improve patient selection.

## High Grade AVM Treatment: Case Series and Literature Review

Dong-Kyu JANG, Young Hoon CHOI, Byung-Rae CHO, Dong Sub KIM

Department of Neurosurgery, Incheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Incheon, ROK

High-Grade arteriovenous malformations (AVMs) remain among the most challenging cerebrovascular lesions because of large nidus volume, high-flow shunting, deep venous drainage, and eloquent cortical involvement. Spetzler-Martin (SM) Grade IV-V lesions carry high treatment-related morbidity, and cure with a single modality is rarely achievable. Over 15 years, 8 of 28 AVMs treated at our institution were SM Grade IV-V; two underwent staged maximal endovascular embolization followed by microsurgical nidus removal. A 54-year-old man presented with headache, syncope, visual disturbance, and cognitive decline. Imaging showed a left hemispheric AVM measuring 8.3 x 6.6 cm (nidus volume 55 cc), SM Grade IV, with an associated dural AVF and a prenidus callosomarginal aneurysm. Feeders arose from the MCA, ACA, PCA, and MMA, draining into the superior sagittal sinus and Sylvian veins. Three sessions of Onyx embolization reduced nidus flow, including coil occlusion for feeder rupture. Microsurgical resection followed, and intraoperative angiography confirmed complete obliteration. A 34-year-old man presented with progressive left visual disturbance, left hemiparesis, and seizures. Imaging demonstrated a 7-cm right temporoparietal AVM, SM Grade V, with markedly elevated global cerebral blood flow (2174 mL/min) on MRA Q-flow analysis. Embolization achieved approximately 55% nidus reduction, but high-flow shunting persisted. Microsurgical resection was near-total; postoperative deterioration revealed residual nidus, and emergent second-stage resection under intraoperative angiography and neurophysiologic monitoring achieved complete obliteration. The patient survived without hemorrhagic complication, with persistent left hemiparesis requiring rehabilitation. In conclusion, selected giant SM Grade IV-V AVMs may be rendered surgically curable by staged maximal embolization followed by definitive microsurgical resection, with preoperative flow reduction critical for safe dissection and complete removal. Despite substantial neurological risk, a planned multimodal strategy with intraoperative angiographic confirmation can achieve angiographic cure. Prospective studies are needed to refine patient selection and long-term outcomes.

S8-4

## The Soft Nidus Concept: Designing Resection Through Embolization -- Toward Fine Microsurgical Dissection --

Naoki NAKAYAMA, Osamu KIKUCHI, Takeshi MURAKI,  
Katsuhiko MARUICHI, Michinari OKAMOTO, Shogo ENDO, Yusuke KINOSHITA,  
Hitoshi MATSUZAWA, Shunsuke TERASAKA

Advanced Cerebrovascular Center, Sapporo Hakuyokai Hospital, Sapporo, Japan

The goal of microsurgical resection for cerebral arteriovenous malformations (AVMs) is complete removal while preserving the surrounding brain. Preoperative embolization is generally intended to facilitate surgery, yet the debate has focused on how far embolization should be pursued. With the widespread use of ONYX, embolization often aims to maximally reduce nidus blood flow by extensive intranidal penetration, converting the nidus into a rigid, bloodless mass. However, maximal flow reduction does not necessarily optimize microsurgical dissection. Instead, a hardened nidus often requires excavation-like manipulation with unnecessary injury to the brain-nidus interface.

Our surgical philosophy is different. During resection, sequential occlusion of the main feeders provides progressive flow control while meticulous circumferential dissection allows the nidus to become increasingly soft and deformable. This enables precise separation along the brain-nidus interface with minimal brain retraction. In the final stage, the softened nidus can be collapsed and reflected from its deepest apex, allowing safe dissection from the underlying brain before division of the draining vein. We define this surgically optimized condition as the **Soft Nidus**.

Accordingly, the purpose of preoperative embolization is not to harden the nidus but to create the conditions necessary for achieving a **Soft Nidus**. Selective embolization should therefore be limited to surgically inaccessible feeders, including deep perforators and feeders on the inferior or medial aspect of the nidus, while avoiding unnecessary intranidal embolization. This strategy simplifies the vascular architecture without compromising tissue flexibility. In this symposium, I will present the **Soft Nidus Concept**, which shifts the focus of embolization from how much to embolize to how best to design microsurgical resection, together with the surgical techniques that embody this concept.

## Neovascularization in the Outer Membrane of Chronic Subdural Hematoma: A Probable Cause of Spontaneous Recurrence

Won-Sang CHO<sup>1</sup>, Jeong Eun KIM<sup>1</sup>, Yoori CHOI<sup>2</sup>, Ye Yoong KIM<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Seoul National University Hospital, Seoul National University College of Medicine, Seoul, ROK, <sup>2</sup>Department of Nuclear Medicine, Seoul National University College of Medicine, Seoul National University Hospital

Chronic subdural hematoma (CSDH) is conventionally attributed to tearing of the bridging veins, yet recurrence occurs in up to 30% of patients after adequate surgery, and a substantial proportion of these recurrences arise spontaneously without any identifiable cause. Embolization of the middle meningeal artery (MMA) has emerged as a powerful preventive measure: six randomized trials have now been reported, the majority favoring embolization, and both the SVIN 2025 and SNIS 2026 guidelines recommend it as an adjunct to standard treatment at the highest class of recommendation. The procedure is therefore established on clinical outcome data alone. Its biological rationale still rests on electron microscopic studies from 1978 to 1997, which described fragile capillaries in the outer membrane (OM) using two-dimensional sections but could neither quantify the vascular burden nor demonstrate continuity between those vessels and the MMA that is the very connection embolization is presumed to interrupt.

We compared normal human dura mater with pathological dura and its adherent OM from a patient with repeat spontaneous CSDH, adding whole-mount tissue clearing with three-dimensional volumetric reconstruction to conventional histology and electron microscopy.

Three findings distinguish this work. The dural border cell (DBC) layer and OM were histologically indistinguishable, indicating that the OM originates from the DBC layer. Three-dimensional reconstruction traced a continuous route from the MMA through penetrating arteries to the capillary network of the DBC layer and OM, with vessel number increased 3.8-fold, vascular volume 5.9-fold, and arterial volume 5.4-fold, while arterial calibers were unchanged. Ultrastructurally, sinusoidal capillaries structurally incapable of containing blood and foreign to normal dura were present only in the pathological specimen. Marked lymphangiogenesis was additionally observed, the first such evidence in this disease.

These findings define an anatomically continuous pathway from the MMA to fragile sinusoidal capillaries, supplying a direct histopathological rationale for MMA embolization.

S9-2

## Baseline Hematoma Burden and Treatment Effect Heterogeneity of Middle Meningeal Artery Embolization for Chronic Subdural Hematoma

Hyungon LEE<sup>1,2</sup>, Jung-soo KIM<sup>2</sup>, Seung Hwan KIM<sup>3</sup>, Ji Hwan JANG<sup>4</sup>

<sup>1</sup>Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, ROK, <sup>2</sup>Department of Neurosurgery, Dongnam institute of Radiological & Medical Science, <sup>3</sup>Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, ROK, <sup>4</sup>Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, ROK

**Background:** Recent randomized trials have shown variable effect sizes of middle meningeal artery embolization (MMAE) for chronic subdural hematoma (C-SDH). We hypothesized that baseline hematoma burden, represented by hematoma thickness and midline shift, may explain part of this treatment heterogeneity.

**Methods:** We performed a PRISMA-compliant systematic review and exploratory trial-level weighted meta-regression of randomized controlled trials comparing MMAE with standard care for C-SDH. Recurrence-related failure events were extracted from each trial or prespecified stratum to calculate relative risk (RR) and log(RR). Weighted pooled baseline hematoma thickness and midline shift were derived from arm-level data. Three inverse-variance weighted meta-regression models tested associations between log(RR) and hematoma thickness, midline shift, or a composite burden variable defined as thickness plus midline shift. Directional robustness was assessed using leave-one-out analysis, STEM-strata combined sensitivity analysis, and reoperation-only outcome analysis.

**Results:** Four trials, EMBOLISE, STEM, MAGIC-MT, and EMPROTECT, provided five trial-level datasets. The pooled RR for recurrence-related failure was 0.52, 95% CI 0.41-0.66, favoring MMAE. All three meta-regression models showed a positive association between greater baseline burden and attenuation of MMAE effect: thickness  $\beta_1=0.089$ ,  $p=0.104$ , weighted  $R^2=0.64$ ; midline shift  $\beta_1=0.100$ ,  $p=0.081$ , weighted  $R^2=0.69$ ; composite burden  $\beta_1=0.048$ ,  $p=0.089$ , weighted  $R^2=0.67$ . Across 33 sensitivity model estimates, the  $\beta_1$  direction was consistently positive.

**Conclusions:** Baseline hematoma burden may contribute to observed heterogeneity in MMAE treatment effect for C-SDH. These exploratory findings support the concept that pressure-related mechanisms beyond MMA-fed neovascularization may attenuate MMAE efficacy in high-burden hematomas. Individual patient-level analyses and burden-stratified prospective studies are warranted.

## Clinical Scenario-Based Patient Selection for Middle Meningeal Artery Embolization in Chronic Subdural Hematoma

Shunsuke TANOUE<sup>1,2</sup>, Masaya NAKAGAWA<sup>2</sup>, Yohei OTSUKA<sup>2</sup>, Yuki NITTA<sup>2</sup>, Kenichiro ONO<sup>2</sup>

<sup>1</sup>Headquarters, 4th Division, Japan Ground Self-Defense Force, Japan, <sup>2</sup>Department of Neurosurgery, Mishuku Hospital

Middle meningeal artery embolization (MMAE) for chronic subdural hematoma (CSDH) can be considered in three clinical scenarios: (1) stand-alone MMAE without surgical drainage, (2) adjunctive MMAE after initial drainage, and (3) adjunctive MMAE after repeat drainage for recurrent CSDH.

Evidence supporting stand-alone MMAE is accumulating. In our series, partial or complete symptomatic recovery within the first week was observed in 10 of 15 patients (66.7%), and complete symptom resolution occurred at a median of 26 days (interquartile range, 6.5-33.5 days). Hematoma volume and midline shift decreased progressively, with significant improvement within the first week ( $P = 0.030$  and  $P = 0.0032$ , respectively). Nevertheless, rescue evacuation was required in 3 patients (20.0%). Therefore, patient selection should account for whether clinical and radiological improvement can be safely awaited and should include predefined criteria for surgical rescue.

Adjunctive MMAE after initial drainage aims to reduce future retreatment. Because retreatment risk is not uniform, pretreatment risk stratification is essential. In our risk-stratified treatment study, 52 patients were treated during the study period, when adjunctive MMAE was introduced for high-risk patients, and 53 during the baseline period. Overall retreatment rates were 5.8% and 17.0%, respectively ( $P = 0.12$ ). Among high-risk patients, retreatment was required in 1 of 31 patients (3.2%) during the study period versus 9 of 32 patients (28.1%) during the baseline period ( $P = 0.01$ ). In contrast, among low-risk patients, retreatment rates were 9.5% and 0%, respectively ( $P = 0.49$ ). No severe complications occurred. These findings suggest that risk stratification may identify patients most likely to benefit from adjunctive MMAE.

Adjunctive MMAE after repeat drainage for recurrent CSDH appears reasonable; however, evidence that it prevents further retreatment remains insufficient.

Thus, appropriate patient selection for MMAE in CSDH differs according to the clinical scenario.

S9-4

## **MMA embolization at early after surgery to prevent recurrent subdural hematoma (MESH study)**

Hyun Jin HAN, Hyun Jin HAN, Solbi KIM, Jung-jae KIM, Keun Young PARK, Yong Bae KIM  
Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

Chronic subdural hematoma (cSDH) remains one of the most common and challenging clinical entities in neurosurgery, particularly in the aging population. While surgical evacuation is the standard of care, it is frequently complicated by significant recurrence rates, typically ranging from 5% to 35%. The objective of the MESH study was to evaluate the clinical efficacy of performing protocolized MMAE in the postoperative period to reduce the risk of radiologic recurrence and the necessity for surgical reoperation.

### Methods

We conducted a clinical analysis of a patient cohort treated for symptomatic cSDH, divided into two distinct groups: the Non-Embolic Group and the Embolic Group. In the Non-Embolic Group, 567 patients included for final analysis. In the Embolic Group, 34 patients were screened, and 23 patients were analyzed after receiving protocolized MMAE after their index surgical procedure. The primary outcomes measured were the rate of radiologic recurrence--defined as the reaccumulation of the hematoma on follow-up imaging--and the incidence of surgical reoperation.

### Results

The findings of the MESH study demonstrated a significant reduction in recurrence for patients receiving adjunctive treatment. In the Non-Embolic Group (n=567), radiologic recurrence occurred in 235 patients (32.0%), and 31 patients eventually required a surgical reoperation. In stark contrast, the Embolic Group (n=45) showed exceptional procedural stability. Only 1 patient (2.2%) in this expanded cohort required a surgical reoperation due to recurrence (approximately 17 days after the embolization procedure).

### Conclusions

The MESH study confirms that performing MMA embolization early after surgery significantly lowers the risk of both radiologic recurrence and the need for subsequent surgical intervention in patients with symptomatic cSDH. By effectively devascularizing the leaky neomembranes supplied by the MMA, early postoperative MMAE serves as a safe and potent adjunct to conventional surgery.

## **From Adjunctive to Stand-Alone Therapy: A 5-Year Experience of Coil-Only Middle Meningeal Artery Embolization (MMAE) for chronic subdural hematoma (CSDH)**

Dae Won KIM, Eun Suk PARK, Hyuncheol JEONG

Department of Neurosurgery, Wonkwang University Hospital, ROK

**Objective:** Middle meningeal artery embolization (MMAE) has emerged as a promising strategy for chronic subdural hematoma (CSDH). While liquid embolic agents are widely utilized, concerns persist regarding non-target embolization via dangerous anastomoses. This study evaluates the clinical efficacy, safety, and radiological outcomes of MMAE using exclusively coils (coil only) over a 5-year period, covering both adjunctive and stand alone applications. **Methods:** We retrospectively analyzed consecutive cases of CSDH treated with coil only MMAE between March 2021 and October 2025 at our institution. Treatment strategies were categorized into adjunctive therapy (combined with burr-hole drainage) and stand-alone therapy (without surgical drainage). Procedural safety, material related complications, recurrence rates, and hematoma resolution on follow up computed tomography (CT) scans were evaluated.

**Results:** A total of 32 cases (mean age 74.1 years; 72.4% male) were evaluated. Successful coil embolization was achieved in 31 cases, while 1 case was intentionally aborted due to an ophthalmic collateral, safely preventing visual complications without material migration. Among the successfully treated cases with follow-up CT, the non-recurrence rate was 96.8% (30/31), with only 1 case experiencing rebleeding. Significant hematoma reduction (complete absorption or large volume decrease) was achieved in 87.1% (27/31) of patients. No procedure-related cranial nerve palsies or ischemic complications occurred.

**Conclusion:** Our 5-year experience demonstrates that coil-only MMAE is a highly effective, safe, and controllable treatment modality across the broad clinical spectrum from adjunctive post surgical prevention to stand alone therapy. Coils provide precise mechanical occlusion while inherently eliminating the risk of dangerous liquid agent migration, making coil only MMAE an ideal strategy for CSDH, particularly in high risk elderly patients.

S9-6

## **Stand-Alone Middle Meningeal Artery Embolization Versus Burr-Hole Trephination for Neurologically Stable, Burr-Hole-Eligible Chronic Subdural Hematoma: A Propensity Score-Matched Comparison**

Hyun Jeong LEE<sup>1</sup>, Jong-kook RHIM<sup>1</sup>, Jeong Jin PARK<sup>2</sup>, Jin Pyeong JEON<sup>3,4</sup>

<sup>1</sup>Department of Neurosurgery, Jeju National University College of Medicine, Jeju, ROK, <sup>2</sup>Department of Neurology, Konkuk University Medical Center, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Hallym University College of Medicine, Chuncheon, ROK, <sup>4</sup>Department of Population and Quantitative Health Sciences, UMass Chan Medical School, Worcester, MA, USA

**Purpose:** The feasibility of stand-alone middle meningeal artery embolization (MMAE) as an initial alternative to burr-hole trephination (BHT) for neurologically stable, BHT-eligible symptomatic chronic subdural hematoma (CSDH) remains unclear. We compared clinical and radiological outcomes after stand-alone MMAE versus BHT using propensity score-based adjustment.

**Methods:** We retrospectively analyzed 364 patients with 420 affected hemispheres from two centers. Primary outcomes were hematoma recurrence and unfavorable clinical outcome. Secondary outcomes included hematoma thickness, midline shift, and procedure-related complications. Maximum 1:2 propensity score matching was the primary adjusted analysis; maximum 1:4 matching and inverse probability of treatment weighting were sensitivity analyses.

**Results:** Among 420 affected hemispheres, 41 (9.8%) were treated with stand-alone MMAE and 379 (90.2%) with BHT. In the unmatched cohort, stand-alone MMAE was associated with lower recurrence than BHT [1/41 (2.4%) vs. 50/379 (13.2%); Firth OR, 0.235; 95% CI, 0.026-0.910; p=0.034] and fewer unfavorable clinical outcomes [0/41 (0%) vs. 36/379 (9.5%); Firth OR, 0.113; 95% CI, <0.001-0.826; p=0.026]. After maximum 1:2 matching, recurrence was numerically lower after stand-alone MMAE, with borderline statistical significance [1/39 (2.6%) vs. 10/71 (14.1%); Firth OR, 0.224; 95% CI, 0.024-1.016; p=0.053], whereas unfavorable clinical outcomes were less frequent [0/39 (0%) vs. 11/71 (15.5%); Firth OR, 0.067; 95% CI, <0.001-0.537; p=0.006]. Secondary outcomes were comparable. Findings were generally consistent in sensitivity analyses.

**Conclusions:** Stand-alone MMAE may be feasible for selected, neurologically stable patients with symptomatic, BHT-eligible CSDH. Prospective randomized studies are needed.

## Who Should Undergo MMAE for Chronic Subdural Hematoma?

Chiaki SAKAI<sup>1</sup>, Nobuyuki SAKAI<sup>2</sup>

<sup>1</sup>Regulatory Science of Medical Device Development and Innovation, Kyoto University Graduate School of Medicine, Kyoto, Japan, <sup>2</sup>Neurosurgery, Seijinkai Shimizu Hospital

Middle meningeal artery embolization (MMAE) has emerged as a promising treatment for chronic subdural hematoma (CSDH), supported by recent randomized controlled trials demonstrating reductions in recurrence, progression, and reoperation. However, an important question remains: which patients benefit most from MMAE?

Patient selection should consider both the immediate need for hematoma evacuation and the risk of recurrence. Patients with severe neurological deterioration or substantial mass effect generally require prompt surgical evacuation because MMAE does not provide immediate decompressive effect to brain. In contrast, MMAE may offer particular benefit in patients at high risk of recurrence, including those with recurrent CSDH, advanced age, receiving antithrombotic therapy, coagulopathy disorder, or other factors increasing surgical risk. Adjunctive MMAE after surgical evacuation is increasingly supported by high-level evidence, whereas stand-alone MMAE may be considered for selected patients with mild symptoms, limited mass effect, or high surgical risk.

The clinical implementation of MMAE also differs between Japan and Korea. In Japan, liquid embolic agents are now approved for hemorrhagic lesions, allowing MMAE to be performed within the national health insurance system, particularly for recurrent CSDH and selected high-risk patients. However, routine use for de novo CSDH remains limited, and patient selection continues to be guided by recurrence risk and clinical necessity. Korean investigators have contributed substantially to the early clinical development of MMAE, including its use as primary therapy and in elderly or surgically high-risk patients. Comparison of these evolving treatment strategies may provide valuable insight into the optimal integration of MMAE into clinical practice.

Rather than asking whether MMAE should replace surgery, the key question is how MMAE should be integrated into the treatment algorithm. A risk-stratified approach combining clinical severity, imaging findings, recurrence risk, and patient-specific factors may define the optimal role of MMAE in CSDH.

S10-1

## **Transmitting a Microsurgical Training Culture in the Endovascular Era: From Sapporo to Kyoto**

Kosumo NODA

Department of Neurosurgery, Soseikai general hospital, Kyoto, Japan

In the endovascular era, maintaining exposure to open cerebrovascular surgery has become a shared training challenge. Japan also shows marked regional variation. In national inpatient claims for fiscal 2023, clipping accounted for about 59% of combined coded clipping and endovascular counts in Hokkaido, the highest prefectural share, and about 21% in Kyoto, the lowest. In 2025 I moved from one to the other.

At Sapporo Teishinkai Hospital, where I served as chief of neurosurgery until 2025, 69 neurosurgeons worked in the stroke center between 2012 and 2025, 238 overseas observers came, and a live microneurosurgery course drew 1,114 registrations, 519 from abroad. It was known at home and abroad as an active center for training open cerebrovascular surgeons. Training ran on a fixed workflow: preoperative examination and hand-drawn illustration, preoperative conference, operation, video editing with postoperative illustration, postoperative discussion, and return of the edited case to a shared video library. That cycle made expert reasoning explicit through verbalization, visualization and formulation grounded in anatomical rationale. Because it was case based, it depended on continued access to open operations.

Two initiatives are under way in Kyoto, both early. With a domestic manufacturer we are developing a polyvinyl alcohol model of the Sylvian fissure, intended in time to let the trans-sylvian approach itself be rehearsed outside the operating room. We are also designing CEPT, a progress tracker in which trainee and supervisor rate knowledge, judgment and technique for each procedure on a five-level entrustment scale, with ratings tracked over time.

Neither has been validated. Whether such tools can carry a microsurgical training culture through a time when clinical exposure is limited is what we must find out.

## Introduction of Neurosurgical Training Programs in the Korean Society of Cerebrovascular Surgeons

Dong-Kyu JANG

Department of Neurosurgery, Incheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Incheon, ROK

The Korean Society of Cerebrovascular Surgeons (KSCVS) has built a nationwide, multi-institutional training platform to standardize and sustain cerebrovascular surgical competence in Korea.

Three microvascular anastomosis workshops form the core of technical skill training. The Microvascular Anastomosis Workshop for Neurosurgeons, launched at Seoul National University Bundang Hospital in 2007 as Korea's first regular anastomosis course, reached its 17th session in 2025 and has expanded internationally through the Asia-Pacific Course, whose 6th session is scheduled for 2026. The Asan Microvascular Anastomosis Workshop, begun in 2008 and now in its 15th session (2026), delivers a three-day progressive curriculum from artificial vessel to in-vivo rat anastomosis; among 97 documented participants, more than 60 institutions and six regions are represented, with 33% from outside the capital area. The Microvascular LAW at Inje University Busan Paik Hospital, established in 2011 and held for the 15th time in 2025, anchors training in the Yeongnam region and has offered separate basic and advanced courses since 2020.

A Hands-On Cadaver Workshop at Chonnam National University, originating in 2007 and adopted as an official KSCVS program in 2013, provides small-group cadaveric training in transcranial aneurysm surgery, carotid endarterectomy, revascularization, and skull base approaches.

The Bucheon Minimal Invasive Neurovascular Surgery Workshop, held 11 times since 2016, integrates neurointerventional procedures with minimally invasive craniotomy including supraorbital keyhole and pterional minicraniotomy.

Since 2023, the Complex Surgery Observership Program has enabled 59 board-certified neurosurgeons to observe high-complexity operations under designated Master Professors at nine surgical training hospitals; in 2026, 25 trainees are participating at eight hospitals.

S10-3

## **Training Cerebrovascular Neurosurgeons in Korea: Fellowship Structure, Certification Systems, and the Dual-Competency Challenge**

Kyu-Sun CHOI

Department of Neurosurgery, Hanyang University, Seoul, ROK

**Background.** Over two decades, cerebrovascular disease management in Korea has shifted substantially toward endovascular treatment while open microsurgical volume has progressively declined. Trainees must therefore acquire two increasingly divergent skill sets under inverse volume trends. We review how Korea currently trains cerebrovascular neurosurgeons and the structural pressures acting on that pipeline.

**Current system.** Korean cerebrovascular subspecialty training is delivered through hospital-based fellowships rather than a nationally standardized curriculum, leaving duration and composition largely to individual institutions. Two societies, the Korean Society of Cerebrovascular Surgeons (KSCVS) and the Korean Neuroendovascular Society (KoNES), maintain complementary certification systems for open microsurgery and endovascular intervention. Fellowship is typically at least two years; because certification requires accumulated independently performed cases, most surgeons qualify three to four years after completion. Both societies offer annual and regional meetings, research group activities, biannual cadaver workshops, microvascular anastomosis workshops, operative observation programs, and the Young Neurovascular Surgeon's Meeting, an annual forum for surgeons aged 45 or younger, now in its 18th year.

**Findings.** A 2025 KSCVS survey of younger members showed a mean fellowship duration of 2.3 years, with 96.6% receiving hybrid open-and-endovascular training. Ninety percent maintain hybrid practice, yet open surgery accounted for under 25% of aneurysm treatment in most respondents. Among those wishing to expand their open caseload, insufficient training exposure was the most frequently cited barrier, ahead of institutional case distribution. Respondents most often requested graded operative responsibility during training and expanded simulation and cadaveric education.

**Conclusion.** Korea's hospital-based model affords flexibility but yields institutional variability in dual-competency training, contrasting with more centrally documented certification requirements elsewhere. Sustaining a dual-competent workforce will require longitudinal exposure to both disciplines, graded operative autonomy during fellowship, and structured simulation-based supplementation.

## Eye-Tracking Analysis of Operator Gaze Behavior During Neuroendovascular Procedures

Koichi ARIMURA<sup>1</sup>, Shunya TANAKA<sup>1</sup>, Katsutoshi MASAI<sup>2</sup>, Ryota KUROGI<sup>1</sup>,  
Akira NAKAMIZO<sup>1</sup>, Koji YOSHIMOTO<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kyushu University, Fukuoka, Japan, <sup>2</sup>Department of Advanced Information Technology, Faculty of Information Science and Electrical Engineering, Kyushu University, Fukuoka, Japan

### Purpose

Neuroendovascular treatment (NET) requires advanced visual-cognitive skills to integrate information from multiple viewpoints while maintaining procedural safety. However, expert gaze strategies remain largely tacit, and objective metrics for their evaluation have not been established. This study quantitatively analyzed gaze behavior during NET using eye-tracking technology to compare expert and novice operators and explore its potential for educational applications.

### Methods

Gaze behavior was analyzed during recorded cerebral aneurysm coil embolization procedures using a desktop-mounted eye-tracking system. Procedures were divided into 10 phases, including guide catheter placement, balloon and microcatheter navigation, and coil deployment. Clinically relevant Areas of Interest (AOIs) were predefined for each phase, and gaze transitions were quantitatively assessed. Board-certified neuroendovascular specialists comprised the expert group, while first-year neurosurgical residents formed the novice group. Three metrics were compared: the proportion of gaze outside predefined AOIs (Outside Ratio; OR), concentration on the primary AOI (Dominant Focus; DF), and estimated fixation duration within AOIs.

### Results

The study included 2 experts and 7 novices. Experts demonstrated a lower mean OR than novices, indicating less unnecessary visual exploration outside predefined AOIs. They also showed a higher mean DF, reflecting greater attention to task-relevant regions during each procedural phase. In addition, estimated fixation duration within AOIs was longer in experts than in novices. Quantitative gaze metrics varied considerably among novice operators.

### Conclusions

Gaze behavior associated with procedural safety during NET differs according to operator expertise. Eye-tracking-based gaze analysis provides objective metrics that may facilitate skill assessment and individualized educational feedback. Quantitative evaluation of gaze behavior has the potential to support the development of next-generation training systems for neuroendovascular procedures.

VS1-1

## **Strategic Decision-Making for Complex Cerebral Aneurysms: The Role of a Hybrid Vascular Neurosurgeon**

Takahiro OTA

Department of Neurosurgery, Tokyo Metropolitan Tama Medical Center, Tokyo, Japan

The treatment of complex cerebral aneurysms increasingly requires decisions that transcend the conventional boundaries between microsurgery and endovascular therapy. A hybrid vascular neurosurgeon should not be defined merely as a practitioner technically capable of performing both modalities. Rather, the essential role is to integrate the strengths, limitations, and failure modes of each approach into a unified, disease-centered treatment strategy.

This perspective becomes particularly important when no single modality offers an unequivocal solution. Giant or partially thrombosed aneurysms, lesions requiring parent artery sacrifice or revascularization, and recurrent aneurysms after previous treatment demand consideration not only of technical feasibility, but also of durability, branch preservation, hemodynamic consequences, and future rescue options. True hybrid decision-making therefore asks not simply, Can this aneurysm be clipped or treated endovascularly? but Which strategy provides the most appropriate long-term solution for this specific disease architecture?

In this video symposium, selected cerebral aneurysm cases will illustrate this cross-platform decision process. These include bilateral giant thrombosed MCA aneurysms requiring individualized strategy selection; a complex ICA aneurysm in which flow diversion was weighed against cervical ICA ligation with low-flow bypass; and microsurgical clipping after previous coil embolization. Operative videos and angiographic imaging will demonstrate how treatment choices were shaped by modality-specific risks, anticipated failure modes, durability, and the feasibility of alternative or rescue strategies.

The value of the hybrid vascular neurosurgeon lies not in performing more procedures, but in minimizing modality-driven bias and improving the quality of treatment selection. For complex aneurysms, optimal care may depend on the ability to select, combine, sequence, or revise microsurgical and endovascular strategies according to the individual disease architecture.

## Strategy for the treatment of aneurysms of hybrid neurosurgeon in “flow diverter and exoscope era”

Shingo TOYOTA

Department of Neurosurgery, Kansai Rosai Hospital, Hyogo, Japan

**Introduction:** In stroke care, which requires seamless management, hybrid neurosurgeons play an important role. In recent years, with the widespread adoption of flow diverter and the introduction of exoscope, the clinical practice style of hybrid neurosurgeons in our hospital has also changed. We present the transition of treatment choices for recurrent aneurysms after coiling in our institution and discuss our novel approaches to direct surgery.

**Methods:** We report on all the 18 cases of clipping for recurrent aneurysms after coiling experienced at our institution. And we present the practical aspects of exoscopic keyhole clipping.

**Results:** With the widespread adoption of flow diverters, the opportunities to perform clipping for recurrent aneurysms after coiling have drastically decreased. Exoscopic keyhole clipping yielded results comparable to conventional microscopic surgery.

**Conclusion:** The widespread adoption of flow diverters has reduced high-risk endovascular cases, leading to fewer opportunities to select clipping even for challenging aneurysm cases. Utilizing an exoscope, which is well-suited for surgical education, serves as a useful approach to maintaining the quality of direct surgery.

VS1-3

## **Managing Complex VA-PICA Aneurysms via a Staged Therapeutic Approach**

Sungpil JOO, You Sub KIM, Tae Sun KIM

Chonnam National University Hospital, ROK

Vertebral artery dissecting aneurysms (VADAs) involving the posterior inferior cerebellar artery (PICA) are the most difficult to treat among variations of VADAs but require prompt treatment. The major challenge is to preserve the PICA while occluding the aneurysm. Despite advances in the management of ruptured VADAs involving the PICA, each treatment, whether it is combined or not, is associated with a significant degree of risk. Although it is sometimes very difficult to determine the exact rupture point of VADAs, ruptures tend to occur at distal segments of a dissecting aneurysm presenting as bleb. Also, when planning a trapping of the VA, careful examination of angiography is needed to assess the contralateral VA and rupture point. Our staged and combined strategy may provide another valuable treatment option for treating VADAs involving the PICA with special emphasis on the safety and efficacy

## Clip, Coil, or Bypass: Strategic Decision-Making for Complex Aneurysms - Three Cases

Sung-Tae KIM<sup>1</sup>, Young Gyun JEONG<sup>2</sup>, Hae Woong JEONG<sup>3</sup>, Sung-chul JIN<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Haeundae Paik Hospital, Inje University College of Medicine, Busan, ROK, <sup>2</sup>Department of Neurosurgery, Busan Paik Hospital, Inje University College of Medicine, Busan, ROK, <sup>3</sup>Department of Radiology, Busan Paik Hospital, Inje University College of Medicine, Busan, ROK

### Purpose

Hybrid aneurysm treatment is more than the ability to perform clipping, coiling, and bypass. Its value lies in selecting and sequencing these modalities while anticipating threats to blood flow and future treatment options. Three cases illustrate this principle.

### Case Series

A distal anterior cerebral artery giant serpentine aneurysm was treated with distal ACA revascularization followed by endovascular occlusion of the entry channel. Planned with my mentor early in my career, this staged treatment became the origin of my hybrid approach.

In a patient with Takayasu arteritis, the superior cerebellar artery (SCA) appeared to arise from the aneurysm sac, and its preservation during embolization could not be guaranteed. STA-SCA bypass was performed before coil embolization, enabling definitive treatment while preserving SCA flow.

A large recurrent middle cerebral artery aneurysm after coiling had a coil mass extending into the neck. Anticipating possible reconstruction or revascularization, the STA was dissected at the outset. During clipping, avulsion of an M2 branch required coil extraction and primary repair with 9-0 sutures. Reduced flow in the repaired branch prompted STA-MCA bypass. The patient recovered without a new neurological deficit, and follow-up angiography confirmed preserved flow.

### Conclusion

Revascularization was not a routine adjunct. It was performed in advance or enabled by preparing a donor artery for immediate use when definitive treatment threatened an important arterial territory. Although the modality and timing differed, the principle remained constant: preserve flow and future options before an irreversible step. A hybrid strategy does not eliminate uncertainty; it preserves the ability to adapt before uncertainty causes irreversible harm.

VS1-5

## **Role of microneurosurgery for complete obliteration and prevention of recurrence of complex ruptured aneurysms from the hybrid surgeon's perspective**

Hitoshi FUKUDA, Naoki FUKUI, Fumihiro HAMADA, Yuma HOSOKAWA,  
Namito KIDA, Yu KAWANISHI, Yusuke UEBA, Shohei FUJITA, Masaki YOKODANI,  
Eiichi NAKAI, Tetsuya UEBA

Department of Neurosurgery, Kochi Medical School Hospital, Kochi University, Kochi, Japan

In the treatment of ruptured cerebral aneurysms, complete obliteration of the rupture point in the acute stage and prevention of recurrence in the chronic stage are critically important. However, these goals are not necessarily straightforward, depending on location and morphology of the aneurysm. In this presentation, we discuss the role of microneurosurgery in the treatment of complex ruptured aneurysms from the perspective of hybrid neurosurgeons, by taking non-saccular aneurysms, extremely small aneurysms, recurrent aneurysms after endovascular treatment as examples.

Although parent artery preservation strategy including stent-assisted coiling and flow diverter have developed, we are still skeptical about application of these modalities to acutely ruptured non-saccular aneurysms, given their high rebleeding rate and residual intraaneurysmal blood flow. We prefer bypass-assisted parent artery occlusion to completely exclude ruptured non-saccular aneurysms. Extremely small aneurysms under 3 mm are less amenable to endovascular treatment due to high complication rate. Surgical clipping is a good alternative, but some of these aneurysms are found unclippable intraoperatively. Preparation of rescue bypass may be considered just in case the extremely small aneurysms are found fragile and require sacrifice of the branch vessels. In our clinical study, short-term functional outcomes of the patients with ruptured large/giant aneurysms treated endovascularly were better than those treated surgically, with lower complication rate and comparable acute rebleeding rate. Thus, choice of endovascular coiling in the acute stage of ruptured large or giant aneurysms is considered reasonable. However, recurrence and rebleeding in the long run remain a concern in the ruptured large or giant aneurysms treated endovascularly. When the recurrent aneurysms are refractory to endovascular retreatment, bypass-assisted flow alteration strategy may work to convert terminal type aneurysms to side wall type ones.

We discuss choice and role of microneurosurgery from the perspective of hybrid neurosurgeons by showing some videos.

## Angioarchitecture of CCJ AVFs

Hiro KIYOSUE<sup>1</sup>, Yasuyuki KAKU<sup>2</sup>

<sup>1</sup>Department of Interventional Radiology and Endovascular Treatment, Kumamoto University, Kumamoto, Japan,

<sup>2</sup>Department of Neurosurgery, Kumamoto University Hospital

**Objective:** While the majority of intracranial and spinal DAVFs can be successfully treated using endovascular techniques, the embolization of CCJDAVFs remains challenging, primarily due to their complicated angioarchitecture. Furthermore, differentiating CCJDAVFs from other AVFs is often difficult. In this presentation, I will demonstrate the typical angiographic features of each type of CCJAVF based on clinical experience, and discuss the role of endovascular treatment for AVFs in this specific region.

**Results:** CCJAVFs are categorized into epidural AVFs (EDAVFs), DAVFs, radicular AVFs (RAVFs), and perimedullary AVFs (PAVFs). EDAVFs and DAVFs are mainly fed by dural and epidural branches of the vertebral artery. RAVFs and PAVFs are fed by the anterior spinal artery (ASA) and/or the lateral spinal artery (LSA). However, CCJ EDAVFs and DAVFs can also be supplied by the LSA and/or ASA. Furthermore, dural branches from the V2-V3 segments are difficult to differentiate from radiculopial arteries without superselective angiography. In any type of AVF with spinal arterial supply, a small aneurysm often develops in the pial feeders (vasa corona), which can cause bleeding. Regarding venous drainage, EDAVFs drain into an epidural venous pouch to the epidural plexus and/or an intradural vein. DAVFs drain into the intradural vein alone. RAVFs usually drain via the radiculomedullary vein into the perimedullary vein alone, but they can drain into the epidural plexus. PAVFs drain into the perimedullary vein. Evaluating the fistula location via superselective angiography and/or 3D angiography is essential for differentiating each type of AVF. Fusion imaging using 3D angiography and high-resolution MRI is useful for this purpose. Among CCJAVFs, the optimal application of endovascular treatment is limited to EDAVFs and DAVFs with an accessible dural feeder. Other types of CCJAVFs carry a higher risk of serious complications.

**Conclusion:** Precise evaluation of the angioarchitecture is essential for the safe treatment of CCJAVFs, including CCJDAVFs

VS2-2

## **Surgical Treatment of CCJ dural AVF**

Jae Seung BANG, Si Un LEE, Sang Hyo LEE, Jehun JANG, Seungbin SUNG, Seung Pil BAN,  
O-ki KWON, Young Duk KIM

The Department of Neurosurgery, Seoul National University, ROK

I will present my surgical video of CCJ dural AVF.

## Treatment Strategy of CCJ Dural AVF

Tomohiko OZAKI, Hajime NAKAMURA, Masatoshi TAKAGAKI, Koshi NINOMIYA,  
Yuji NARAMOTO, Masami KURAMOTO, Naoki NISHIZAWA, Haruhiko KISHIMA

The Department of Neurosurgery, University of Osaka, Osaka, Japan

**Objective:** With advances in imaging modalities, the angioarchitecture of cranio-cervical junction dural arteriovenous fistula (CCJ DAVF) including the precise location of the shunt has become clear, and reports on treatment strategies have increased with advances of endovascular treatment devices. In this presentation, We describe our treatment strategies for CCJ DAVFs and present accompanying videos of representative cases.

**Cases:** We present three representative cases. Case 1 was treated with open surgery alone; Case 2 underwent transarterial embolization (TAE) to treat a residual shunt following direct surgery; and Case 3 was treated with TAE alone. All cases were treated without complications.

**Discussion:** Broadly defined, CCJ DAVF encompasses the foramen magnum (FM) type and the type located between occipital bone and C1 (OC1 type). The FM type often has feeders from anterior pharyngeal artery or the occipital artery. Endovascular treatment is effective if security margins to cranial nerve vascular supply can be ensured. In contrast, the OC1 type frequently has only tiny dural branches from the vertebral artery as the main feeders that is too small to advance microcatheter. In addition, there is possibility to have feeder from spinal arteries such as anterior spinal artery. Therefore, direct surgery has been considered safe and effective.

**Conclusion:** Although the indications for endovascular treatment of CCJ-DAVF have expanded due to advances of devices, direct surgery continues to play a major role in the management of CCJ DAVF. It is important to leverage the strengths of both modalities in the treatment for CCJ DAVF.

VS2-4

## **Midline Suboccipital Approach for Craniocervical Junction Dural AVF: Approach, Feeder Anatomy, and Disconnection**

Tae Keun JEE

Department of Neurosurgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, ROK

Arteriovenous fistulas of the craniocervical junction (CCJ) arise within a narrow anatomical corridor where dural, radicular, and perimedullary shunts converge, and their distinction on preoperative angiography can be less clear than classification schemes suggest, which makes surgery more challenging. This video presentation describes the midline suboccipital approach and our surgical strategy for CCJ dural AVF, with operative videos arranged along a spectrum of increasing complexity.

We first present a typical dural AVF, in which identification of the arterialized draining vein at its dural entry and simple disconnection are curative. We then present dural AVF with a pial feeder. Finally, we review cases in which the preoperative diagnosis of dural AVF was not confirmed at surgery: no typical dural attachment of the draining vein was found, and instead a microaneurysm embedded in the C1 nerve root and entangled medial perimedullary vessels were encountered within a limited surgical field, blurring the boundary with radicular and perimedullary AVF.

Across this spectrum, the operative plan is determined less by the categorical label than by the location and multiplicity of shunt points. We discuss patient positioning, exposure, feeder identification, and the strategy of disconnection for each situation.

## Key principles for avoiding troubles in cerebrovascular and endovascular surgeries

Yusuke EGASHIRA, Shoji YASUDA, Hirofumi MATSUBARA,  
Yukiko ENOMOTO, Tsuyoshi IZUMO

Department of Neurosurgery, Gifu University, Japan

Avoiding troubles should be distinct from “troubleshooting”. We present key principles for avoiding troubles in both direct and endovascular surgeries for cerebrovascular disorders. (1) Understanding basic anatomy: Before treatment, surgeons must understand the course of target vessels, such as the internal carotid, middle cerebral, and basilar arteries, within their respective cisterns; their relationships to the surrounding brain tissue and bony structures; and the locations and directions of their branches. Endovascular procedures additionally require a thorough assessment of the access route. (2) Proximal flow control: This is a fundamental principle of vascular surgery. It includes the proximal flow control in aneurysm surgery, and also includes ensuring in both the proximal and distal ends during carotid endarterectomy. (3) Bypass techniques and hybrid approaches: These are essential for both “avoiding troubles” and “troubleshooting”. Bypass surgery can prevent critical ischemia in the target vessel territory. Hybrid approaches enable real-time vascular visualization and are most effective when combined with bypass surgery. In this presentation, these three principles and an overview of their practical application are provided with operative images.

VS3-2

## **Rescue Anastomosis to Prevent Complications During Unexpected Intraoperative Events**

**Si Un LEE, Jehun JANG, Sang Hyo LEE, Jae Seung BANG**

Department of Neurosurgery, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam-si, ROK

Unexpected arterial injury during microsurgical clipping of an unruptured intracranial aneurysm can result in catastrophic ischemic complications. When primary repair or preservation of the injured artery is not feasible, timely rescue anastomosis may provide an effective strategy for maintaining cerebral blood flow and preventing neurological deficits. We present two cases in which intraoperative arterial injury was successfully managed with different rescue bypass techniques.

The first case involved a large ACoA UIA. During microsurgical clipping, an unexpected tear occurred in the A2 segment. Because direct repair and preservation of the injured segment were not feasible, the affected A2 was occluded. Cerebral blood flow to the distal ACA territory was restored using an M2-STA-A2 bypass. Postoperative evaluation confirmed adequate bypass flow, and the patient recovered without major neurological sequelae.

The second case involved a large MCAB UIA treated through a refined minipterional approach. During dissection of the inferior division M2 from the aneurysm dome, the artery was inadvertently torn. The injured segment was occluded, and the distal end of the inferior division M2 was transected and reimplanted into the superior division M2 using an end-to-side intracranial anastomosis. Successful revascularization was achieved with preservation of distal perfusion.

These cases demonstrate that unexpected arterial injury during aneurysm surgery does not necessarily lead to irreversible ischemic complications. Familiarity with multiple bypass and reimplantation techniques, together with rapid intraoperative decision-making, is essential for effective rescue revascularization and may substantially improve outcomes following major arterial injury.

## Intentional Partial Clipping and Endovascular Treatment of Complex Unruptured Intracranial Aneurysms

Jae Sung AHN, Eunji MOON, Jung Cheol PARK

Department of Neurosurgery, Asan Medical Center, Univ. of Ulsan, ROK

**Objective:** Treating intracranial aneurysms with complex characteristics presents significant challenges for microsurgical treatment. In cases where preserving the patency of the parent artery and branching vessels is crucial, incomplete clipping may be necessary to avoid worse outcome. We intentionally performed partial clipping to reduce the size of the aneurysmal neck, facilitating subsequent coil placement and promoting spontaneous occlusion.

**Methods:** From January 2019 to December 2024, total 3247 patients with unruptured intracranial aneurysms treated by clipping were reviewed retrospectively. Among them, 24 cases (12 males) underwent intentional partial clipping followed by endovascular treatment of the clipped aneurysm.

**Result:** The Most common location of the partially clipped aneurysms was the anterior cerebral artery(n=9), with 7 cases at the anterior communicating artery, 1 case at A1 and 1 case at distal ACA. This was followed by distal internal carotid artery(n=7), middle cerebral artery (n=6) and posterior circulation (n=2). The mean maximal size of the aneurysms was 6.2  $\pm$  2.3 mm. The main reasons for partial clipping was atherosclerosis (n=12), and the relation with incorporated branches (n=6). Subsequent endovascular treatment was performed after an average of 143.5  $\pm$  90.9 days (range 42-410 days). The majority of the clipped aneurysms showed a reduction in size at the time of endovascular treatment, with 4 cases achieving complete, spontaneous occlusion and 9 cases showing a decrease in size. Maintained the same size of aneurysm was 10 and only one case showed an increase in the residual sac size with hemorrhage. Most cases were treated with coil alone (n=13), while 3 cases underwent stent-assisted coil embolization and 1 case underwent flow diversion.

**Conclusion:** Combined endovascular treatment with intentional partial clipping of unclippable aneurysms can be an effective strategy in complex cases

VS3-4

## How to Minimize Complications in Flow Diversion Treatment

Akira ISHII

Department of Neurosurgery, Juntendo University Hospital, Japan

Flow diversion has become an established treatment for intracranial aneurysms; however, ischemic and hemorrhagic complications remain important concerns. We have developed a standardized strategy to minimize these complications throughout the perioperative period. To reduce ischemic events, platelet function is assessed using the P2Y12 reaction unit (PRU) in every patient before treatment. Antiplatelet therapy is individually adjusted according to the PRU value. When the PRU is below 100, the antiplatelet regimen is reduced to avoid excessive platelet inhibition. In patients with a PRU above 200, a surface-coated flow diverter is routinely selected to reduce device-related thrombogenicity. This PRU-guided approach allows us to balance the risks of thromboembolism and hemorrhage.

Hemorrhagic complications, particularly delayed aneurysm rupture, are addressed not only by optimizing antiplatelet therapy but also by performing adjunctive coil embolization in all cases. Coils are loosely placed within the aneurysm to promote early intra-aneurysmal thrombosis and provide additional protection during the period before complete endothelialization of the flow diverter. Careful coil placement is essential to avoid excessive device manipulation and mass effect.

Access-site complications are minimized by adopting the transradial approach whenever anatomically feasible. Currently, approximately 80% of our flow diversion procedures are performed via radial access, which facilitates early mobilization and reduces the risk of major groin-related bleeding.

A systematic strategy combining individualized PRU-guided antiplatelet management, appropriate selection of coated devices, routine adjunctive coiling, and the transradial approach may substantially improve the safety of flow diversion treatment.

## The Role of Direct Surgery for Complex Cerebral Aneurysms: Importance of Skull Base Techniques

Hiroshi ABE, Hiromasa KOBAYASHI, Koichiro TAKEMOTO, Mitsutoshi IWAASA

Department of Neurosurgery, Fukuoka University, Fukuoka, Japan

**Background and Aims:** Despite advances in endovascular techniques, some complex cerebral aneurysms still require direct surgery. In many of these cases, both endovascular and microsurgical treatment are technically challenging. We evaluated the surgical outcomes of direct surgery for complex cerebral aneurysms.

**Methods:** We retrospectively reviewed 93 patients with complex cerebral aneurysms who underwent direct surgery between October 2010 and December 2025.

**Results:** The aneurysm locations were the internal carotid artery (ICA) in 29 patients, middle cerebral artery (MCA) in 7, anterior cerebral artery (ACA) in 4, superior cerebellar artery (SCA) in 4, posterior cerebral artery (PCA) in 7, posterior inferior cerebellar artery (PICA) in 16, and vertebral artery (VA) in 26. Bypass surgery was performed in 82 patients, often using advanced skull base surgical techniques to obtain adequate surgical exposure and vascular control, and hybrid treatment combining direct surgery with endovascular procedures was performed in 16 patients. Complete aneurysm occlusion was achieved in 93.5% of patients, and a favorable functional outcome (modified Rankin Scale score 0-2) was observed in 92.5%. Transient and permanent complications occurred in 33.9% and 7.5% of patients, respectively. Perforator infarction occurred relatively frequently during treatment of PCA, posterior communicating artery (PCoA), SCA, and VA aneurysms requiring parent artery occlusion.

**Conclusions:** Direct surgery remains an indispensable treatment option for complex cerebral aneurysms. Favorable outcomes can be achieved through advanced microsurgical expertise combined with skull base surgical techniques, particularly in cases requiring complex vascular reconstruction and deep operative exposure. Careful preservation of perforating arteries during parent artery occlusion is critical to minimizing ischemic complications.

VS4-2

## **Microscopic cerebrovascular neurosurgery using bypass and skull base technique**

Tomohiro INOUE

Department of Neurosurgery, NTT medical center Tokyo, Japan

In the Era of Endovascular and Less invasive treatment, we cerebrovascular microscopic neurosurgeons need to sincerely consider radicality and safety of the treatment. To accomplish Radicality and Safety in microscopic neurosurgery, I would say there are two important issues. First, appropriate and enough surgical corridor including skull base approaches. Second, cerebral revascularization techniques including various bypasses. Surgical videos including various approaches such as anterior clinoidectomy, transcondylar fossa approach, transpetrosal drilling, as well as high flow bypass, A3A3, STASCA would be presented and discussed.

## Optimizing the Posterior Fossa Corridor: A Tailored Skull-Base Microsurgical Strategy

Hyun Jin HAN, Hyun Jin HAN, Keun Young PARK, Jung-jae KIM, Solbi KIM, Yong Bae KIM  
Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

In the modern endovascular era, tailored microsurgical approaches remain essential for treating complex cerebrovascular lesions in the posterior fossa. This presentation highlights the efficacy of specialized skull-base strategies through two challenging cases.

The first case involves a craniocervical junction dural arteriovenous fistula (dAVF), where a far-lateral approach provided the necessary visualization for definitive surgical ligation. The second case describes a cerebellar AVM associated with a flow-related aneurysm located in the internal acoustic canal (IAC), requiring intricate microsurgical clipping and resection.

These cases demonstrate that customized surgical corridors, grounded in precise anatomical knowledge, are critical for managing lesions where endovascular access is limited or high-risk. We conclude that microsurgery continues to play a vital role as a primary or complementary treatment in contemporary neurovascular practice.

VS4-4

## **Surgical Treatment for Complex Aneurysms using Adenosine-Induced Cardiac Standstill**

**Dong-Kyu JANG, Young Hoon CHOI, Byung-rae CHO, Dong Sub KIM**

Department of Neurosurgery, Incheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Incheon, ROK

This report presents two cases of complex cerebral aneurysms successfully managed using adenosine-induced cardiac standstill. Case 1: A 20-year-old female presented with an unruptured left ophthalmic aneurysm closely involving the ophthalmic artery origin. To avoid arterial compromise from endovascular coiling, a contralateral frontosphenotemporal craniotomy was performed. Intravenous adenosine (24, 36, and 42 mg) induced transient asystole (3, 40, and 33 seconds), facilitating safe dissection and successful clipping without postoperative cardiac or new neurological deficits. Case 2: A 65-year-old female presented with a symptomatic giant left P1 posterior cerebral artery (PCA) aneurysm alongside left superior cerebellar artery (SCA) and anterior inferior cerebellar artery (AICA) aneurysms. After failed endovascular attempts, a partial orbitozygomatic and transcavernous approach was conducted under navigation guidance. Total 18 mg of adenosine was administered, enabling safe clipping of the SCA and AICA aneurysms during cardiac standstill. The P1 segment was proximally ligated with perforator preservation. The giant aneurysm was successfully excluded with collateral flow via the posterior communicating artery. Despite transient postoperative deficits, the patient improved to a modified Rankin Scale score of 2 at 18 months. In conclusion, adenosine-induced cardiac standstill is a safe and valuable adjunct in the microsurgical management of complex anterior and posterior circulation aneurysms, particularly when endovascular approaches are unfavorable or have failed. By providing temporary flow arrest, it facilitates safe dissection and precise clipping in challenging anatomical locations without significant cardiac complications.

## **Microsurgical Strategies for Complex Internal Carotid-Posterior Communication Aneurysms Unsuitable for Endovascular Therapy**

Katsumi TAKIZAWA

Department of Neurosurgery, Japanese Red Cross Asahikawa Hospital, Japan

Factors complicating the treatment of internal carotid-posterior communicating (IC-PC) artery aneurysms differ significantly between microsurgery and endovascular therapy. Anatomical barriers encountered during open surgery--such as the projection of the aneurysm dome or firm adhesions to cranial nerves and critical vessels, including the anterior choroidal artery--are typically circumvented in endovascular treatment. Therefore, an endovascular approach should be prioritized in such instances.

Conversely, cases involving a fetal-type posterior communicating artery (PCoA), microaneurysms, large or thrombosed aneurysms, and recurrent lesions remain challenging even with endovascular techniques. While microsurgery should be considered for anatomically suitable cases, the technical demands remain exceptionally high. Achieving optimal outcomes for these complex aneurysms necessitates surgical strategies meticulously tailored to their specific anatomical characteristics. Key steps include securing reliable proximal control, achieving adequate surgical exposure via skull base techniques such as anterior clinoidectomy, and ensuring definitive aneurysm obliteration using multiple-clip reconstruction or concomitant bypass surgery.

In this presentation, we demonstrate intraoperative videos of challenging cases to illustrate the formulation of surgical strategies that ensure safe and definitive outcomes.

VS5-2

## Surgical strategy for safe microsurgical clipping of complex internal carotid-posterior communicating artery aneurysms

Shuntaro TOGASHI, Junta MOROI, Hiroaki SHIMIZU

Department of Neurosurgery, Akita Cerebrospinal and Cardiovascular Center, Akita, Japan

**Background:** Complex internal carotid-posterior communicating (IC-PC) aneurysms including large/giant aneurysms and regrowth after microsurgical or endovascular treatment, sometimes require microsurgical clipping for the reason such as oculomotor nerve compression or fetal type posterior communicating artery originating from the aneurysmal dome. Several adjunctive techniques are necessary for safe microsurgical clipping of the complex IC-PC aneurysms.

**Methods:** We performed a retrospective personal review of 18 IC-PC aneurysm cases treated by microsurgical clipping between April 2024 and July 2026. The anterior temporal approach was performed as a basic technique in all cases. Various adjunctive techniques such as anterior clinoidectomy, tentorial dissection, endoscopic inspection and retrograde suction decompression were combined if necessary.

**Results:** Three complex IC-PC aneurysms treated with adjunctive techniques. Temporary mild oculomotor palsy was observed in all cases, and additional endovascular coiling for the residual aneurysmal dome was needed in one case. All cases discharged with a favorable outcome (modified Rankin Scale 1).

**Conclusion:** For the safe microsurgical clipping of complex IC-PC aneurysms, several adjunctive techniques are necessary. Herein, we demonstrate surgical videos and would like to discuss about the strategy.

## Technical Pearls and Pitfalls in Pcom Aneurysm Clipping

Yong Bae KIM

Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, ROK

Posterior communicating artery (PCoA) aneurysms are one of the most frequently encountered Internal carotid artery (ICA) aneurysms, and microsurgery for PCoA aneurysms are still an important tool for cerebrovascular neurosurgeons even in the era of endovascular treatment. However, the variation in the surrounding anatomy of aneurysms, large parent arteries, critical perforators and unique direction of the aneurysm dome may make microsurgery challenging.

Main concerns between PCoA aneurysm and anatomical relations are dural folds consisting of cavernous sinus roof, oculomotor nerve and medial aspect of temporal lobe. The attachment of aneurysms to the oculomotor nerve and uncus can lead to unexpected cranial nerve injury or premature rupture of aneurysm during the clip placement and ICA manipulation. As following the principles of aneurysm surgery, attention must to be paid to predict the difficulty of proximal vascular control. Anterior clinoid process (ACP) is sometimes cumbersome to secure proximal ICA so that removal of ACP is required either intra or extradurally.

From our analysis for the relation of 22 serial PCoA aneurysms to the anterior petroclinoid fold (APCF), 9 cases were pointing downward of APCF (Infrafold type) and the rest of 13 cases were overhanging the APCF (Suprafold type), which affected quite a lot to surgical nuances from neck dissection to final clip deployment.

From our previous investigation, the ICA aneurysms were the most common location for post clip remnants. Advancements in surgical equipment such as intraoperative endoscope may help to confirm the completeness of clip ligation.

In this presentation, the authors try to convey lessons learned from their experiences of PCoA aneurysm clipping in accordance to the factors written above using photos and videos of clinical cases.

VS5-4

## **Surgical treatment of an angiographically obliterated large IC-PC aneurysm presenting with oculomotor nerve palsy: a case report**

Jiwook RYU, Jae Sung HONG, Gyudong YEO, Seok Keun CHOI

Department of Neurosurgery, Kyung Hee university, Seoul, ROK

### Introduction

Coil embolization is a well-established treatment for ruptured intracranial aneurysms, but angiographic obliteration does not always reflect true biological stability of the aneurysm wall. We report a case of an angiographically obliterated large IC-PC aneurysm presenting with oculomotor nerve palsy that was treated surgically.

### Case description

A 61-year-old woman who had undergone coil embolization for a ruptured IC-PC aneurysm at another hospital three years earlier presented to our institution with third nerve palsy. Digital subtraction angiography showed near-total obliteration of the aneurysm; however, vessel wall MRI revealed circumferential enhancement of the aneurysm wall, suggesting wall instability, and surgical treatment was therefore planned. Because of the possibility of parent artery occlusion, an insurance high-flow bypass using a radial artery graft was performed first. The aneurysm was then exposed and the coils were removed in a piecemeal fashion. Intraoperative bleeding from the aneurysm occurred during coil removal and was controlled with a fenestration clip. Approximately 60-70% of the coil mass was ultimately removed, and the operation was completed after confirming that the oculomotor nerve was intact. At two years of follow-up, the patient had an excellent outcome with a final modified Rankin Scale score of 0.

### Conclusion

An angiographically obliterated coiled aneurysm may still warrant surgical treatment when a progressive cranial nerve palsy and vessel wall enhancement suggest wall instability. A protective high-flow bypass enables safe coil removal and clipping when the parent artery is at risk, and with careful management of complications such as CSF leak, a favorable clinical outcome can be achieved.

## **Stratified Assessment of Clazosentan Efficacy Following Subarachnoid Hemorrhage: New era of cerebral vasospasm treatment**

**Hiroyuki SAKATA, Hidenori ENDO**

Department of Neurosurgery, Tohoku University Graduate School of Medicine, Sendai, Japan

Japanese phase 3 trials demonstrated efficacy and safety of clazosentan for aneurysmal subarachnoid haemorrhage (SAH) management. However, real-world data remain limited, particularly in elderly, poor-grade, or outside of Fisher group 3 patients. Therefore, we aimed to evaluate its safety and efficacy in real-world clinical settings. This study utilized prospectively collected data from consecutive SAH patients across four stroke centres, comparing 187 patients treated with clazosentan to 223 patients receiving standard of care. The incidence of favorable functional outcomes at 90 days after SAH, occurred more frequently in patients receiving clazosentan. Multiple logistic analyses identified clazosentan administration as independently associated with favorable functional outcomes. Angiographic vasospasm and vasospasm-related infarcts were less frequent among patients receiving clazosentan. Stratification analyses revealed that clazosentan usage increased the incidence of favorable functional outcomes regardless of age, sex, SAH severity, and clot volume. These results underscore the therapeutic potential of clazosentan against cerebral vasospasm independent of patient characteristics.

## Update Management for Cerebral Vasospasm

Shinsuke MURAOKA<sup>1,2</sup>, Ryuta SAITO<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, JCHO Chukyo Hospital, Aichi, Japan,

<sup>2</sup>Department of Neurosurgery, Nagoya University Graduate School of Medicine

Cerebral vasospasm and delayed cerebral ischemia (DCI) remain leading determinants of outcome after aneurysmal subarachnoid hemorrhage (aSAH). Since Ecker and Riemenschneider first depicted angiographic spasm in 1951, prevention has evolved through the triple-H era, oral nimodipine (the Western standard), and the Rho-kinase inhibitor fasudil in Japan. The CONSCIOUS trials then exposed a fundamental disconnect: clazosentan markedly reduced angiographic spasm yet did not improve functional outcome, shifting the paradigm from large-vessel spasm toward a multifactorial model of DCI that includes microthrombosis, cortical spreading depolarization, blood-brain-barrier breakdown, and impaired autoregulation.

Japan occupies a distinctive position: nimodipine has never been licensed, fasudil-based multimodal prophylaxis is standard, and in April 2022 Japan became the first country worldwide to approve clazosentan for aSAH. In our multicenter RECOVER program (inverse-probability-weighted, n=466), clazosentan versus fasudil reduced angiographic vasospasm (33.7% to 15.4%) and vasospasm-related DCI (10.2% to 4.4%) and improved favorable outcome (modified Rankin Scale 0-2, 50.5% to 62.2%). Machine-learning (SHAP) analysis identified clazosentan use and treatment completion as key favorable predictors, whereas fluid-retention complications predicted poor outcome. An early positive fluid balance (at least +750 mL/day over postoperative days 1-3) independently predicted discontinuation, which halved the odds of favorable recovery; a euvolemia-anchored protocol and cilostazol combination (DCI 0% versus 7.5%) mitigate this limiting factor.

The field is now moving from real-world evidence toward randomization: the SAVIOR trial directly compares clazosentan with fasudil, with 90-day functional independence as the primary endpoint. Because Japan share a nimodipine-free practice, they are uniquely positioned to jointly define the future standard for vasospasm and DCI prevention. This presentation synthesizes a century of progress into practical, individualized management.

## Perioperative Low-dose Aspirin Management for Planned Clipping Surgery: When, How Long, and With What Precautions?

Hyun Jin HAN, Yong Bae KIM, Jung-jae KIM, Keun Young PARK

Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

**BACKGROUND and OBJECTIVE:** Perioperative low-dose aspirin (ASA) management for open craniotomy surgery lacked information. We analyze to establish the perioperative ASA strategy to minimize both hemorrhagic and thromboembolic complications.

**METHODS:** The investigators designed a multicenter retrospective study, which included patients scheduled to have clipping surgery for unruptured intracranial aneurysm (UIA). The incidence and risk factors were analyzed for postoperative hemorrhagic complications and major cardio- and cerebrovascular events (MACCEs) within one-month post-operation.

**RESULTS:** The present study included 503 long-term ASA users out of 3654 patients at three tertiary centers. The incidence of hemorrhagic complications and MACCEs was 7.4% (37/503) and 8.8% (44/503), respectively. Older age ( $> 70$  years, OR: 2.928, 95% CI [1.337, 6.416]), multiple aneurysms operation (OR: 2.201, 95% CI [1.017, 4.765]), large aneurysm ( $> 10$ mm, OR: 4.483, 95% CI [1.485, 13.533]), and ASA continuation (OR: 2.604, 95% CI [1.222, 5.545]) were independent risk factors for postoperative hemorrhagic complications. Intracranial hemorrhage was the only type of hemorrhagic complication that increased in the ASA continuation group (10.6% vs 2.9%,  $p = .001$ ). Between the ASA continuation and discontinuation groups, the overall incidence of MACCEs was not significantly different (log-rank  $p = .8$ ). In the subgroup analysis, ASA discontinuation significantly increased the risk of MACCEs in the secondary prevention group (aHR: 2.580, 95% CI [1.015, 6.580]).

**CONCLUSION:** ASA continuation increased the risk of postoperative intracranial hemorrhage. Simultaneously, ASA discontinuation was the major risk factor for postoperative MACCEs in the high-risk group. Without evidence of intracranial hemorrhage, early ASA resumption was indicated (a total cessation duration  $< 7$ -10 days) in the secondary prevention group.

O1-2

## **Staged Multimodal treatment of Complex Unruptured Intracranial Aneurysms Using Deep Bypass and Endovascular Reconstruction**

Yuto SHINGAI<sup>1</sup>, Atsushi KANOKE<sup>1</sup>, Yoshimichi SATO<sup>1</sup>, Hiroyuki SAKATA<sup>2</sup>,  
Syunsuke OMODAKA<sup>3</sup>, Yuya KATO<sup>3</sup>, Arata NAGAI<sup>3</sup>, Hidenori ENDO<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Kohnan Hospital, Sendai, Miyagi, Japan, <sup>2</sup>Department of Neurosurgery, Tohoku University Graduate School of Medicine, Sendai, Miyagi, Japan, <sup>3</sup>Department of Neuroendovascular Therapy, Kohnan Hospital, Sendai, Miyagi, Japan

**Background:** Complex unruptured intracranial aneurysms incorporating major branches or perforators are often difficult to cure safely with either microsurgical or endovascular treatment alone. In such lesions, staged multimodal strategy, integrating deep bypass, endovascular reconstruction, imaging surveillance, and retreatment should be considered.

**Methods:** We retrospectively reviewed 19 patients with complex unruptured intracranial aneurysms treated between April 2014 and March 2024 using deep bypass combined with endovascular therapy. Deep bypass procedures included STA-SCA bypass, STA-PCA bypass, and OA-AICA bypass, with a total of 24 anastomoses. Evaluated variables included aneurysm location and size, prior endovascular treatment, partial thrombosis, endovascular procedure, need and timing of retreatment, final imaging findings, aneurysm control, and clinical outcome. Aneurysm control was assessed using interval aneurysm growth, new hemorrhage, and worsening mass effect on surrounding structures besides occlusion status.

**Result:** Aneurysm locations were the basilar apex in 6 patients, basilar-superior cerebellar artery junction in 6, internal carotid-posterior communicating artery in 5, basilar trunk in 1, and posterior cerebral artery dissection in 1. Median maximum diameter was 16.7 mm (7.7-32.2 mm). 18 aneurysms were large, 8 were recurrent after prior endovascular therapy, and 3 were partially thrombosed. All patients underwent stent-assisted coil embolization after bypass. During follow-up, 5 patients underwent additional endovascular treatment for aneurysm progression, at a median of 12 months (1-36 months). One patient underwent flow-diverter treatment. Final imaging showed complete obliteration in 7 patients, neck remnant in 6, and residual body filling in 6. Aneurysm control was maintained in 17 of 19 patients. Final modified Rankin Scale scores were 0-2 in 15 patients.

**Conclusion:** For complex unruptured aneurysms, long-term aneurysm control may require a staged multimodal strategy rather than a single definitive procedure. Deep bypass can expand the safety and flexibility of endovascular reconstruction and retreatment, enabling stepwise control of otherwise difficult lesions.

## A Retrospective Single-center Study on Treatment Strategy and Clinical Outcome of Giant Intracranial Aneurysm

Ju Whan LEE<sup>1</sup>, Sung Tae KIM<sup>2</sup>, Seung Gi LEE<sup>1</sup>, Jin LEE<sup>1</sup>,  
Hae Woong JEONG<sup>3</sup>, Young Gyun JEONG<sup>1</sup>

<sup>1</sup>The Department of Neurosurgery, Inje University Busan Paik Hospital, Busan, ROK, <sup>2</sup>Department of Neurosurgery, Inje University Haeundae Paik Hospital, Busan, ROK, <sup>3</sup>Department of Radiology, Inje University Busan Paik Hospital, Busan, ROK

**Background:** A giant intracranial aneurysm (GIA) measures “>” 25mm and is a rare, challenging condition to treat with a poor prognosis. Selecting the appropriate treatment approach, whether surgical, endovascular, or a combination of both, is crucial for achieving favorable outcomes. However, the unique characteristics of each GIA imply that no single treatment option can be considered optimal universally. This study aimed to evaluate the treatment strategies and clinical outcomes at our center.

**Methods:** This retrospective single-center study conducted between 2012-2026 included about 25 patients with GIA. We comprehensively reviewed demography, aneurysm characteristics, clinical and radiography data, treatment strategies, and angiography and clinical outcomes.

**Results:** The average maximum GIA was 29.4 (excluding serpentine). 17 aneurysms were located in the internal carotid artery (ICA); 3, anterior cerebral artery; and 5, middle cerebral artery. Morphologically, 23 saccular and 2 serpentine aneurysms were observed. Among them, 14 were symptomatic, with 9 presenting with subarachnoid hemorrhage, of which 5 were accompanied by intracerebral hemorrhage. Cranial nerve-related symptoms were observed in five ICA aneurysms, and two involved a carotid cavernous fistula. Five patients had multiple aneurysms accompanied by GIA. The treatment modalities varied; eight patients initially underwent surgical treatment. Regarding the number of treatment steps, 18 patients required one step, 5 required two steps, and 2 required three steps. In eight patients, parent artery occlusion (with or without bypass surgery) was the final treatment approach. After 1 year, 70% of patients achieved a favorable outcome, as indicated by a modified rankin scale score “<”3

**Conclusion:** Patient-specific treatments are crucial for improving clinical outcomes. Advancements in endovascular treatment have been made owing to the development of new devices. Parent artery occlusion with vascular bypass was a reliable treatment option.

O1-4

## **Enhanced Recovery After Surgery in clipping surgery for unruptured cerebral aneurysm: prospective nonrandomized controlled trial**

Jung-Jae KIM, Jaemin YU, Susy YOUN, Hyun Jin HAN, Keun Young PARK, Yong Bae KIM,  
Solbi KIM, Jiwoong OH

Department of Neurosurgery, Yonsei University, Seoul, ROK

As endovascular coiling has gained popularity, clipping has evolved to reduce operative burden, yet improvements have centered on surgical technique rather than perioperative care. Enhanced Recovery After Surgery (ERAS) programs improve outcomes across surgical fields but remain inconsistently applied in neurosurgery, with few pathology-specific frameworks. This study evaluated whether an ERAS protocol for elective aneurysm clipping could improve pain control, reduce postoperative nausea and vomiting (PONV), and enhance recovery quality.

This single-center, prospective, open-label study enrolled adults undergoing elective clipping of unruptured intracranial aneurysms at Severance Hospital, Seoul. Consecutive patients were assigned to pre-ERAS (January 2023-February 2024) or ERAS (February-December 2024) cohorts. The ERAS protocol incorporated preoperative education, optimized fasting, local anesthesia, antiemetics, and early ambulation with nonopioid analgesia. Pain scores, PONV incidence, and Quality of Recovery-40 (QoR-40) results were compared using the Mann-Whitney U-test, Fisher's exact test, and multivariate regression to adjust for confounders.

Of 414 procedures analyzed (234 pre-ERAS, 180 ERAS), baseline demographics and aneurysm characteristics were comparable. Postoperative pain scores were significantly lower in the ERAS group across postoperative days (PODs) 0-3 (all  $p < 0.001$ ), and ERAS was the only independent protective factor for pain. Opioid use decreased markedly, with earlier transition to oral nonopioid analgesics. PONV incidence was significantly lower from PODs 1-3, with ERAS remaining an independent protective factor after adjustment. QoR-40 scores on POD 2 were higher in the ERAS group, indicating improved comfort and well-being, while hospital stay and complication rates were comparable.

The ERAS protocol improved pain control, reduced PONV, and enhanced recovery after aneurysm clipping. These findings support the feasibility of ERAS in craniotomy and highlight potential for further optimization.

## Flow Diverter Therapy for Intracranial Aneurysms in Japan: Device Selection, Expanding Indications, and Contemporary Challenges

Masakazu OKAWA

The department of Neurosurgery, National Cerebral and Cardiovascular Center, Osaka, Japan

Flow diverter (FD) therapy has become an essential modality for the treatment of complex intracranial aneurysms in Japan, particularly following the introduction and clinical dissemination of three major devices: Pipeline Shield, FRED X, and Surpass Evolve. Each device exhibits distinct structural and surface characteristics, which influence device selection based on aneurysm morphology, parent vessel anatomy, and clinical presentation. Pipeline Shield, with its phosphorylcholine surface modification, is often favored in cases requiring enhanced biocompatibility and thromboresistance, whereas FRED X offers dual-layer design advantages that may be beneficial in tortuous vessels or wide-neck aneurysms. Evolve, characterized by high mesh density and resheathability, provides additional procedural flexibility.

Recent expansion of indications has broadened the application of FD therapy in Japan. Notably, FD use in branching aneurysms, particularly those involving fetal-type posterior communicating arteries (PCoM), remains controversial. These cases pose a risk of branch occlusion or insufficient aneurysm occlusion due to persistent flow demand. Similarly, the treatment of aneurysms presenting with mass effect symptoms introduces unique challenges, as delayed thrombosis and transient aneurysm enlargement may exacerbate neurological deficits before clinical improvement is achieved.

Furthermore, recent regulatory updates have permitted the application of Pipeline Embolization Device (PED) and Evolve to medium-sized aneurysms, extending the therapeutic scope beyond large or giant aneurysms. Emerging evidence from recent international studies suggests improved occlusion rates and acceptable safety profiles in this cohort, although long-term data remain limited.

In this presentation, we summarize current practices in Japan, focusing on device selection strategies, technical considerations in complex aneurysm subtypes, and evolving indications.

O1-6

## Predictors of delayed adverse events after discontinuation of dual antiplatelet therapy in patients undergoing stent-assisted coiling and flow diverter placement

Takenori OGURA<sup>1,2</sup>, Takeru UMEMURA<sup>2</sup>, Takeshi MIYATA<sup>2,3</sup>, Yuji AGAWA<sup>2,4</sup>,  
Yusuke NAKAZAWA<sup>2,5</sup>, Taketo HATANO<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, National Cerebral and Cardiovascular Center, Suita, Osaka, Japan, <sup>2</sup>Department of Neurosurgery, Kokura Memorial Hospital, Kitakyushu, Fukuoka, Japan, <sup>3</sup>Department of Neurosurgery, Kyoto University Graduate School of Medicine, Kyoto, Kyoto, Japan, <sup>4</sup>Department of Neurosurgery, Medical Research Institute Kitano Hospital, Osaka, Osaka, Japan, <sup>5</sup>Department of Neurology, Saiseikai Fukuoka General Hospital

**Purpose:** Antiplatelet therapy (APT) is essential to prevent adverse ischemic events related to stent-assisted coiling (SAC) and flow diverter (FD) placement. However, the optimal management of APT to avoid delayed adverse events are still not fully understood. The aim of this study is to investigate factors contributing delayed adverse ischemic events after switching from dual (DAPT) to single antiplatelet therapy (SAPT) and assess the impact of antiplatelet agent selection.

**Materials and Methods:** We retrospectively analyzed data from patients who underwent SAC or FD between 2018 and 2022 and were followed up for >12 months in Kokura Memorial Hospital. The data on patient demographics, aneurysm characteristics, procedural details, peri- and postprocedural APT regimens, aneurysm obliteration status, and adverse events were obtained from medical records. Ischemic events were defined as newly recognized cerebral infarctions or clinically recognized neurological or visual symptoms associated with the treated vascular territory. Patients with and without delayed ischemic events following DAPT discontinuation were compared with respect to all evaluated variables.

**Results:** A total of 295 patients enrolled in the study. The median follow-up period after treatment was 37 months. Eleven (3.7%) patients presented with delayed ischemic events after DAPT discontinuation. Univariate analysis revealed that smoking history ( $p = 0.025$ ), diabetes mellitus ( $p = 0.020$ ), multiple stent deployment ( $p = 0.036$ ), aneurysm occlusion status at DAPT discontinuation ( $p = 0.025$ ), and antiplatelet agent selection ( $p = 0.028$ ) were associated with the incidence of delayed ischemic events. In the multivariate analysis with a Cox proportional hazards model, discontinuation of P2Y12 inhibitor was an independent predictor (odds ratio: 4.69, 95% confidence interval: 1.01 - 21.8,  $p = 0.049$ ) after adjusting for incomplete occlusion at DAPT discontinuation.

**Conclusions:** P2Y12 inhibitors were a feasible option for reducing delayed adverse events related to SAC and FD when switching from DAPT to SAPT.

## Angioarchitecture and Management of Vein of Galen Dural Arteriovenous Fistulas

Kyu Seon CHUNG<sup>1</sup>, Kyu Seon CHUNG<sup>1</sup>, Jung Keun LEE<sup>1</sup>, Sang Kyu PARK<sup>1</sup>, Hyun Jin HAN<sup>2</sup>,  
Jung-jae KIM<sup>2</sup>, Keun Young PARK<sup>2</sup>, Yong Bae KIM<sup>2</sup>, Dong Joon KIM<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, ROK,

<sup>2</sup>Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, Seoul, ROK, <sup>3</sup>Department of Radiology, Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

### Background

Vein of Galen dural arteriovenous fistulas (VoG DAVFs) are rare lesions located at the anterior falcotentorial junction. This study aimed to characterize the angioarchitectural features of VoG DAVFs and evaluate the treatment outcomes.

### Methods

Among 608 patients treated for DAVFs between January 2009 and June 2025, seven patients with VoG DAVFs were identified. Angioarchitectural features including the type of feeders, drainage pattern, clinical characteristics, and treatment outcomes were evaluated.

### Results

Among the seven patients, four were male and the median age was 51 years. Hydrocephalus was present in 2 patients (28.6%). Four patients (57.1%) were asymptomatic, and none presented with cerebral hemorrhage. Dural and pial arterial feeders converged to the posterior and the anterior aspect of the VoG, respectively. Pial arterial feeders were identified in six patients (85.7%). Venous reflux was observed in five patients (71.4%). Dissociation of venous drainage pattern with reflux into the basal veins of Rosenthal but antegrade flow in the ICVs was noted in two patients. Four patients were treated with stereotactic radiosurgery (SRS) alone, and three underwent combined endovascular treatment (EVT) and SRS. One patient experienced thalamic infarction following EVT. During follow-up, all patients demonstrated favorable clinical outcomes, with complete obliteration in five cases and significant regression in two cases.

### Conclusion

VoG DAVFs are rare lesions with unique characteristics in terms of the frequent pial feeder recruitment and the venous drainage pattern. Careful analysis of the angioarchitecture with a tailored treatment strategy including SRS is warranted for safe and effective management.

O2-2

## Microsurgical resection for intermediate-grade brain arteriovenous malformations

Taku SUGIYAMA<sup>1</sup>, Masaki UJIHARA<sup>1</sup>, Toshiya OSANAI<sup>1</sup>,  
Naoki NAKAYAMA<sup>2</sup>, Miki FUJIMURA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Hokkaido University Graduate School of Medicine, Sapporo, Japan, <sup>2</sup>Department of Neurosurgery, Sapporo Hakuyokai Hospital, Sapporo, Japan

**Background:** Intermediate-grade brain arteriovenous malformations (AVMs), corresponding to Spetzler-Martin (S-M) grade III lesions, encompass heterogeneous subtypes and remain challenging for treatment selection. We evaluated outcomes of microsurgical resection for intermediate-grade AVMs at our institution.

**Methods:** We retrospectively reviewed 25 consecutive patients with S-M grade III AVMs who underwent microsurgical resection between April 2015 and October 2025. Postoperative deterioration was defined as modified Rankin Scale (mRS) worsening by 2 or more points, including transient deterioration, and favorable outcome as final mRS 0-2. Factors associated with deterioration were analyzed using Fisher exact test and Cochran-Armitage trend test.

**Results:** Mean age was 32.7 years (range 5-67); 18 patients (72%) presented with hemorrhage and 6 (24%) had deep-seated lesions. Subtypes were S1V1E1 (III-) in 11 patients (44%), S2V1E0 in 2 (8%), and S2V0E1 (III+) in 12 (48%). Preoperative embolization was performed in 10 patients (40%). Complete obliteration was achieved in 24 patients (96%), and final mRS 0-2 in 22 (88%). Postoperative neurological deterioration occurred in 5 patients (20%), including permanent deterioration in 1 (4%). S2V0E1 subtype ( $p=0.012$ ), nidus size 3-6 cm ( $p=0.05$ ), and unruptured presentation ( $p=0.01$ ) were associated with deterioration. Deterioration was more frequent in unruptured than ruptured AVMs (4/7, 57% vs 1/18, 6%).

**Conclusions:** Microsurgical resection for intermediate-grade AVMs achieved high obliteration rates and favorable functional outcomes. However, S2V0E1 lesions and unruptured AVMs were associated with postoperative deterioration, indicating the need for careful treatment selection and individualized surgical strategy.

## Treatment of Spinal Arteriovenous Fistulas Associated with Spinal Lipoma

Yasuyuki KAKU<sup>1</sup>, Hiro KIYOSUE<sup>2</sup>, Hiroki UCHIKAWA<sup>1</sup>, Yukihiro IMAOKA<sup>1</sup>,  
Takeshi TONEGAWA<sup>1</sup>, Takeshi MIYATA<sup>3</sup>, Taketo HATANO<sup>3</sup>, Akitake MUKASA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kumamoto University Hospital, Kumamoto, Japan, <sup>2</sup>Department of Radiology, Kumamoto University Hospital, Kumamoto, Japan, <sup>3</sup>Department of Neurosurgery, Kokura Memorial Hospital, Fukuoka, Japan

### BACKGROUND:

Spinal arteriovenous fistulas (SAVFs) rarely occur in association with spinal lipoma and tethered cord syndrome. Because of their unique angioarchitecture, diagnosis and treatment can be challenging. We analyzed the clinical and angiographic features, treatment strategies, and outcomes of SAVFs associated with spinal lipoma.

### MATERIALS AND METHODS:

Five consecutive patients with SAVFs associated with spinal lipoma treated at two institutions over the past four years were retrospectively reviewed. Clinical presentation, MRI/MRA findings, angiographic characteristics, treatment modalities, and outcomes were analyzed.

### RESULTS:

All five patients had SAVFs within spinal lipoma and concomitant tethered cord. The mean age at presentation was 62 years. The most common symptom was lower-extremity sensory disturbance, followed by motor weakness and bladder/bowel dysfunction. Fistulas were located at the L4, S1, S2-3, S3-4, and below-S4 levels. A single fistulous point was identified in one patient, whereas four had multiple fistulas. Arterial supply arose from the lateral sacral artery and the artery of the filum terminale in three patients, an L4 segmental artery in one, and the inferior gluteal artery in one. Venous drainage was exclusively intradural in four patients and both intradural and extradural drainage in one. Treatment consisted of microsurgical disconnection alone in two patients, transarterial embolization (TAE) with NBCA alone in two, and combined TAE and microsurgery in one. Clinical symptoms improved in all patients, and neurological status remained stable during follow-up (2-26 months).

### DISCUSSION:

SAVFs associated with spinal lipoma commonly exhibit complex angioarchitecture, including multiple fistulas and recruitment of the artery of the filum terminale from the anterior spinal artery. Careful evaluation of the relationship between the fistula and the conus medullaris is essential when considering TAE to avoid inadvertent embolization of the anterior spinal artery. Therefore, treatment should be individualized based on the angioarchitectural characteristics of each lesion.

O2-4

## Interesting Surgical Approached Transvenous Embolization for Cavernous Sinus dAVF

Bum-Tae KIM, Dong-seong SHIN, Ho Jun YI

Soonchunhyang University Bucheon Hospital, ROK

Background: To present interesting transvenous embolization combined with surgical approach in patients with cavernous sinus dural arteriovenous fistulas (CS dAVFs).

Method: In three of the four cases, access was through the ophthalmic vein (Oph.V), and in one case, access was possible through the superficial middle cerebral vein (SMCV) after craniotomy.

Results

A 73-year-old woman was diagnosed with bilateral CS dAVF. Approach through the left Oph.V was attempted, but the vein collapsed and puncture failed. After a second attempt, access was possible with a 5Fr. short sheath, and coil embolization was performed from the contralateral CS to the ipsilateral side through a SL-10 microcatheter.

71-year-old female patient: Right Oph.V rupture occurred during entry using micropuncture and a 5Fr sheath with 035 wire. With a meticulous technique, entry to the CS was possible and coil embolization was successfully completed.

73-year-old female patient: Surgical approach was tried through the Oph. V. with a 16 Gauge angio catheter, but further access was impossible at the point where the vein course was turned 90 degrees. 18 Gauge angio catheter was secured to the Oph.V. again, and the microcatheter was accessed to the CS.

Finally, we present a case via SMCV routed embolization in a 68-year-old man with CS dAVF who presented with temporal lobe intracerebral hematoma. Transfemoral routed embolization has been failed due to inaccessible CS. After the right craniotomy, intracerebral hematoma was removed, then, with a 16 Gauge angio catheter, SMCV was punctured and microcatheter insertion to the CS was available. Coil packing of the affected CS was successfully performed.

Conclusion: In transvenous surgical approaches for the treatment of CS dAVFs, the route & surgical procedure should be determined by considering the diameters, tortuosity and curvatures of the approached vein, so that a safe access to the CS through combined surgery is available.

## Functional Preservation Surgery for High-Grade Cerebral Arteriovenous Malformations Utilizing Visualization Techniques

Hirofumi NAKATOMI

Department of Neurosurgery, International University of Health and Welfare

**Objective:** In the current era where Stereotactic Radiosurgery (SRS) is the conventional standard treatment, surgical intervention for cerebral arteriovenous malformations (AVMs) is now predominantly applied to ruptured cases with Spetzler-Martin (SM) grades 3-5. This study reports on the surgical strategies and outcomes.

**Methods:** The study included a consecutive series of 64 cerebral AVM cases treated surgically between 2006 and 2024 (SM1: 4 cases, SM2: 11 cases, SM3: 26 cases, SM4: 22 cases, SM5: 1 case). Preoperative 3D fusion imaging was used to visualize the deep perforating feeder arteries, allowing for "vascular anatomy visualization." Concurrently, continuous or intermittent evoked potential monitoring was employed for "neural function visualization," enhancing surgical strategy, surgical radicality, and neural function preservation. Intraoperative monitoring included transcranial MEP, SEP, cortical MEP, VEP, and ABR. Furthermore, since 2022, an AVM board comprising leading SRS specialists and endovascular therapists has been established to comprehensively review and determine the appropriate treatment strategies.

**Results:**

1. A right parietal lobe grade 4 AVM case with feeders from ACA, MCA, PCA, and large perforators from LSA, where a deep nidus aneurysm was identified. Based on MEP amplitude changes, the large perforating arteries were occluded. Complete nidus removal and preservation of the LSA feeding the pyramidal tract were confirmed.
2. For cases involving bilateral fornix or motor tract inclusion with rupture, a strategy of feeder aneurysm clipping combined with SRS was selected.
3. For a grade 4 case with a ruptured AVM involving the internal capsule (IC) and PDCL, an extracapsular excision combined with SRS was chosen.
4. Intraoperative MEP deterioration was observed in four cases, but paralysis completely recovered with steroid pulse therapy and high fluid therapy. Permanent worsening of hemianopia was observed in one case, and mRS deterioration in another. No other neurological adverse effects were observed in the remaining cases.
5. Complete resection or planned obliteration was confirmed intraoperatively using ICG/angiography.

**Conclusion:** Understanding the deep perforating feeders and the perinidal dilated capillary network within deep white matter through preoperative 3D fusion imaging is beneficial for surgical planning. Effective utilization of feedback from continuous neural function monitoring is crucial for preserving neural function and enhancing surgical radicality.

O2-6

## Atypical Direct Carotid-Cavernous Fistula Presenting as Brainstem Edema Without Ocular Symptoms

Arata NAGAI<sup>1</sup>, Shunsuke OMODAKA<sup>1,2</sup>, Yuya KATO<sup>1</sup>, Hidenori ENDO<sup>3</sup>

<sup>1</sup>Department of Neuroendovascular Therapy, Kohnan hospital, Miyagi, Japan, <sup>2</sup>Department of Advanced Neuroendovascular Surgery, Tohoku University Graduate School of Medicine, Miyagi, Japan, <sup>3</sup>Department of Neurosurgery, Tohoku University Graduate School of Medicine, Miyagi, Japan

### Background:

Direct carotid-cavernous fistula (CCF) typically presents with ocular manifestations such as proptosis, chemosis, and orbital bruit. We report a rare case of direct CCF presenting with brainstem edema without ocular symptoms.

### Case Presentation:

A 55-year-old woman had undergone mechanical thrombectomy for cerebral infarction secondary to left internal carotid artery dissection 10 years previously. She had suffered from persistent headaches for 3 months prior to admission. One month before admission, routine magnetic resonance angiography retrospectively demonstrated abnormal flow-related signal around the left cavernous sinus. She was emergently admitted with dizziness, vomiting, diplopia, and facial palsy. Magnetic resonance imaging revealed diffuse T2-weighted hyperintensity involving the left side of the brainstem. Infectious, inflammatory, and metabolic disorders were initially suspected. Digital subtraction angiography subsequently demonstrated a left direct CCF. Venous drainage coursed through the superior petrosal sinus and petrosal vein into the anterior pontomesencephalic vein, causing venous congestion and brainstem edema. Transarterial access through the fistulous point into the cavernous sinus was achieved, and targeted coil embolization adjacent to the shunt resulted in complete obliteration. Neurological symptoms gradually improved, and follow-up MRI demonstrated marked resolution of the brainstem lesion.

### Discussion:

Direct CCF without ocular symptoms is extremely rare. Furthermore, non-hemorrhagic cases presenting primarily with brainstem edema are even less common. Their clinical and radiological features may mimic infection, neoplasm, demyelinating disease, or brainstem infarction, potentially delaying diagnosis and treatment. Recognition of atypical venous drainage patterns, particularly posterior drainage toward the pontomesencephalic venous system, is crucial for accurate diagnosis and timely intervention.

### Conclusion:

Direct CCF should be considered in the differential diagnosis of unexplained brainstem edema, even in the absence of typical ocular manifestations.

## **Recurrent Intraventricular Hemorrhage with Suspected Angiography-Negative Craniocervical Junction Dural Arteriovenous Fistula in a Hemodialysis Patient**

Sungho AHN

Department of Neurology, Pusan National University Yangsan Hospital, Yangsan, ROK

**Background:** Craniocervical junction dural arteriovenous fistulas (CCJ-dAVFs) can cause subarachnoid and intraventricular hemorrhage but may remain occult on catheter angiography.

**Case:** A patient receiving maintenance hemodialysis presented with sudden severe occipital-to-diffuse headache. The patient had recurrent intraventricular hemorrhage, prior cerebellar hemorrhage, ischemic stroke during hemodialysis, diabetes, and diffuse systemic and intracranial atherosclerosis. Initial MRI showed new intraventricular hemorrhage, posterior fossa hemosiderin deposition, and a right cerebellomedullary cistern lesion surrounding adjacent vascular structures. Five days later, contrast-enhanced MRI demonstrated interval hematoma evolution consistent with rebleeding, increased diffuse subarachnoid hemorrhage, persistent intraventricular hemorrhage, and a multinodular lesion adjacent to the right PICA, strongly suggesting a bleeding-related CCJ-dAVF. Catheter angiography showed subtle right vertebral arterial staining, PICA-AICA complex stenosis and dilatation, right V4 narrowing, and severe calcific bilateral distal internal carotid artery stenosis, but no fistulous component or aneurysm. Cavernous malformation remained a radiologic alternative; however, an angiography-negative low-flow CCJ-dAVF was clinically considered most likely. Neurosurgery judged open resection high risk because of lesion location and comorbidities; Gamma Knife radiosurgery was considered but not pursued. Conservative management emphasized dialysis-adjusted blood pressure control and reduced antiplatelet intensity. Because of substantial ischemic risk, low-dose cilostazol monotherapy was maintained. Follow-up MRI at 12 weeks demonstrated complete resolution of the localized extra-axial hemorrhage, subarachnoid hemorrhage, and intraventricular hemorrhage, with persistent multicentric superficial siderosis and no visible vascular malformation. At the latest follow-up, peri-dialytic systolic blood pressure remained highly variable (131-202 mm Hg), prompting continued management focused on blood pressure.

**Conclusion:** Recurrent intraventricular and subarachnoid hemorrhage in hemodialysis patients may reflect an angiographically occult CCJ-dAVF when serial MRI shows focal craniocervical junction hemorrhage and rebleeding. Serial imaging and tight peri-dialytic blood pressure control are central when definitive intervention is not feasible.

## **Middle cerebral artery bifurcation geometry and aneurysm formation: a propensity score-matched 3D rotational DSA morphometry study**

Kyu-Sun CHOI<sup>1,2</sup>, Shin Hyuck BANG<sup>1,2</sup>, Hyeong-joong YI<sup>1</sup>, Sang Hyung LEE<sup>2,3</sup>, Jaiyoung RYU<sup>2,4</sup>, Simon SONG<sup>2,5</sup>, Kunhee HAN<sup>1,2</sup>

<sup>1</sup>Department of Neurosurgery, Hanyang University Medical Center, Hanyang University College of Medicine, Seoul, ROK, <sup>2</sup>Center for Precision Medicine Platform Based-on Smart Hemo-Dynamic Index, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Jeju National University Hospital, Jeju National University College of Medicine, Jeju, ROK, <sup>4</sup>Department of Mechanical Engineering, Korea University, Seoul, ROK, <sup>5</sup>Department of Mechanical Convergence Engineering, Hanyang University, Seoul, ROK

**Background and Objectives:** The middle cerebral artery (MCA) bifurcation is a common site of intracranial aneurysm formation. This study aimed to evaluate the association between MCA bifurcation geometry and aneurysm presence, and to explore the relationship between aneurysm rupture and sac-level morphology using a standardized three-dimensional morphometry pipeline.

**Methods:** This single-center, retrospective, propensity score-matched case-control study included 133 MCA bifurcation aneurysms and 266 control MCA bifurcations without aneurysms. Bifurcation geometry and aneurysm sac morphology were quantified using three-dimensional rotational digital subtraction angiography. Associations with aneurysm presence were assessed using generalized estimating equation (GEE) logistic regression clustered by patient ID. The discriminatory ability of individual geometric markers was evaluated using receiver operating characteristic (ROC) curve analysis.

**Results:** After matching, baseline covariates were well balanced between groups. In univariate comparisons, aneurysm-bearing bifurcations showed larger opening angles, smaller dominant and non-dominant M1-M2 branch angles, smaller parent vessel diameters and cross-sectional areas, a higher opening-to-caliber index, and lower parent-to-dominant-branch and daughter-branch diameter ratios. In multivariable GEE analysis, a larger opening angle, smaller dominant branch angle, and lower daughter-branch diameter ratio were independently associated with aneurysm presence. Each 5-degree increase in opening angle was associated with approximately 40% higher odds of aneurysm presence. The opening-to-caliber index showed the highest single-marker ROC-AUC but did not remain independently significant after adjustment. Among aneurysms, rupture was not associated with bifurcation geometry; instead, ruptured aneurysms were larger. Across increasing aneurysm size strata, the opening angle and opening-to-caliber index increased, whereas the dominant branch angle decreased.

**Conclusion:** MCA bifurcation aneurysm presence was associated with a wider and more asymmetric bifurcation geometry, whereas rupture appeared to be more closely related to sac-level morphology. These findings suggest that parent-vessel geometry may contribute to aneurysm formation, while rupture risk assessment should emphasize aneurysm-specific morphological features.

## **Multiple anterior choroidal arteries and perioperative ischemic complications in unruptured anterior choroidal artery aneurysms treated with microsurgical clipping**

Jai Ho CHOI

Department of Neurosurgery, Seoul St Mary's Hospital, The Catholic University of Korea, ROK

**Background:** This study aimed to identify the association between the number of anterior choroidal arteries (AchoAs) and procedure-related ischemic complications in microsurgical clipping of unruptured AchoA aneurysms.

**Methods:** We retrospectively reviewed the clinical, radiological, and intraoperative findings of 153 patients with unruptured AchoA aneurysms treated with microsurgical clipping between January 2012 and November 2020 in a single tertiary institution. Intraoperative video clips were reviewed, and the AchoA type was categorized into two according to the number of AchoAs: 1) single-type group with single origin and single branch and 2) multiple-type group with duplicated origin or divided multiple branches. Uni- and multivariate analyses were performed to assess the relationship between clinical and radiological factors and perioperative ischemic complications.

**Results:** Of the 153 patients, 52 (34%) were categorized as multiple-type group. The frequency of perioperative ischemic complications, including decreased intraoperative motor evoked potential (MEP), silent infarction, and postoperative ischemic symptoms, was significantly higher in the multiple-type group than in the single-type group (13 [25%] vs 6 [5.9%],  $p=0.001$ ). Multivariate logistic regression analysis showed that multiple-type group (odds ratio [OR]: 3.725, 95% confidence interval [CI]: 1.171-11.845,  $p=0.026$ ) and multilobulated shape (OR: 9.512, 95% CI: 2.093-43.224,  $p=0.004$ ) were significantly associated with perioperative ischemic complications. Among 9 patients with decreased MEP, postoperative ischemic symptoms developed in 2 patients after clip adjustment.

**Conclusions:** Multiple-type AchoA aneurysms and multilobulated shape are significantly correlated with perioperative ischemic complications. Postoperative ischemic complications can be minimized by recognizing these variations and using multimodal approach with MEP monitoring.

O3-3

## **Delayed symptomatic cerebral vasospasm after uneventful clipping of an unruptured middle cerebral artery aneurysm without subarachnoid hemorrhage: a case report**

Dongwook SEO, Sukh Que PARK

Soonchunhyang University Seoul Hospital, Seoul, ROK

Background: Symptomatic cerebral vasospasm after clipping of an unruptured intracranial aneurysm, in the absence of subarachnoid hemorrhage, is rare and likely under-recognized. We report such a case, complicated by a residual deficit, with possible procedural contributors.

Case Presentation: A 72-year-old right-handed woman with incidentally discovered bilateral middle cerebral artery (MCA) bifurcation aneurysms underwent elective navigation-guided pterional craniotomy and neck clipping of the larger, morphologically complex left aneurysm. Sylvian fissure dissection and multiple clip applications were required. Intraoperative indocyanine-green videoangiography and Doppler confirmed complete aneurysm obliteration with preserved parent and branch patency; neuromonitoring was unremarkable. Hemostasis included perivascular fibrin sealant and additional hemostatic agents. No intraoperative rupture occurred, and subarachnoid hemorrhage was absent on postoperative imaging.

The early course was uneventful until postoperative day 7, with subtle decline from day 6, when aphasia and right hemiparesis developed. Diffusion MRI showed acute left frontal infarction, and angiography revealed distal MCA vasospasm, most severe in the superior division, with the aneurysm fully obliterated, excluding clip-related stenosis. Intra-arterial nimodipine (6 mg) produced partial angiographic improvement. The subsequent intensive-care course was complicated by a transient metabolic derangement requiring renal replacement therapy.

Outcome: The acute aphasia and hemiparesis improved substantially with rehabilitation, leaving a persistent fine-motor deficit of the dominant right hand at long-term follow-up.

Conclusion: Delayed symptomatic vasospasm can follow uneventful clipping of an unruptured aneurysm without SAH. Extensive Sylvian dissection and perivascular hemostatic or fibrin-based materials are plausible but unproven contributors. Because onset may be subtle and residual deficits can occur despite chemical angioplasty, a low threshold for vascular imaging and intervention is warranted when unexplained neurological deterioration follows such surgery.

## **Additional rescue stenting with Neuroform Atlas stents during stent-assisted coiling of saccular aneurysms**

Dayoung KIM<sup>1</sup>, Jun Kyeong KO<sup>1</sup>, Tae Hong LEE<sup>2</sup>, Lee HWANGBO<sup>2</sup>, Sang Min SUNG<sup>3</sup>,  
Eun Joo KIM<sup>3</sup>, Yeon Soo CHOO<sup>4</sup>

<sup>1</sup>Department of Neurosurgery, Pusan National University, Busan, ROK, <sup>2</sup>Department of Diagnostic Radiology, Biomedical Research Institute, Pusan National University Hospital, School of Medicine, Pusan National University, Busan, the ROK,

<sup>3</sup>Department of Neurology, Biomedical Research Institute, Pusan National University Hospital, School of Medicine, Pusan National University, Busan, the ROK, <sup>4</sup>Department of Neurosurgery, Bongseng memorial hospital, Busan, the ROK

**Objective:** Overlapping stenting is sometimes attempted during endovascular treatment of cerebral aneurysm as a rescue for coil herniation, stent mal-positioning, or in-stent thrombosis. We retrospectively evaluated the efficacy and safety of additional rescue stenting (ARS) in telescoping fashion with Neuroform Atlas stent (NAS) during stent-assisted coiling of saccular aneurysms.

**Methods:** We collected clinical and radiological data of patients with saccular aneurysms treated with ARS using NASs between March 2018 and December 2021. Y or X-stent-assisted coiling technique was excluded.

**Results:** Eighteen unruptured and 5 ruptured aneurysms in 23 patients were treated with ARS using NASs. Sizes of aneurysms ranged from 2.0 mm to 10.0 mm (mean: 5.0 mm). Immediate angiographic results were complete occlusion in 11 aneurysms, residual neck in 4 aneurysms, and residual sac in 8 aneurysms. Peri-operative morbidity was 4.3 %. Nineteen of 23 patients underwent follow-up conventional angiography (mean, 9.9 months). Results showed progressive occlusion in 10 (52.6 %) cases and asymptomatic in-stent stenosis in 3 (15.8 %) cases. At the end of the observation period (mean, 17.4 months), all 18 patients without subarachnoid hemorrhage had excellent clinical outcomes (mRS of 0), except one (mRS of 1). Of five patients with subarachnoid hemorrhage, four had a favorable outcome (mRS of 0-1), while the other one was dependent (mRS of 4).

**Conclusion:** In this report on 23 patients, ARS with NASs for treating saccular aneurysms showed good technical safety with favorable clinical and angiographic outcomes. However, delayed in-stent stenosis was not uncommon. Thus, regular imaging follow-up is required.

## **The Association of First Follow-up Blood Pressure Level with Recurrent Stroke and Mortality in Survivors of Spontaneous Intracerebral Hemorrhage**

Jongwon CHO<sup>1</sup>, Hyun Jin HAN<sup>1</sup>, Seonji KIM<sup>2,3</sup>, Jung-jae KIM<sup>1</sup>,  
Yong Bae KIM<sup>1</sup>, Keun Young PARK<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, Seoul, ROK, <sup>2</sup>Department of Biomedical Systems Informatics, Yonsei University College of Medicine, Seoul, ROK, <sup>3</sup>Institute for Innovation in Digital Healthcare, Yonsei University, Seoul, ROK

Although blood pressure is an important modifiable factor for the prevention of recurrent stroke after spontaneous intracerebral hemorrhage (ICH), the target blood pressure remains uncertain. Using the National Health Insurance Service database from January 2005 to December 2022, patients who survived for more than one year with prescribed antihypertensive drugs were identified. We compared the risks of mortality, ischemic stroke, and recurrent ICH among six groups divided according to systolic blood pressure (SBP). The incidence rates, hazard ratios (HRs), and 95% confidence intervals (CIs) were estimated using the Cox proportional hazards model. Among the 11,034 ICH survivors, five-year incidence rates of mortality, ischemic stroke, and recurrent ICH were 13.26 per 1,000 person-year, 7.71, and 12.90, respectively. Mortality incidence was lowest in the SBP 120–129 mmHg group, and SBP  $\geq$  160 mmHg was associated with a higher risk of mortality (adjusted HR [aHR]: 1.55 [95% CI: 1.06–2.28]) compared with the reference group. Acute ischemic stroke followed a linear increasing trend with significance at SBP  $\geq$  150 mmHg (SBP 150–159 mmHg, aHR: 1.80 [95% CI: 1.18–2.74]), while recurrent ICH was significantly increased at SBP  $\geq$  160 mmHg (aHR: 1.87 [95% CI: 1.27–2.74]). The present study showed that maintaining an SBP between 120–129 mmHg was associated with the lowest risk of mortality, while higher SBP levels were associated with increased risk of ischemic stroke and ICH recurrence. These findings suggest a designated blood pressure range for managing this high-risk population.

## Pathophysiology and Treatment of Large and Giant Fusiform and Dolichoectatic Aneurysms

Hirofumi NAKATOMI

Department of Neurosurgery, International University of Health and Welfare

**Objective:** This study reports on the techniques and outcomes of surgical treatment for fusiform and dolichoectatic aneurysms, which are challenging to manage with endovascular therapy.

**Methods:** The study included a consecutive series of 109 cases of fusiform and dolichoectatic aneurysms treated surgically between 1996 and 2024. The aneurysm locations included the ICA (35 cases), ACA (4 cases), MCA (6 cases), VA (19 cases), BA trunk/VB junction (30 cases), BA top (3 cases), BA-SCA (1 case), PICA (4 cases), AICA (1 case), PCA (4 cases), and choroidal artery (2 cases). Various bypass techniques were employed in 73 cases. Since 2010, preoperative 3D fusion imaging has been used to visualize the "vascular anatomy" of high-risk perforating branches near the aneurysm neck, combined with continuous or intermittent evoked potential monitoring for "neural function visualization," to improve surgical radicality and preserve neural function.

**Results:**

1. In 9 untreated cases with autopsy findings, all cases showed revascularization, increased vasa vasorum, wall thrombosis/hemorrhage formation, and multiple intimal/dissection within the thrombus.
2. 3D fusion imaging was effective in identifying the course of high-risk perforating branches such as Ach. A., LSA, and Ant. spinal a.
3. The perioperative morbidity and mortality rates improved from 18/43 (41.9%) and 4/43 (9.3%) in the early period (1996-2009) to 5/66 (7.5%) and 2/66 (3.0%) in the later period (2010-2024).
4. In cases where staged flow reduction was performed based on CFD analysis, there was a significant reduction in postoperative intramural aneurysm hemorrhage and contrast enhancement.
5. Intraoperative ICG/angiography confirmed bypass patency and aneurysm obliteration.
6. Stent/coil embolization was combined in 3 cases.

**Conclusion:** Understanding the course of high-risk perforating branches through preoperative 3D fusion imaging is beneficial for constructing surgical strategies. The flow reduction strategy based on CFD contributes to stabilizing the aneurysm wall surrounding the true lumen. Effective utilization of feedback from continuous neural function monitoring is crucial for preserving neural function and enhancing surgical radicality.

O3-7

## **Perforator-Related Infarction Detected by Diffusion-Weighted Imaging After Treatment of A1 Segment Aneurysms**

Sang Kyu PARK, Jung Keun LEE, Kyu Seon CHUNG

Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, Seoul, ROK

Aneurysms of the A1 segment of the anterior cerebral artery (ACA) are rare and anatomically close to multiple perforating arteries, but the incidence and pattern of post-treatment perforator-related ischemic injury have not been well characterized. We retrospectively reviewed 4,505 intracranial aneurysms treated between January 2021 and December 2025 at two tertiary centers and identified 67 A1 segment aneurysms. Postoperative magnetic resonance imaging with diffusion-weighted imaging (DWI) was available in 61 patients (91.0%). DWI-positive lesions were detected in 28/61 imaged patients (45.9%): 13/61 (21.3%) were classified as procedural-related infarctions (lesions outside predefined perforator territories) and 15/61 (24.6%) as perforator-related infarctions (lesions within predefined perforator territories). All perforator-related infarctions were clinically silent. Perforator-related infarction occurred in 10 of 53 proximal A1 aneurysms (18.9%), 3 of 5 middle A1 aneurysms (60.0%), and 2 of 3 distal A1 aneurysms (66.7%). Proximal A1 location was independently associated with a lower likelihood of perforator-related infarction after adjustment for treatment modality (adjusted odds ratio, 0.12; 95% confidence interval, 0.02-0.63;  $p = 0.012$ ), whereas treatment modality was not independently associated with this outcome. Perforator-related ischemic lesions are not uncommon after treatment of A1 segment aneurysms, even when clinically silent. Careful preprocedural assessment of aneurysm-perforator anatomy, meticulous preservation of perforators during microsurgical or endovascular treatment, and routine early postoperative DWI should be considered, particularly for middle or distal A1 aneurysms.

## Frailty Has a Greater Negative Impact on CAS Than on CEA in Carotid Revascularization: A Nationwide Japanese DPC Analysis

Nobutaka HORIE<sup>1</sup>, Nobuaki MICHIHATA<sup>2</sup>, Shingo MATSUDA<sup>1</sup>, Kenji HARA<sup>1</sup>,  
Masashi KUWABARA<sup>1</sup>, Fusao IKAWA<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Hiroshima University School of Medicine, Hiroshima, Japan, <sup>2</sup>Department of Clinical Epidemiology and Health Economics, School of Public Health, The University of Tokyo, Tokyo, Japan, <sup>3</sup>Department of Neurosurgery, Shimane Prefectural Central Hospital, Shimane, Japan

**Introduction:** Frailty is increasingly recognized as an important determinant of perioperative risk in elderly patients. In carotid artery stenosis, where the benefit of intervention must be balanced against contemporary best medical therapy, frailty may influence both procedural risk and treatment selection.

**Objective:** To determine whether frailty differentially affects outcomes after carotid endarterectomy (CEA) and carotid artery stenting (CAS).

**Methods:** We analyzed a nationwide Japanese Diagnosis Procedure Combination database including 85,782 patients treated between 2010 and 2023. Among them, 28,507 underwent CEA and 57,275 underwent CAS. Frailty was assessed using the 5-factor modified frailty index (mFI-5). Multivariable logistic regression analyses were performed separately for CEA and CAS for worsening Barthel Index (BI), in-hospital mortality, and in-hospital complications.

**Results:** Frailty adversely affected outcomes in both groups, with a greater impact in CAS. In CEA, mFI-5  $\geq 2$  was independently associated with worsening BI (OR 1.43, 95% CI 1.25-1.63) and in-hospital complications (OR 1.98, 95% CI 1.78-2.21), but not mortality. In CAS, mFI-5  $\geq 2$  was associated with worsening BI (OR 1.88, 95% CI 1.71-2.07), in-hospital mortality (OR 2.12, 95% CI 1.50-2.98), and complications (OR 1.95, 95% CI 1.80-2.12). Advanced age also had a stronger negative impact in CAS.

**Conclusion:** Frailty is a meaningful predictor of adverse outcomes after carotid revascularization and has a greater negative impact on CAS than CEA. These findings support incorporating frailty into procedure selection.

O4-2

## **Safety of Carotid Artery Stenting Using a Dual-Layer Mesh Stent in Elderly Patients Aged 70 Years or Older**

Toshiya OSANAI<sup>1</sup>, Kota KURISU<sup>1</sup>, Kikutaro TOKAIRIN<sup>1</sup>, Yusuke SHIMODA<sup>2</sup>,  
Haruto UCHINO<sup>1</sup>, Miki FUJIMURA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Faculty of Medicine, Hokkaido University, Japan, <sup>2</sup>Sapporo Asabu Neurosurgical Hospital

[Background and Purpose] Large randomized controlled trials have reported a significantly elevated risk of periprocedural stroke with carotid artery stenting (CAS) compared with carotid endarterectomy (CEA) in patients aged 70 years or older. The CASPER stent, featuring a dual-layer micromesh design that suppresses plaque prolapse, is expected to reduce embolic complications; however, data on its safety and efficacy in elderly patients remain limited. This study aimed to evaluate the periprocedural safety of CAS using the CASPER stent in patients aged 70 years or older with carotid artery stenosis. [Methods] We conducted a multicenter retrospective observational study across five institutions. Sixty-six consecutive patients aged 70 years or older (mean age 76.6  $\pm$  4.3 years; 92.4% male) who underwent CAS with the CASPER stent were enrolled. Primary outcomes included the rate of new diffusion-weighted imaging (DWI) lesions within 48 hours postoperatively, the composite rate of ipsilateral stroke, myocardial infarction, and death within 30 days, and the incidence of restenosis requiring reintervention during follow-up. Results were compared with those reported in prior large-scale RCTs. [Results] The technical success rate was 100%. The 30-day composite rate of ipsilateral stroke, myocardial infarction, and death was 4.5% (3/66); no myocardial infarction or death occurred. New DWI lesions were detected in 24.2% of patients. Hyperperfusion syndrome occurred in 4.5%, and restenosis requiring treatment was observed in 1.5%. [Conclusion] The 30-day stroke and death rate of 4.5% compared favorably with the 10.5% reported in the pooled analysis of ICSS, EVA-3S, and SPACE for patients aged 70 years or older. These findings suggest that CAS using the CASPER stent can be performed safely in elderly patients, supported by advances in device technology, appropriate patient selection, and improved operator experience. Larger comparative studies including younger cohorts are warranted.

## Visual function improves after carotid endarterectomy but not after carotid artery stenting despite comparable ocular blood flow augmentation

Soichi OYA<sup>1,2</sup>, Shinsuke YOSHIDA<sup>2</sup>, Akira SAITO<sup>2</sup>, Satoshi IIHOSHI<sup>2</sup>,  
Masaaki SHOJIMA<sup>2</sup>, Kaima SUZUKI<sup>3</sup>, Hidetoshi OOIGAWA<sup>3</sup>, Shinya KOHYAMA<sup>4</sup>,  
Yuichiro KIKKAWA<sup>5</sup>, Hiroki KURITA<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Gunma University Graduate School of Medicine, Maebashi, Japan, <sup>2</sup>Department of Neurosurgery, Saitama Medical Center, Saitama Medical University, Saitama, Japan, <sup>3</sup>Department of Cerebrovascular Surgery, Saitama International Medical Center, Saitama Medical University, Saitama, Japan, <sup>4</sup>Department of Endovascular Neurosurgery, Saitama International Medical Center, Saitama Medical University, Saitama, Japan, <sup>5</sup>Department of Neurosurgery, Saitama Cardiovascular and Respiratory Center, Saitama, Japan

**Background:** We previously demonstrated that carotid endarterectomy (CEA) increases ipsilateral chorioretinal blood flow and that this increase is associated with postoperative visual improvement in patients with carotid artery stenosis (Acta Neurochir Wien, 2020). The present prospective observational study investigated whether carotid artery stenting (CAS) provides similar benefits on ocular blood flow and visual function.

**Methods:** Thirty-nine patients undergoing CEA and 39 undergoing CAS were prospectively enrolled. Ocular blood flow and visual function were evaluated before and after revascularization. Chorioretinal blood flow was quantified by mean blur ratio (MBR) using laser speckle flowgraphy, and visual function was assessed by area under the log contrast sensitivity function (AULCSF) using the Contrast Sensitivity Vision-1000 system. Retinal vessel density was additionally evaluated, and postoperative diffusion-weighted MRI was performed to detect cerebral microembolic lesions.

**Results:** Both CEA and CAS significantly increased ipsilateral chorioretinal blood flow (MBR: 31.4 to 37.9,  $P < 0.0001$ , for CEA; 33.9 to 37.8,  $P = 0.007$ , for CAS). Visual function improved significantly after CEA (AULCSF: 1.03 to 1.06,  $P = 0.02$ ) but not after CAS (AULCSF: 1.08 to 1.06,  $P = 0.37$ ). Patients with postoperative cerebral microembolic lesions demonstrated significantly lower retinal vessel density than those without such lesions. Retinal vessel density was preserved after CEA but was significantly reduced after CAS.

**Conclusions:** Although both CEA and CAS improved ocular blood flow, only CEA was associated with significant visual improvement. The absence of visual benefit after CAS may be related to microembolism-associated retinal microvascular impairment. These findings suggest that evaluating visual acuity and retinal blood flow on the ipsilateral side may contribute to improved quality of life in patients with carotid artery stenosis in addition to stroke prevention. This approach may offer valuable insights when surgeons plan for personalized treatment approaches based on individual visual profiles and stroke risk.

## Hemodynamic Analysis of the Carotid Web as a Potential Cause of Stroke

Kunhee HAN<sup>1,2</sup>, Hyeong-joong YI<sup>1</sup>, Sang Hyung LEE<sup>2,3</sup>, Jaiyoung RYU<sup>2,4</sup>,  
Simon SONG<sup>2,5</sup>, Kyu-sun CHOI<sup>1,2</sup>

<sup>1</sup>Department of Neurosurgery, Hanyang University Medical Center, Hanyang University College of Medicine, Seoul, ROK, <sup>2</sup>Center for Precision Medicine Platform Based-on Smart Hemo-Dynamic Index, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Jeju National University Hospital, Jeju National University College of Medicine, Jeju, ROK, <sup>4</sup>Department of Mechanical Engineering, Korea University, Seoul, ROK, <sup>5</sup>Department of Mechanical Convergence Engineering, Hanyang University, Seoul, ROK

**Purpose:** Carotid web is an intimal abnormality characterized by a thin, shelf-like protrusion, usually arising from the posterior wall of the carotid bulb. It has been increasingly recognized as a potential cause of cryptogenic stroke, particularly in younger patients without conventional vascular risk factors. This study aimed to investigate how carotid web morphology contributes to local flow disturbance and thrombotic potential using computational fluid dynamics (CFD).

**Materials and Methods:** Patients with acute ischemic stroke or transient ischemic attack of unknown etiology were retrospectively screened for imaging findings consistent with carotid web. Multimodal vascular imaging, including CT angiography, MR angiography, and digital subtraction angiography in selected cases, was used to characterize web morphology. Patient-specific three-dimensional vascular models were reconstructed from CT angiography data. CFD analysis was performed to compare hemodynamic patterns among arteries with carotid web, arteries without web, and arteries with significant stenosis. Velocity fields, relative residence time, oscillatory shear index, time-averaged wall shear stress, and pulsatility index were analyzed.

**Results:** CFD simulations showed that carotid web caused flow separation and recirculation in the proximal internal carotid artery, mainly distal to the shelf-like protrusion. The web region demonstrated increased relative residence time, suggesting prolonged blood stagnation and a higher thrombotic potential. Peak systolic velocity and local wall shear stress were also elevated around the web, particularly in severe carotid webs. Moderate webs produced less prominent but still detectable flow disturbance. These hemodynamic findings were consistent with the clinical tendency toward recurrent embolic events in patients with carotid web.

**Conclusion:** Carotid web may promote thrombus formation through localized flow stagnation, recirculation, and increased shear stress. CFD analysis may help identify high-risk carotid webs and support treatment decisions, including endarterectomy or stenting, to prevent recurrent stroke.

## **Carotid Endarterectomy at Showa Medical University: Surgical Techniques and Surgeon Training Based on a 472-Case Experience**

Kenji SUMI<sup>1</sup>, Tohru MIZUTANI<sup>2</sup>, Tatsuya SUGIYAMA<sup>2</sup>, Shintaro ARAI<sup>1</sup>,  
Masaki MATSUMOTO<sup>1</sup>, Youichi MOTOFUJI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Showa Medical University, Tokyo, Japan,

<sup>2</sup>Department of Neurosurgery, Showa Medical University Koto Toyosu Hospital

**Background:** Carotid endarterectomy (CEA) is an established treatment for carotid artery stenosis. At our institution, CEA has been performed using a standardized surgical protocol, while a structured training program has enabled junior neurosurgeons to progressively perform the procedure as primary surgeons.

**Objective:** To evaluate surgical techniques associated with safe and reliable CEA and to assess surgical outcomes and surgeon training at our institution.

**Methods:** We retrospectively reviewed all consecutive CEAs performed between April 2012 and October 2025. Surgical techniques, postoperative imaging findings, perioperative complications, and surgeon training were analyzed.

**Results:** A total of 472 CEAs were performed. In all cases, meticulous hemostasis was achieved to maintain a bloodless operative field. Symptomatic procedure-related complications within 30 days occurred in eight patients (1.7%), including one death (0.2%). One additional patient (0.2%) developed cardiogenic cerebral infarction during the postoperative stable phase. Overall, 463 patients (98.1%) had an uneventful postoperative course without neurological deficits attributable to the procedure. During the study period, the number of surgeons capable of independently performing CEA increased from four to eighteen.

**Conclusions:** Favorable surgical outcomes were consistently achieved through meticulous hemostasis, creation of a wide and shallow operative field, and routine internal shunt placement using bloodless techniques, minimizing the influence of carotid cross-clamping time. Our experience suggests that standardized surgical techniques, comprehensive perioperative management, and structured surgeon training enable reproducible, high-quality CEA with excellent safety, regardless of surgeon experience.

O4-6

## **The case of successful simultaneous removal of the stent and carotid plaque for the recurrent severe carotid artery stenosis after carotid artery stenting (CAS)**

Tae-Sun KIM, Sung-pil JOO, You-seob KIM, Wan PARK, Yong-jun LEE

Department of Neurosurgery, Chonnam National University Hospital & Medical School, Gwangju, ROK

I will present an ecstasy case of successful simultaneous removal of the stent and carotid plaque for recurrent severe carotid artery stenosis after carotid artery stenting (CAS).

A 76-year-old-male admitted due to the acute embolic cerebral infarction on right frontal lobe. Carotid angiography showed the right severe carotid artery stenosis, so carotid artery stenting (CAS) was performed. Due to the tortuous curvature of the distal ICA, the stent did not completely cover the stenosis. However, carotid artery patency was maintained relatively well. The patient was well recovered and discharged without any neurological symptoms.

The patient returned to the hospital 8 months later with acute cerebral infarction on the ipsilateral side. Carotid angiography showed that carotid artery stenosis on the ipsilateral side became more aggravated. The plaque appeared to have progressed to the distal portion of the previously deployed stent. Therefore, it was decided to remove the stent and carotid plaque at the same time.

Carotid arteries were exposed as long as possible considering the stent length (4 cm). After the clamping of carotid arteries, arteriotomy was performed. The stent was cut with sharp scissors carefully. After the stent and distal plaque were sufficiently exposed, the stent was first removed by carefully dissecting it from the carotid artery. Then, the CEA was completed after removing the plaque from the distal portion of the stent. The patient recovered well without any problems.

CEA was successfully performed for severe carotid restenosis after CAS. Removal of the stent was not a major problem during CEA. Therefore, CEA may be an alternative choice for severe carotid restenosis after CAS in selective case.

## **STA - Sparing Minipterional Approach with Isolated Distal Sylvian Fissure opening without opening of carotid cisternal membrane for Clipping of supraclinoid ICA aneurysms**

Younggyun JEONG, Jin LEE, Juhwan LEE

Department of Neurosurgery, Busan Paik hospital, Inje university, Busan, ROK

Arachnoid plasty is performed to reduce the incidence of chronic subdural hemorrhage, a potential postoperative complication in elderly patients undergoing cerebral aneurysm surgery. Recently, there have been reports of using the mini-pterional approach for unruptured cerebral aneurysm surgery, and in some cases, a focused Sylvian opening has been employed to operate on middle cerebral artery aneurysms.

The author performs surgery using a superficial temporal artery (STA)-sparing mini-pterional approach for unruptured cerebral aneurysms. For elderly patients, to facilitate arachnoid plasty, the author performed surgery on internal carotid artery (ICA) aneurysms by opening only the lateral part of Sylvian fissure (distal Sylvian fissure), thereby reducing the incidence of complications.

In other words, without opening of the membrane of the carotid cistern or the chiasmatic cistern, the author performed clipping of aneurysms of the anterior choroidal artery aneurysm, the posterior communicating artery aneurysm, and the ICA bifurcation aneurysm by opening only a portion of the Sylvian fissure-distal sylvian opening.

O5-2

## Microsurgical Tactics of Kissing Aneurysms

Hyun Jin HAN<sup>1</sup>, Yong Bae KIM<sup>1</sup>, Keun Young PARK<sup>1</sup>, Seung Kon HUH<sup>2</sup>

<sup>1</sup>Severance Hospital, Yonsei University College of Medicine, Seoul, ROK, <sup>2</sup>Presbyterian Medical Center, Jeonju, ROK

### Objective:

To review the surgical management and define optimal microsurgical strategies for treating rare “kissing aneurysms” encountered during single-session surgical clipping.

### Methods:

A retrospective review was conducted on a database of 5,304 aneurysm clipping procedures performed at Severance Hospital from 2001 to 2025, during which 20 cases of kissing aneurysms were identified. Additionally, at Jeonju Presbyterian Medical Center, 2 cases of kissing aneurysms were identified among 110 aneurysm clipping procedures performed between April 2022 and April 2026. We analyzed the imaging and operative notes of these cases to identify and evaluate surgical outcome of kissing aneurysms

### Results:

A total of 22 patients (19 females, 3 males) with a mean age of 59.5 years were included in this study. The most frequently involved aneurysm locations were the internal carotid artery communicating segments (50.0%), followed by the middle cerebral artery (18.2%) and the distal anterior cerebral artery (13.6%). Regarding surgical outcomes, 1 case with unruptured MCA aneurysm had an intraoperative rupture during neck dissection (4.5%). Ischemic complications were observed in 3 cases (13.6%); of these, two were attributed to perforator infarction located between the aneurysm domes, and one was associated with clip-induced parent artery encroachment. Notably, all ischemic events occurred in instances where complete aneurysm separation was not achieved, and a single clip was applied to both aneurysms simultaneously.

### Conclusion:

The surgical management of kissing aneurysms presents unique technical challenges. Successful and safe clipping requires meticulous preoperative 3D planning, strict adherence to proximal control, delicate handling of the adherence point, and a strategically sequenced clipping approach.

## Endoscopic Trans-Orbital Approach for clipping a middle cerebral artery aneurysm: A cadaveric study with clinical application

Chang Ki JANG<sup>1</sup>, Sun YOON<sup>2</sup>, Jiwoong OH<sup>1</sup>, Hyun Jin HAN<sup>1</sup>, Ju Hyung MOON<sup>1</sup>,  
Eui Hyun KIM<sup>1</sup>, Keun Young PARK<sup>1</sup>, Seungwoo PARK<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Severance Hospital, Yonsei University College of Medicine, ROK, <sup>2</sup>Department of Neurosurgery, Hallym University Dongtan Sacred Heart Hospital, Hallym University College of Medicine,

<sup>3</sup>Department of Neurosurgery, College of Medicine, Kangwon National University

**objectives:** we examined the clipping of middle cerebral artery (mca) aneurysms using the etoa with cadavers and in clinical cases to clarify which patients are good candidates based on preoperative imaging data.

**methods:** to determine the indications for mca clipping using the etoa with superior-lateral orbital rim osteotomy, 10 sides of five cadavers were investigated. the clippable range, defined as the horizontal range, and exposure of the middle cranial fossa base, defined as the vertical extent area, were evaluated. to assess the etoa trajectory in the mca, the superior and inferior maximal angles based on the nasion sellar line were evaluated during cadaveric dissection. to test the surgical properties for actual use, two clinical cases were evaluated.

**results:** the suction tip and clip applier did not conflict with each other when access was made approximately 17.6mm laterally from the cranial midline and 6mm from the median temporal bone margin (clippable range). the superior angle was 16.7°, and the inferior angle was 18.7°.

two clinical cases were operated on using the etoa. the aneurysms were mca bifurcation in the anterior direction. the clippable ranges of the patients were 29mm, 32mm and 31mm, 36mm from midline and median temporal bone margin respectively. the m1 lengths were 14.5 mm and 17.2 mm, and the maximal diameters of the aneurysms were 3.67 and 3.58 mm.

**conclusion:** clipping using the etoa is an appropriate approach for mca aneurysms with anterior, superior, and inferior dome projections. aneurysms with a horizontal boundary from the anterior clinoid process to the lateral bone margin of the orbital ball and a vertical boundary around and below the sphenoid ridge can be properly clipped using the etoa.

O5-4

## **Modified Supraorbital Keyhole Approach with Partial Extradural Anterior Clinoidectomy for Clipping of Internal Carotid Artery Aneurysms: Surgical Technique and Outcomes**

**Dong-Kyu JANG, Young Hoon CHOI, Byung-rae CHO, Dong Sub KIM**

Department of Neurosurgery, Incheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Incheon, ROK

**Background:** The supraorbital keyhole approach (SOKA) is a minimally invasive technique for anterior circulation intracranial aneurysm clipping. However, its limited lateral surgical corridor restricts access to the anterior clinoid process (ACP), which is often essential for internal carotid artery (ICA) aneurysm clipping.

**Objective:** To present a modified SOKA technique that extends the craniotomy laterally to include part of the sphenoid ridge, enabling partial extradural anterior clinoidectomy under microscopic visualization, and to evaluate its safety and efficacy.

**Methods:** Between January 2020 and February 2025, 120 patients underwent aneurysm clipping via the modified SOKA. Among them, 17 patients (18 unruptured ICA aneurysms) required partial extradural anterior clinoidectomy. Clinical data, operative videos, and imaging studies were retrospectively reviewed.

**Results:** Treated aneurysm locations included the posterior communicating artery (n=12), anterior choroidal artery (n=4), and ophthalmic artery (n=2). The modified approach allowed secure proximal control and adequate exposure for safe clip placement in all cases. Complete aneurysm occlusion was achieved without intraoperative rupture or neurovascular injury. Two patients developed postoperative wound infections (one related to frontal sinus opening); both were managed successfully. No patients experienced new permanent neurological deficits or cosmetic complications.

**Conclusions:** The modified SOKA with partial extradural anterior clinoidectomy overcomes the lateral exposure limitation of the classic SOKA, providing a safe and effective corridor for ICA aneurysm clipping without endoscopic assistance, while preserving minimally invasive and cosmetic advantages.

## Microsurgery for posterior circulation aneurysms in endovascular era

Yosuke AKAMATSU<sup>1</sup>, Yosuke AKAMATSU<sup>1</sup>, Msahiro YABUKI<sup>1</sup>, Wataru YANAGIHARA<sup>1</sup>,  
Kenya MIYOSH<sup>1</sup>, Jun YOSHIDA<sup>1</sup>, Koji YOSHIDA<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Iwate Medical University, Yahaba, Iwate, Japan,

<sup>2</sup>Department of Neurosurgery, Hachinohe Red Cross Hospital

**Introduction:** The number of microsurgical treatments for posterior circulation aneurysms is decreasing in current endovascular era. However, relatively high incidences of retreatment remain an issue after endovascular treatment (EVT). Furthermore, open surgical strategies are still in demand for some posterior circulation aneurysms deemed challenging for EVT. However, surgical skills such as skull base craniotomy comes to unfamiliar for vascular surgeons, although the sufficient surgical corridor for securing proximal and distal arteries as well clipping. We aim to demonstrate our experiences of microsurgical treatment strategy for posterior circulation aneurysms across the subspecialties.

**Method:** A single institutional database was queried from 2018-2025.

**Results:** Ten aneurysms (8 ruptured, 2 unruptured) were treated with microsurgical or combined strategies. Aneurysm location is as follows: 3 VA-PICA, 2 PICA, 2 PCA, 2 VA, 1 BA-SCA. Of those, craniotomies were performed by the vascular-skull base combined team in 9 patients. Then, clipping and/or bypass for aneurysm obliteration was performed by vascular surgeons. Aneurysm clipping and trap-bypassing were performed in 7 and 3 cases, respectively. Complete obliteration of the aneurysms was achieved in all cases. Decline in neurological function was not observed at 6 months after the treatment in eight (80%) patients after the surgeries. There were two patients with a thrombosed giant vertebral aneurysm showing neurological deterioration after the treatment (mRS 5).

**Conclusions:** In the present era, cross-disciplinary microsurgical strategy for posterior circulation aneurysms may be an alternative for favorable outcomes and transferring the skills to future generation.

O5-6

## **Contralateral approach for para-clinoid aneurysms: the usefulness of high-resolution vessel MRI**

Seok Keun CHOI, Jiwook RYU, Ju In PARK

Kyung Hee University Hospital, ROK

**Purpose:** When we choose surgical treatment for para-clinoid aneurysms, ipsilateral neck exposure for proximal control and clinoidectomy for aneurysm exposure is a stereotypical strategy. However, we can encounter difficult surgical situations because of variations in anatomical relationships between the optic nerve, ophthalmic artery, and clinoid process. Even if we perform the full exposure of the bony structure, sometimes it is very difficult to do a complete clipping. So we may need to go into the aneurysm from the contralateral side to get a good surgical view. In case we get into an aneurysm around the clinoid process from the contralateral side, high-resolution vessel wall MRI can give good presurgical information. The authors intend to share the surgical experience of the para-clinoid aneurysm which were selected for the contralateral approach because we had expected difficulties if we chose the ipsilateral approach

**Material:** Ten aneurysms of nine patients are enrolled in this treatment case series. Clinical characteristics are: mean aneurysm size (large diameter mean 4.89mm; range 2-7.8mm), age (mean 55.4; range 27-74), sex(2male 7female).

Five aneurysms were diagnosed with superior hypophyseal artery aneurysms, 4 patients were ophthalmic aneurysms and one isolated dorsal wall aneurysm. Five patients were planned with an intentional contralateral approach, 4 patients were treated combined with the surgical clipping of other multiple aneurysms. One case was treated with intentional combined treatment of surgical and endovascular

**Results:** All patients were treated well surgically without any complications or intraoperative bleeding

**Conclusion:** In the aneurysm surgery, the proximal control is a demanding strategy; however, sometimes to get a complete clipping, a contralateral approach can be chosen. On the contralateral approach, because of no way out for proximal control, we need a more careful surgical strategy, and high-resolution vessel wall MRI should be helpful.

## Symptomatic Perforator Infarction after Clipping of P-com to Proximal A1 Aneurysms: Incidence, Clinical Characteristics, and Surgical Implications

Woo Cheul CHO<sup>1</sup>, Jai Ho CHOI<sup>2</sup>, Kwan Sung LEE<sup>3</sup>, Yong Sam SHIN<sup>4</sup>

<sup>1</sup>Seoul St. Mary's Hospital, The Catholic University of Korea, ROK, <sup>2</sup>Jai Ho Choi, <sup>3</sup>Kwan Sung Lee, <sup>4</sup>Yong Sam Shin

### Objective

To investigate the incidence and clinical characteristics of symptomatic perforator infarction following microsurgical clipping of aneurysms located from the posterior communicating artery (P-com) to the proximal A1 segment.

### Methods

We retrospectively reviewed our institutional aneurysm database from September 2008 to May 2026. Among 7,344 intracranial aneurysms, 3,494 were treated with microsurgical clipping. A total of 1,010 aneurysms located from the P-com to the proximal A1 segment were included, comprising 500 P-com, 431 anterior choroidal artery, 57 ICA bifurcation, and 22 proximal A1 aneurysms. Cases with symptomatic postoperative perforator infarction were identified and their clinical and radiological characteristics were analyzed.

**Results:** Symptomatic perforator infarction occurred in 9 of the 1,010 patients (0.89%). Among these, three patients developed infarction involving the left genu of the internal capsule. Notably, none exhibited immediate postoperative motor weakness; instead, they presented with transient disorientation and aphasia. All neurological symptoms improved within 3-4 days after surgery without permanent deficits.

**Conclusion:** Although symptomatic perforator infarction after clipping of P-com to proximal A1 aneurysms is rare, it may present as transient cognitive dysfunction rather than motor deficit, particularly in cases involving the left internal capsule genu. Meticulous perforator preservation remains the key to preventing these complications.

O6-1

## Perioperative Management Protocol to Reduce Complications of STA-MCA Bypass Surgery in Adult Hemorrhagic Moyamoya Disease

Shoko HARA, Takumi KOSAKA, Fuga AYABE, Yuji TAKANO, Yosuke ISHII, Motoki INAJI  
Department of Neurosurgery, Institute of Science Tokyo, Tokyo, Japan

**Introduction:** While STA-MCA bypass surgery is an established method to reduce recurrent hemorrhage in adult hemorrhagic moyamoya disease (MMD), it carries the risk of hyperperfusion syndrome that may result in significant morbidity. From 2022, we established a standard perioperative management protocol within the institution to reduce this complication and aimed to evaluate its effectiveness.

**Methods:** Patients with adult hemorrhagic MMD who underwent STA-MCA bypass from 2014 to 2025 were retrospectively evaluated. The perioperative management protocol from 2022 was as follows: perioperative administration of aspirin, postoperative administration of edaravone and levetiracetam, single bypass, postoperative target BP “<” 120-130 mmHg, perfusion studies at POD1 and POD7, and bed rest until POD7 if hyperperfusion was observed in perfusion studies. Before the standardized protocol, each patient was managed at the discretion of each physician; postoperative target BP was usually “<” 140 mmHg, and antiseizure medications were not routinely administered.

**Results:** Of 37 patients included (44.9 (13.6) years of age, 20 females), 19 patients were managed at each physician’s discretion, and 18 patients were managed under the standardized protocol. Before and after the standardized protocol, the incidence of radiological hyperperfusion (52.6% vs. 72.2%), hyperperfusion syndrome (52.6% vs. 50%), intracerebral hemorrhage (10.5% vs. 11.1%), or transient neurological symptoms (31.6% vs. 38.9%) did not differ; however, the incidence of seizure was lower in patients managed under the standardized protocol (4/19, 21.1% vs. 0/18, 0%,  $P = 0.11$ ).

**Conclusion:** Standardized perioperative management including routine antiseizure medication may be effective in reducing the incidence of seizure, but not hyperperfusion syndrome. Further improvements are necessary to ensure better outcomes for patients with adult hemorrhagic MMD.

## Hemodynamic and Morphologic Differences between Ruptured and Unruptured Periventricular Anastomosis in Adult moyamoya disease

Jiwook RYU<sup>1</sup>, Kyung Mi LEE<sup>2</sup>, Jae Sung HONG<sup>1</sup>, Ju In PARK<sup>1</sup>, Seok Keun CHOI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kyung Hee university, Seoul, ROK,

<sup>2</sup>Department of Radiology, Kyung Hee university, Seoul, ROK

### OBJECTIVES

Periventricular anastomosis (PA) has been implicated as a major source of hemorrhagic stroke in adult moyamoya disease. However, the hemodynamic and morphological factors associated with PA rupture remain poorly understood. This retrospective study aimed to identify potential risk factors associated with PA rupture.

### MATERIALS AND METHOD

Clinical and radiological data from patients with PA between 2019 and 2025 were retrospectively analyzed. Rupture status was determined using previously described criteria. Two independent raters quantitatively measured the TOF signal ratio and cross-sectional area (CSA) of each PA using high-resolution vessel wall imaging. Generalized linear mixed models were used to identify the risk factors for ruptured PA.

### RESULTS

A total of 366 PAs (46 ruptured, 320 unruptured) were identified in 103 patients, with a mean of 3.55 PAs per patient. Univariate analysis showed that the mean TOF signal ratio ( $2.48 \pm 0.89$  vs.  $1.83 \pm 0.47$ ,  $p < 0.001$ ) and CSA ( $1.13 \pm 0.34$  vs.  $0.83 \pm 0.25$  mm<sup>2</sup>,  $p < 0.001$ ) were significantly greater in the ruptured group than in the unruptured group. When stratified by PA subtype, the rupture rate was highest in choroidal anastomosis (ChA, 31/153, 20.3%), followed by thalamic anastomosis (THA, 7/95, 7.4%) and lenticulostriate anastomosis (LSA, 8/118, 6.8%). In a generalized linear mixed model adjusting for patient-level clustering, higher TOF signal ratio (OR 4.81, 95% CI 1.92-12.07,  $p < 0.001$ ) and larger CSA (OR 8.85, 95% CI 1.23-63.65,  $p = 0.030$ ) were independently associated with rupture, whereas LSA (OR 0.27, 95% CI 0.10-0.72,  $p = 0.009$ ) and THA (OR 0.21, 95% CI 0.07-0.69,  $p = 0.010$ ) subtypes showed significantly lower risk compared with ChA.

### CONCLUSIONS

Higher TOF signal ratio, larger CSA, and the ChA subtype were independently associated with PA rupture. These findings suggest that both hemodynamic and morphologic factors may contribute to rupture risk and may help guide treatment decisions for unruptured PA.

O6-3

## **Hemodynamic change in contralateral unoperated hemispheres following unilateral combined bypass surgery in adult patients with moyamoya disease**

Won-Sang CHO, Jeong Eun KIM

Department of Neurosurgery, Seoul National University Hospital, Seoul National University College of Medicine, ROK

**Background and Objectives:** Hemodynamic changes in the contralateral hemisphere after unilateral bypass surgery in patients with moyamoya disease (MMD) remain controversial. We aimed to investigate the hemodynamic changes in the contralateral hemisphere following unilateral combined bypass surgery in adult patients with MMD.

**Methods:** This retrospective study included 151 consecutive adult patients who underwent unilateral combined bypass surgery for bilateral MMD between August 2010 and December 2018. Clinical outcomes in the patients and hemodynamic changes in the operated and unoperated hemispheres were evaluated with the modified Rankin scale and acetazolamide-challenged single-photon emission computed tomography, respectively, at 6 months after surgery.

**Results:** Clinical status improved 6 months after surgery ( $p < 0.001$ ). In the operated hemisphere, basal cerebral blood flow (CBF) substantially increased across all the vascular territories (all  $p \leq 0.006$ ). Cerebrovascular reservoir capacity significantly increased in all territories (all  $p \leq 0.03$ ), except in the posterior cerebral artery territory. In the contralateral unoperated hemisphere, CBF increased significantly in some territories of the anterior, anterior middle, and posterior cerebral arteries (all  $p \leq 0.04$ ), with no significant change in terms of reservoir capacity.

**Conclusion:** CBF in the contralateral unoperated hemisphere significantly increased after surgery. These findings suggest that unilateral revascularization may exert bilateral hemodynamic effects, reducing the need for staged bilateral operations in certain cases. Surgical intervention should be considered selectively for hemispheres with symptomatic manifestations and hemodynamic instability.

## Prediction of Postoperative Neovascularization After Indirect Bypass in Adult Moyamoya Disease: A Preoperative Clinical and Perfusion-Based Model

Si Un LEE, Sang Hyo LEE, Jaehoon JANG, Jae Seung BANG

Department of Neurosurgery, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam-si, ROK

### OBJECTIVE

To identify preoperative clinical, angiographic, and quantitative perfusion predictors of postoperative neovascularization (PNV) after indirect bypass (IB) in adult moyamoya disease (MMD).

### METHODS

We retrospectively reviewed 128 hemispheres from adult MMD patients who underwent IB. Preoperative volumes of time-to-maximum (Tmax) longer than 4 seconds (4s) and longer than 6 seconds (6s) were obtained from CT perfusion analysis. PNV was evaluated 6 months after surgery using the Matsushima grading system. Multivariable logistic regression analyses were performed to identify independent predictors of favorable PNV, defined as Matsushima grade (MGr) A and as MGr A or B. Receiver operating characteristic curve analysis was used to determine optimal cut-off values.

### RESULTS

At 6 months postoperatively, 38.3 percent of hemispheres achieved MGr A PNV, and 67.2 percent achieved MGr A or B PNV. For MGr A PNV, younger age (OR 0.95, 95 percent CI 0.91-0.99;  $p=0.009$ ) and a larger preoperative volume of Tmax longer than 6s (OR 1.022, 95 percent CI 1.01-1.03;  $p$  below 0.001) were significant predictors, with an optimal cut-off value of 33.5 mL for Tmax longer than 6s (AUC 0.805; sensitivity 76 percent; specificity 75 percent). For MGr A or B PNV, transient ischemic attack (TIA) presentation (OR 2.90, 95 percent CI 1.12-7.97;  $p=0.033$ ) and a larger preoperative volume of Tmax longer than 4s (OR 1.019, 95 percent CI 1.01-1.03;  $p$  below 0.001) were significant predictors, with an optimal cut-off value of 111.5 mL for Tmax longer than 4s (AUC 0.817; sensitivity 70 percent; specificity 93 percent).

### CONCLUSION

In adult MMD, greater preoperative ischemic burden measured by volume of Tmax longer than 4s or 6s predicted favorable PNV after IB. Younger age and TIA presentation were also associated with better PNV. These findings suggest that quantitative perfusion parameters, together with clinical factors, may support surgical decision-making and individualized treatment planning.

O6-5

## **Modified STA Side-Branch Bypass for Adult Moyamoya Disease: A Tailored Revascularization Strategy**

Shintaro ARAI<sup>1</sup>, Tatsuya SUGIYAMA<sup>2</sup>, Tohru MIZUTANI<sup>2</sup>, Kenji SUMI<sup>1</sup>,  
Masaki MATSUMOTO<sup>1</sup>, Yoichi MOROFUJI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, School of Medicine, Showa Medical University, Japan,

<sup>2</sup>Department of Neurosurgery, Koto-Toyosu Hospital, Showa Medical University

### Background:

Direct bypass surgery is an established treatment for adult moyamoya disease (MMD), but postoperative cerebral hyperperfusion syndrome remains a significant concern. In selected patients with marked donor-recipient vessel caliber mismatch, standard superficial temporal artery to middle cerebral artery (STA-MCA) bypass may result in excessive flow augmentation.

### Methods:

We applied a modified revascularization strategy using a superficial temporal artery side branch as the donor vessel in adult MMD patients considered at increased risk of hyperperfusion or technical difficulty with conventional bypass. Clinical data, perioperative findings, and postoperative outcomes were retrospectively reviewed.

### Results:

Five cerebral hemispheres in adult MMD patients underwent side-branch STA-MCA bypass. Successful anastomosis was achieved in all cases, and postoperative imaging confirmed bypass patency in every patient. No perioperative ischemic complications, wound complications, or symptomatic cerebral hyperperfusion syndrome were observed. All patients demonstrated favorable postoperative clinical courses.

### Conclusions:

STA side-branch bypass may represent a useful alternative revascularization strategy in selected adult MMD patients with donor-recipient caliber mismatch. Tailoring bypass design according to vascular anatomy may improve surgical safety and optimize cerebral blood flow augmentation.

## Impact of Reduced-Size Arteriotomy on Postoperative Cerebral Hyperperfusion Syndrome in Moyamoya Bypass Surgery

Hye Won CHOI, Jin Woo BAE, Je Young YEON, Jong-soo KIM, Tae Keun JEE

Samsung medical center, ROK

**Background:** Cerebral hyperperfusion syndrome (CHS) is a painful, unpredictable complication after direct revascularization for moyamoya disease (MMD), with a reported incidence up to 23% and hemorrhage in about 15%. CHS is often attributed to fixed patient factors and impaired autoregulation. We hypothesized that arteriotomy (anastomotic stoma) size is a modifiable surgical variable: a smaller stoma limits the sudden hemodynamic surge and reduces CHS.

**Methods:** We retrospectively analyzed a single-surgeon series of adult MMD patients undergoing combined bypass (STA frontal branch direct anastomosis plus parietal branch EDAS) between January 2024 and March 2026. After September 2025, arteriotomy used a steeper (approximately 60 degrees) transection angle, reducing the cut circumference to 50-70% and the opening area by 44-75%. The reduced-size (Case) group comprised 38 hemispheres and the conventional (Control) group 66 hemispheres. Recipient selection and pedicle handling were standardized. The primary outcome was symptomatic CHS (newly developed neurologic deficit or seizure, or postoperative SAH/ICH within 1 week); secondary outcomes were ischemic stroke, pedicle occlusion, and anastomosis time.

**Results:** Age, sex, and MMD type were comparable between groups. Median suture count fell from 13 to 9 and median anastomosis time from 27.3 to 22.5 minutes. Symptomatic CHS was lower in the Case group (7.9% vs 22.7%), including newly developed deficit (5.3% vs 13.6%) and hemorrhage (2.6% vs 9.1%). Intraoperative hyperemic change (0% vs 6.1%) and ischemic stroke (0% vs 3.0%) also favored the Case group. Graft patency was maintained in both (occlusion 2.6% vs 4.5%).

**Conclusions:** Reducing arteriotomy size during direct MMD bypass provides a safer hemodynamic transition and lowers hyperperfusion-related complications, while shortening the ischemic window without compromising revascularization.

O6-7

## Association Between Reduced Cerebral Oxygen Metabolism and Prolonged TNEs After Revascularization for Moyamoya Disease

Koki ONODERA, Koki ONODERA, Eika HAMANO, Kazuki KOMIYAMA,  
Junichiro OCHIAI, Yu YAMAMOTO, Takenori OGURA, Hisae MORI, Koji IIHARA,  
Hiroharu KATAOKA, Masakazu OKAWA  
National Cerebral and Cardiovascular Center, Japan

**Background:** Transient neurological events (TNEs) frequently occur after direct revascularization for moyamoya disease (MMD). Although hyperperfusion, ischemia, and seizures have been proposed as underlying mechanisms, differentiating these conditions remains challenging. We investigated the association between prolonged TNEs and postoperative cerebral hemodynamic and metabolic changes.

**Methods:** We retrospectively analyzed patients with MMD who underwent direct revascularization between 2013-2018 and received <sup>15</sup>O-gas positron emission tomography (PET) before surgery and within 14 days postoperatively. The middle cerebral artery (MCA) territory was divided into anterior and posterior regions. Pre- to postoperative ratios of cerebral blood flow (CBF) and cerebral metabolic rate of oxygen (CMRO<sub>2</sub>) were calculated. Prolonged TNEs were defined as symptoms lasting  $\geq 7$  days. Logistic regression analyses evaluated associations of CBF and CMRO<sub>2</sub> ratios with prolonged TNEs. CMRO<sub>2</sub> ratios were scaled per 0.1-unit decrease and CBF ratios per 0.1-unit increase. Additional analyses were performed in hemispheres with increased postoperative CBF (CBF ratio  $\geq 1$ ).

**Results:** Thirty-five hemispheres from 31 patients were included, and prolonged TNEs occurred in 12 hemispheres (34%). CBF and CMRO<sub>2</sub> ratios were positively correlated in both MCA regions (both  $P < 0.001$ ). In multivariable analysis, each 0.1-unit decrease in the CMRO<sub>2</sub> ratio was independently associated with prolonged TNEs in the posterior MCA region (OR, 2.34; 95% CI, 1.12-4.89;  $P = 0.023$ ), whereas the CBF ratio was not. Among hemispheres with increased postoperative CBF, each 0.1-unit decrease in the CMRO<sub>2</sub> ratio remained independently associated with prolonged TNEs in both the anterior (OR, 2.19;  $P = 0.047$ ) and posterior (OR, 2.49;  $P = 0.020$ ) MCA regions.

**Conclusions:** Reduced cerebral oxygen metabolism is independently associated with prolonged TNEs after direct revascularization for MMD, even in hemispheres with increased postoperative CBF. Assessment of CMRO<sub>2</sub> may provide insight into the pathophysiology of prolonged postoperative TNEs.

## Technical System for Becoming a Cerebral Bypass Surgeon: Acquisition and Transmission of Bypass Techniques Based on 250 Cases and Clinical Research

Sho TSUNODA<sup>1</sup>, Sho TSUNODA<sup>1</sup>, Tomohiro INOUE<sup>2</sup>,  
Toshimitsu YOKOI<sup>1</sup>, Shigehiko TAKANASHI<sup>1</sup>

<sup>1</sup>The Department of Neurosurgery, Tokyo Metropolitan Geriatric Hospital, Japan, <sup>2</sup>NTT Medical Center Tokyo

### Background:

Cerebral revascularization includes procedures ranging from superficial temporal artery to middle cerebral artery (STA-MCA) bypass to deep and complex reconstructions such as STA-superior cerebellar artery (SCA) bypass and radial artery graft (RAG) bypasses. Despite advances in endovascular therapy, bypass surgery remains essential for complex aneurysms, moyamoya disease, and major cerebral artery occlusive disease. However, reproducible training systems for bypass surgeons remain insufficient.

### Methods:

We present a structured technical system based on mentorship under expert bypass surgeons, 250 personally performed cases, and clinical research. The series included 218 STA-MCA bypasses and 32 complex bypasses, including EC-RAG-M2, OA-PICA, STA-SCA, A3-A3, A3-STA-A3, STA-RAG-A3, V3-RAG-PICA, and V3-RAG-P2 bypasses. Microsurgical suturing practice (30 stitches/day) began during postgraduate year 1 and gradually transitioned into clinical surgery. Early operative experience was intentionally focused on STA-MCA bypasses, with technical stabilization achieved through approximately 30 annual cases at a high-volume cerebrovascular center. After successful completion of complex bypasses in postgraduate year 9, the surgical focus shifted toward advanced bypass procedures and education.

### Results:

Three essential factors for bypass surgeon development were identified: (1) mentorship by experienced bypass surgeons, (2) sustained exposure in a high-volume environment, and (3) objective technical evaluation through clinical research. Key technical principles included preservation of scalp collateral circulation during donor harvesting, creation of a dry operative field using skull base techniques, and durable anastomosis through intimal eversion and optimized needle handling. These principles were applicable across superficial, deep, and graft-assisted bypasses.

### Conclusions:

Cerebral bypass surgery can be systematized and effectively transmitted through structured training, appropriate surgical environments, and clinical data analysis. This study provides a practical roadmap for neurosurgeons seeking independence as cerebrovascular microsurgeons.

07-2

## **Mechanical Revascularization and Acute-Phase Bypass Surgery at Our Hospital**

**Akio TERANISHI, Kazuaki KURIHARA, Ryota SAITO, Yuto INOUE, Haruka KUME, Kenu RYO,  
Takuma MAEDA, Yushiro TAKE, Takayuki HARA, Hiroki KURITA**

Department of Neurosurgery, International Medical Center, Saitama Medical University, Japan

(Introduction) Thrombectomy has become the standard of care in Japan, and its indications have expanded rapidly in recent years. Among the conditions where diagnosis is challenging and there is no established consensus on treatment strategies, intracranial atherosclerotic disease (ICAD) is a prime example. We have observed cases in which, despite achieving recanalization, reocclusion occurs, ultimately leading to poor clinical outcomes. At our institution, we carefully evaluate the indications and perform acute-phase stamca bypass surgery in cases where symptoms progressively worsen despite medical therapy following reocclusion. We will outline recent trends and treatment policies at our institution. (Results and discussion) Although there are scattered reports on the efficacy of acute-phase bypass surgery for ICAD cases, there are no established indications, and the current situation is that each institution has established its own intervention criteria. At our hospital, we consider treatment for cases with a preoperative mRS score of 2 or lower who present with imaging evidence of expanding ischemic foci and progressive symptom worsening, provided they have received optimal medical therapy upon admission. In all patients at our hospital in which acute-phase bypass surgery was performed within one week of endovascular treatment, patency of the bypass was confirmed, and at the 3-month follow-up, patients showed improvement in symptoms compared to their condition at admission. Recent trends show an increase in the total number of mechanical thrombectomy procedures performed. Furthermore, with the continuous introduction of new devices, it is anticipated that the number of ICAD procedures—and consequently, the number of cases with favorable outcomes—will continue to rise. In other words, there may be increasing opportunities to consider bypass surgery for preventable cases where cerebral blood flow is barely maintained through optimal medical and endovascular treatments.

## Association Between Intraoperative Blood Pressure Reduction and Postoperative Infarct Enlargement in Acute EC-IC Bypass for Progressive Ischemic Stroke

Hiroyuki MIZUNO<sup>1,2</sup>, Tatsuya SHIMIZU<sup>1</sup>, Takehiko YOSHIMI<sup>1</sup>, Koki NAKAZATO<sup>1</sup>, Yumeki YAMAMOTO<sup>1</sup>, Takahiro SAITO<sup>1</sup>, Naoto MUKADA<sup>2</sup>, Ryosuke SHINTOKU<sup>2</sup>, Rei YAMAGUCHI<sup>2</sup>, Masanori AIHARA<sup>2</sup>, Soichi OYA<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Japanese Red Cross Maebashi Hospital, Gunma, Japan, <sup>2</sup>Department of Neurosurgery, Gunma University Graduate School of Medicine, Gunma, Japan

**Background:** In acute extracranial-intracranial (EC-IC) bypass for progressing ischemic stroke, maintaining perfusion until bypass patency is crucial. The effect of post-induction blood pressure reduction on infarct growth remains unclear. We investigated the association between pre-patency blood pressure management and postoperative increase in diffusion-weighted imaging (DWI) infarct volume.

**Methods:** We retrospectively analyzed 15 patients who underwent acute EC-IC bypass for progressing ischemic stroke due to intracranial steno-occlusive disease at two institutions between 2016 and 2026. Delta National Institutes of Health Stroke Scale (NIHSS) was the difference between NIHSS before deterioration or at presentation and NIHSS before surgery. Patients were classified into severe (Delta NIHSS 4 or higher) and mild (Delta NIHSS less than 4) progression groups. Baseline mean arterial pressure (MAP) was resting MAP before induction; the low-MAP threshold was 80% of baseline. Low-MAP burden (mmHg\*min) was calculated by summing MAP reduction below this threshold multiplied by duration from induction to patency. Associations with DWI infarct volume increase were evaluated using Spearman's rank correlation. Hypotensive events were defined as systolic blood pressure below 90 mmHg.

**Results:** The mild group included 9 patients, with median Delta NIHSS of 2 and median DWI infarct growth of 2.0 mL. The severe group included 6 patients, with median Delta NIHSS of 6.5 and median DWI infarct growth of 8.4 mL. Overall, low-MAP burden tended to correlate with DWI infarct growth ( $\rho=0.46$ ,  $p=0.084$ ). Stratified analysis showed no clear correlation in the mild group ( $\rho=0.12$ ,  $p=0.758$ ), whereas the correlation was more evident in the severe group ( $\rho=0.71$ ,  $p=0.114$ ). Hypotensive event counts showed a similar trend in the severe group ( $\rho=0.63$ ,  $p=0.180$ ).

**Conclusions:** Low-MAP burden before bypass patency may be associated with postoperative increase in DWI infarct volume, particularly in patients with marked neurological progression.

07-4

## **COMparision of clinical and radiological outcomes between suction asPiration method and combination mEthod of mechanical Thrombectomy in acute cerebral infarction: (COMPETE) trial interim analysis**

Sung-Chul JIN

Department of Neurosurgery, Inje University, Haeundae Paik Hospital, ROK

### Background

To compare aspiration thrombectomy and combination thrombectomy for acute ischemic stroke in a multicenter randomized setting.

### Methods

Interim analysis of the COMPETE trial including 328 patients (aspiration, n=173; combination, n=155). Angiographic, procedural, and clinical outcomes were compared. Multivariable modified Poisson regression was performed with site adjustment.

### Results

First-pass recanalization occurred in 46.8% of aspiration and 58.1% of combination patients ( $P=0.072$ ). Successful reperfusion (mTICI  $\geq 2b$ ) was achieved in 95.4% and 94.8%, respectively ( $P=0.972$ ). Favorable 90-day outcome (mRS 0-2) was observed in 50.3% and 50.7% of patients, respectively ( $P=0.866$ ). Complication rates were similar between groups. In adjusted analysis, combination thrombectomy showed a trend toward improved first-pass recanalization (adjusted RR 1.23, 95% CI 1.00-1.51;  $P=0.052$ ), but treatment modality was not associated with favorable clinical outcome.

### Conclusions

Aspiration thrombectomy demonstrated angiographic and clinical outcomes comparable to combination thrombectomy. While combination therapy tended to improve first-pass recanalization, no corresponding improvement in functional outcome was observed.

## Management of Aneurysms in Hemorrhagic Moyamoya Disease: Hemodynamic Insights from a Case Series

Yong-Jun LEE, Wan PARK, You-sub KIM, Sung Pil JOO, Tae Sun KIM

Department of Neurosurgery, Chonnam National University Hospital & Medical School, ROK

### Background

Intracranial aneurysms and pseudoaneurysms associated with moyamoya disease (MMD) are uncommon but clinically important causes of hemorrhage. Because these lesions frequently arise from collateral vessels exposed to chronic hemodynamic stress, their natural history and optimal management remain poorly defined. We reviewed our institutional experience to evaluate the relationship between angiographic findings, hemodynamic status, and treatment strategies.

### Methods

Seven patients with hemorrhagic MMD in whom intracranial aneurysms or pseudoaneurysms were identified on transfemoral cerebral angiography were retrospectively reviewed. Clinical presentation, angiographic characteristics, perfusion studies, treatment strategies, and clinical outcomes were analyzed.

### Results

Aneurysms and pseudoaneurysms were identified in diverse vascular territories, including the anterior communicating artery, anterior and posterior choroidal arteries, posterior cerebral artery branches, and deep collateral-related vessels. Clinical courses were heterogeneous. In one patient, a deep collateral-related pseudoaneurysm was anatomically inaccessible for endovascular treatment and demonstrated spontaneous regression with eventual angiographic disappearance during follow-up. Despite a focal perfusion defect on subsequent acetazolamide-challenged SPECT, the patient remained clinically stable and was managed conservatively. In contrast, another patient experienced recurrent hemorrhagic events and impaired cerebral perfusion before a distal anterior choroidal artery pseudoaneurysm was identified and successfully treated with endovascular embolization. Across the series, angiographic evolution alone did not consistently correlate with subsequent clinical outcomes. Management decisions were primarily influenced by lesion accessibility and the overall hemodynamic context rather than aneurysm morphology alone.

### Conclusion

Hemorrhagic moyamoya-associated aneurysms appear to represent dynamic manifestations of altered collateral hemodynamics rather than isolated focal vascular lesions. Angiographic findings alone may be insufficient for treatment decision-making. Integration of lesion accessibility and cerebral hemodynamic status may provide a practical framework for individualized management of these complex lesions.

07-6

## **Hemodynamic and Morphologic Differences Between Complex- and Original-Type Choroidal Anastomosis in Adult Moyamoya Disease: A Cross-Sectional MRI Study**

Jae Seong HONG<sup>1</sup>, Jiwook RYU<sup>1</sup>, Kyung Mi LEE<sup>2</sup>, Ju In PARK<sup>1</sup>, Seok Keun CHOI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kyung Hee university hospital, Seoul, ROK, <sup>2</sup>Department of Radiology, Kyung Hee university hospital, Seoul, ROK

### OBJECTIVES

Choroidal anastomosis (ChA), particularly the complex type, has recently been reported as a predictor of hemorrhagic risk in adult moyamoya disease. However, the hemodynamic and morphologic characteristics underlying this high-risk collateral phenotype remain unclear. This study aimed to identify morphologic and hemodynamic factors associated with complex-type ChA using high-resolution MRI.

### MATERIALS AND METHOD

Clinical and radiological data from ChA positive hemispheres between 2019 and 2025 were retrospectively analyzed. ChA branching patterns were classified as original-type or complex-type based on the presence of medullary branches extending into both supra- and infrasyllvian territories. Two independent raters quantitatively measured the TOF signal ratio and cross-sectional area (CSA) of each ChA using high-resolution vessel wall imaging. Logistic regression analyses were performed to identify factors associated with complex-type ChA.

### RESULTS

A total of 155 ChAs (112 original-type and 43 complex-type) were identified in 100 patients. On univariate analysis, both the TOF signal ratio ( $2.19 \pm 0.65$  vs.  $1.81 \pm 0.44$ ,  $p < 0.001$ ) and CSA ( $1.06 \pm 0.29$  vs.  $0.86 \pm 0.27$  mm<sup>2</sup>,  $p < 0.001$ ) were significantly higher in the complex-type group. In multivariate logistic regression adjusted for age and sex, a higher TOF signal ratio remained independently associated with complex-type ChA (OR 2.51, 95% CI 1.01-6.22,  $p = 0.046$ ).

### CONCLUSIONS

Complex-type ChA is primarily associated with increased flow-related signal rather than vessel size alone, suggesting that this collateral pattern represents a hemodynamically driven phenotype. These findings provide mechanistic insight into the association between complex-type ChA and hemorrhagic risk.

## **Cerebrospinal Fluid Cytokine Profiling Reveals a Shared Inflammatory Signature Between Pneumococcal Meningitis-Associated and Subarachnoid Hemorrhage-Associated Cerebral Vasospasm: A Pediatric Case Report**

Gen YAMAUCHI<sup>1,2</sup>, Kosuke AOKI<sup>2,3</sup>, Koji OSUKA<sup>4</sup>, Masahiro WAKABAYASHI<sup>2</sup>,  
Ryosuke OSHIMA<sup>2</sup>, Shigemasa HAYASHI<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Chukyou Hospital, Aichi, Japan, <sup>2</sup>Department of Neurosurgery, Kasugai Municipal Hospital, Aichi, Japan, <sup>3</sup>Department of Neurosurgery, Graduate School of Medicine, Nagoya University, Aichi, Japan, <sup>4</sup>Department of Neurological Surgery, Aichi Medical University, Aichi, Japan

### Background

Cerebral vasospasm following subarachnoid hemorrhage (SAH) has been extensively associated with inflammatory cytokine responses in the cerebrospinal fluid (CSF), particularly interleukin-6 (IL-6). In contrast, the inflammatory mechanisms underlying cerebral vasospasm following bacterial meningitis, especially in pediatric patients, remain poorly understood. We report a pediatric case of pneumococcal meningitis-associated cerebral vasospasm in which serial CSF cytokine profiling was performed and compared with previously reported CSF cytokine profiles in SAH.

### Case presentation

A 10-year-old boy developed pneumococcal meningitis following influenza A infection. Despite appropriate antimicrobial therapy, he developed cerebral vasospasm with cerebral infarction. MRI demonstrated a right frontal infarction, and MRA revealed diffuse vasospasm involving the bilateral M1 segments, A1 segments, and supraclinoid internal carotid arteries. Serial CSF samples were obtained on hospital days 1 and 18 during the acute and recovery phases. CSF concentrations of IL-6, monocyte chemoattractant protein-1 (MCP-1), interferon gamma-induced protein-10 (IP-10), and monokine induced by interferon gamma (MIG) were measured using enzyme-linked immunosorbent assays and compared with previously reported CSF cytokine profiles from patients with SAH-associated cerebral vasospasm and unruptured intracranial aneurysms. Acute-phase CSF cytokine analysis demonstrated marked elevations of all four cytokines. Compared with SAH-associated cerebral vasospasm, IL-6, IP-10, and MIG were markedly higher, whereas MCP-1 showed a comparable increase. All cytokine concentrations decreased substantially during recovery, paralleling neurological improvement and radiological resolution of cerebral vasospasm.

### Discussion

This case suggests that meningitis-associated cerebral vasospasm may share inflammatory pathways with SAH-associated cerebral vasospasm while reflecting a more pronounced inflammatory response associated with bacterial infection. Serial CSF cytokine profiling may provide insight into the pathophysiology of this condition.

### Conclusions

Serial CSF cytokine profiling revealed a distinct inflammatory profile in meningitis-associated cerebral vasospasm. Further studies are warranted to determine whether inflammatory cytokines may serve as biomarkers of disease activity or therapeutic targets to guide treatment in meningitis-associated cerebral vasospasm.

O8-1

## Outcomes of cranioplasty with customized artificial bone flap made by 3D printing technique in patients with aneurysmal subarachnoid hemorrhage

Sung-Tae KIM<sup>1</sup>, Min Geun GIL<sup>2</sup>, Se Young PYO<sup>2</sup>, Juwhan LEE<sup>2</sup>, Jin LEE<sup>2</sup>, Won Hee LEE<sup>2</sup>, Keun Soo LEE<sup>2</sup>, Sung-chul JIN<sup>1</sup>, Sung Hwa PAENG<sup>2</sup>, Moo Seong KIM<sup>2</sup>, Young Gyun JEONG<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Haeundae Paik Hospital, Inje University College of Medicine, Busan, ROK, <sup>2</sup>Department of Neurosurgery, Busan Paik Hospital, Inje University College of Medicine, Busan, ROK

### Objective

This study compared clinical and cosmetic outcomes of cranioplasty using customized three-dimensional (3D) printed implants versus autologous bone in patients with aneurysmal subarachnoid hemorrhage (aSAH) after decompressive craniectomy (DC).

### Methods

We retrospectively reviewed 50 patients who underwent cranioplasty after DC for aSAH between July 2018 and December 2023. Patients were divided into the three-dimensional cranioplasty (3DC, n=26) and autologous bone cranioplasty (AC, n=24) groups. Demographics, aneurysm characteristics, surgical parameters, morphometric analysis of defect coverage, complications, and functional outcomes assessed by the modified Rankin Scale (mRS) were compared.

### Results

A total of 54 hemispheres underwent cranioplasty. Compared with AC, the 3DC group had larger defects but achieved higher coverage (96.7% vs. 93.4%,  $p=0.044$ ) and smaller residual defects ( $338.7 \pm 274.2$  mm<sup>2</sup> vs.  $528.5 \pm 331.3$  mm<sup>2</sup>,  $p=0.049$ ). Complication rates were lower in 3-DC (9 cases) than AC (15 cases,  $p=0.0994$ ). Wound dehiscence and fluid collection were more frequent with 3-DC, while bone flap resorption and epidural abscess occurred only with AC. Revision surgery was required in six patients, five initially treated with autologous bone. Neurological outcomes (mRS) were maintained or improved in both groups.

### Conclusions

In aSAH patients undergoing cranioplasty after DC, customized 3D printed implants achieved significantly better anatomical restoration and showed a numerical trend toward fewer complications compared with autologous bone. While AC remains feasible, its risks of resorption and infection often necessitate revision. 3-D printed implants may be considered a reasonable alternative, particularly in aSAH patients at higher risk of complications.

## **Microscopic cerebrovascular neurosurgery using bypass and skull base technique**

Tomohiro INOUE

Department of Neurosurgery, NTT medical center Tokyo, Japan

In the Era of Endovascular and Less invasive treatment, we cerebrovascular microscopic neurosurgeons need to sincerely consider radicality and safety of the treatment. To accomplish Radicality and Safety in microscopic neurosurgery, I would say there are two important issues. First, appropriate and enough surgical corridor including skull base approaches. Second, cerebral revascularization techniques including various bypasses. Surgical videos including various approaches such as anterior clinoidectomy, transcondylar fossa approach, transpetrosal drilling, as well as high flow bypass, A3A3, STASCA would be presented and discussed.

O8-3

## **Intracranial hypotension presenting with brain sagging ; a decision making and treatment strategies in various neurosurgical field**

Sungpil JOO<sup>1,2</sup>, You Sub KIM<sup>1</sup>, Tae Sun KIM<sup>1</sup>

<sup>1</sup>Chonnam National University Hospital, ROK, <sup>2</sup>Chonnam National University Hospital,

<sup>3</sup>Chonnam National University Hospital

**Background:** Large reduction in intracranial cerebrospinal fluid (CSF) volume can cause complications including intracranial hypotension characterized by brain sag, loss of CSF cisterns or tonsillar herniation. We reviewed our experience of bilateral subdural hygrom (SDH) secondary to spontaneous intracranial hypotension (SIH) mainly focusing on decision making and treatment strategies.

**Methods:** We retrospectively reviewed bilateral SDH secondary to SIH including brain sagging between March 2010 and September 2025. Baseline characteristics of patients, diagnosis, radiologic findings, treatments and clinical outcome were investigated.

**Results:** A total of 21 patients (10 men, 11 women) were included in this study. The patients were initially treated with conservative treatment (4 patients, 26.7%), epidural blood patch (EBP, 3 patients, 20.0%), and SDH drainage through burr hole followed by Trendelenburg position (8 patients, 53.3%). All 3 patients initially treated with EBP required SDH drainage. Of the 10 patients initially treated with SDH drainage through burr hole followed by Trendelenburg position, 7 patients (7/8, 87.5%) achieved sustained improvement of both symptom and radiologic findings without additional EBP but 1 patient needed additional EBP. Over the admitted course, deterioration to coma occurred in 6 of 15 patients (40.0%), of which 3 patients during radiologic evaluation, and the remaining 3 patients few days after EBP. Trendelenburg position after SDH drainage achieved immediate improvements of consciousness in all 8 deteriorated patients. Of the 6 patients, 7 patients achieved sustained improvement without additional EBP, but 1 patient required additional EBP.

**Conclusions:** Careful review of radiologic findings including SDH thickness, midbrain sagging and cistern effacement is critical for timely diagnosis and treatment.

## CT-Guided MMA Frontal-Parietal Bifurcation-Targeted Burr Hole Trephination: A Refined Single-Stage Surgical Approach for Chronic Subdural Hematoma

Shin-Woong KO, Sang Mook KANG, Jin Hwan CHEONG, Yu Deok WON

Department of Neurosurgery, Hanyang University Guri Hospital, ROK

### Background:

Middle meningeal artery (MMA) embolization has emerged as a promising endovascular treatment for chronic subdural hematoma (cSDH), demonstrating significant reduction in recurrence rates. However, under current Korean National Health Insurance reimbursement criteria, MMA embolization is approved only for recurrent cSDH following prior surgical drainage. Consequently, patients experiencing postoperative recurrence are subjected to a multistep treatment pathway – initial burr hole drainage followed by either repeat surgical evacuation or a separate endovascular procedure – imposing considerable financial burden and procedural risk upon an already vulnerable, predominantly elderly population.

### Methods:

Since December 2025, we prospectively implemented a refined surgical technique in patients with symptomatic cSDH requiring decompression. Rather than conventional burr hole placement at Kocher's point or the parietal eminence, trephination is performed at the frontal-parietal bifurcation of the MMA, identified preoperatively on standard brain CT via the MMA vascular groove along the inner table of the skull. Intraoperatively, this site enables direct visualization of the MMA bifurcation through the dura, which is selectively coagulated using bipolar electrocautery, replicating the effect of endovascular embolization, while simultaneous dural opening achieves subdural decompression. Ten consecutive patients were treated.

### Results:

All ten patients underwent successful MMA bifurcation coagulation with concurrent subdural drainage. Symptom relief was achieved promptly in all cases. At the time of reporting, no recurrence has been observed in any patient throughout the follow-up period.

### Conclusion:

CT-guided MMA bifurcation-targeted burr hole trephination with direct bipolar coagulation is a technically feasible, single-stage surgical approach that simultaneously achieves subdural decompression and MMA devascularization. This technique may offer a cost-effective, insurance-compatible alternative to the current multistep treatment paradigm within the Korean healthcare framework. Larger prospective studies are warranted to validate its efficacy and safety.

O8-5

## **The Novel Trocar for Laparoscopic Ventriculoperitoneal Shunt Surgery for Post-Hemorrhagic Hydrocephalus**

Eun Suk PARK<sup>1</sup>, Jong Min LEE<sup>2</sup>, Se Jeong JEON<sup>3</sup>, Dae-won KIM<sup>1</sup>, Sung-don KANG<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Wonkwang University Hospital, Wonkwang University School of Medicine, Iksan, ROK, <sup>2</sup>Department of Neurosurgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, ROK,

<sup>3</sup>Department of Radiology, Wonkwang University Hospital, Wonkwang University School of Medicine, Iksan, ROK

**Background:** Laparoscopy-assisted ventriculoperitoneal (VP) shunt surgery improves visualization during distal catheter placement but may require additional abdominal punctures for pneumoperitoneum or catheter insertion. We developed a single-port trocar that enables insufflation and catheter placement through one access site.

**Objective:** To assess the safety and feasibility of this novel trocar in laparoscopy-assisted VP shunt surgery for post-hemorrhagic hydrocephalus.

**Methods:** This prospective, single-arm pilot study included patients undergoing VP shunt surgery from March 2024 to December 2025. The trocar featured a lateral catheter-handling opening, transparent body for direct visualization, and integrated gas insufflation. It was designed to be removed without catheter displacement. Primary outcomes were procedural feasibility and intraoperative safety.

**Results:** Twenty patients were enrolled. Mean trocar incision length was 1.2 +/- 0.3 cm. Mean abdominal and total operative times were 17 +/- 4 minutes and 55 +/- 5 minutes, respectively. Distal catheter placement through a single abdominal port was successful in all cases. No intraoperative technical difficulties or trocar-related adverse events occurred.

**Conclusion:** The novel single-port trocar was safe and feasible for laparoscopy-assisted VP shunt surgery. This system may simplify distal catheter placement and reduce access-related trauma, although larger comparative studies are required.

## Standardization and Advancement of Full Exoscopic Direct Cerebrovascular Surgery

Tsutomu ICHINOSE, Kengo KISHIDA, Takeo GOTO

Department of Neurosurgery, Osaka Metropolitan University, Osaka, Japan

### Introduction

The usefulness of exoscopes in neurosurgery has been increasingly reported. Our department introduced a 4K-3D exoscope in April 2024 and has since worked to standardize the operative setup for full-exoscopic surgery, including the positional relationship between the surgeon and assistant, to maximize its advantages. This study reviews our experience across multiple cerebrovascular procedures and examines strategies for standardization and future applicability.

### Methods

Fifty-eight cases were included: 18 clipping procedures, 14 carotid endarterectomies (CEA), 21 STA-MCA bypasses (17 moyamoya disease), 3 high-flow bypasses, and 1 arteriovenous malformation (AVM) resection.

### Results

Clipping: Initially, the surgeon and assistant were positioned side-by-side sharing the main monitor, but excessive neck rotation impaired the assistant's operability. A face-to-face configuration with optimized head positioning improved maneuverability. Rearrangement of anesthesia equipment also shortened preparation time.

Bypass surgery: Adjusting head position enabled face-to-face four-handed (4-hands) full-exoscopic surgery from STA dissection to anastomosis. During anastomosis, autofocus, camera-position adjustments, and digital zoom enhanced precision.

CEA: A face-to-face configuration with a sub-monitor facilitated 4-hands operation. Ergonomic strain during submandibular exposure was reduced, allowing safe access to high cervical lesions without extending the skin incision.

High-flow bypass and AVM resection: Phase-specific adjustments of team positioning enabled smooth anastomosis. In AVM resection, 4-hands operation contributed to safe and efficient removal.

### Discussion and Conclusion

Full-exoscopic surgery offers advantages such as shared high-definition 3D visualization and improved surgeon ergonomics. Our experience suggests that standardization of surgeon-assistant positioning may provide operability surpassing that of the conventional microscope. Across multiple procedures, standardized full-exoscopic cerebrovascular surgery appears to enhance safety, efficiency, and educational value.

O8-7

## **Distinct Hematoma-Absorption Dynamics After Repeat Surgery Versus Particle Middle Meningeal Artery Embolization for Recurrent Chronic Subdural Hematoma**

Jinhwan KOO<sup>1</sup>, Kangmin KIM<sup>1</sup>, Jeong Eun KIM<sup>1</sup>, Hyun-seung KANG<sup>1</sup>, Won-sang CHO<sup>1</sup>,  
Young Dae CHO<sup>2</sup>, Dong Hyun YOO<sup>2</sup>, Tae Yoon PARK<sup>3</sup>, Moowan PARK<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Seoul National University Hospital, Seoul, ROK, <sup>2</sup>Department of Radiology, Seoul National University Hospital, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Gachon University Gil Medical Center, Incheon, ROK

**Objective.** Retreatment of recurrent chronic subdural hematoma (cSDH) - repeat surgery, middle meningeal artery embolization (MMAE), or both - is usually compared by binary recurrence rates, ignoring how the hematoma resolves. We used serial volumetric trajectories to test whether absorption dynamics differ by modality.

**Methods.** In this single-center retrospective cohort, 87 recurrent-cSDH episodes (351 serial CTs) after initial surgery were retreated by repeat surgery only (n=48), MMAE only (n=18; 150-250 micron polyvinyl alcohol particles), or repeat surgery + MMAE (n=21). Hematoma volume was measured by slice-by-slice planimetry integrated over slice thickness. Residual-ratio trajectories were analyzed with a restricted-cubic-spline mixed model (group-by-time interaction), per-patient half-life, and a within-patient surgery-phase versus embolization-phase comparison. Radiologic recurrence was an increase of at least 13 cc versus the previous CT. Key results were covariate-adjusted.

**Results.** Inter-rater reliability was excellent (ICC 0.988). Trajectory shape differed by group (interaction p=0.002), whereas the overall fractional rate did not (p=0.730) - a difference in timing, not speed - and persisted after baseline-volume adjustment (p=0.014). Median time to 50% resolution was 16, 53, and 9 days for surgery-only, MMAE-only, and surgery+MMAE (p<0.001); decline-rate curves crossed near day 21. Within surgery+MMAE patients, the surgery phase resolved about 22-fold faster than the embolization phase (p<0.001), which matched MMAE-only. Radiologic recurrence showed a dose-response with embolization (22.9%, 9.5%, 0%; adjusted OR 0.23, p=0.015); clinical recurrence occurred only after surgery-only (9/48; p=0.017). Final modified Rankin Scale and utility-weighted mRS were similar (both p=0.217).

**Conclusion.** Repeat surgery and low-cost particle MMAE achieve equivalent outcomes through distinct absorption dynamics - rapid surgical clearance versus slow, sustained, re-expansion-free embolization - confirmed by a within-patient analysis. These findings support prospective evaluation of particle MMAE for recurrent cSDH.

## Comparative Effectiveness of Clazosentan- and Cilostazol-Based Strategies for Vasospasm Prevention After Aneurysmal Subarachnoid Hemorrhage: The CLACILO Multicenter Retrospective Study

Hidehito KIMURA<sup>1</sup>, Tomoaki NAKAI<sup>2</sup>, Yoshio SAKAGAMI<sup>3</sup>, Daisuke YAMAMOTO<sup>4</sup>,  
Shigeru MIYAKE<sup>4</sup>, Naoya TAKEDA<sup>5</sup>, Naoto NAKAMURA<sup>1</sup>, Tatsuya OKAMURA<sup>2</sup>,  
Masaaki KOHTA<sup>1</sup>, Atsushi FUJITA<sup>1</sup>, Takashi SASAYAMA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Kobe University Graduate School of Medicine, Kobe, Japan,

<sup>2</sup>Department of Neurosurgery, Toyooka Hospital, Toyooka, Japan, <sup>3</sup>Department of Neurosurgery, Hyogo Prefectural Awaji Medical Center, Sumoto, Japan, <sup>4</sup>Department of Neurosurgery, Kita-harima Medical Center, Ono, Japan,

<sup>5</sup>Department of Neurosurgery, Junshin Hospital, Kakogawa, Japan

### Objective:

Delayed cerebral ischemia (DCI) due to cerebral vasospasm remains a major determinant of outcome after aneurysmal subarachnoid hemorrhage (aSAH). Clazosentan has recently been introduced for vasospasm prevention, while cilostazol has also been reported to reduce DCI. However, the optimal pharmacological strategy remains unclear. We evaluated whether adding cilostazol to clazosentan improves outcomes and whether clazosentan-based strategies provide advantages over conventional therapy.

### Methods:

This multicenter retrospective study included patients with aSAH treated between April 2022 and September 2025. Patients aged 20-79 years who underwent aneurysm treatment within 72 hours were categorized into three groups: clazosentan alone (Group A), clazosentan plus cilostazol (Group B), and cilostazol plus fasudil without clazosentan (Group C). The primary endpoint was symptomatic vasospasm within 14 days. Secondary endpoints included angiographic vasospasm, new cerebral infarction within 14 days, and favorable functional outcome (modified Rankin Scale score 0-2). Multivariable Firth logistic regression and propensity score-based inverse probability of treatment weighting (IPTW) analyses were performed.

### Results:

A total of 169 patients were analyzed (Group A: n=20, Group B: n=79, Group C: n=70). Symptomatic vasospasm occurred in 5.0%, 8.9%, and 10.0% of Groups A, B, and C, respectively, with no significant differences. In multivariable analysis, neither Group B (OR 1.50, 95% CI 0.22-10.35) nor Group C (OR 1.88, 95% CI 0.26-13.68) was associated with symptomatic vasospasm compared with Group A. New cerebral infarction was significantly more frequent in Group C in unadjusted analysis ( $p=0.025$ ), although this association was not significant after adjustment. Clazosentan-based strategies showed a consistent trend toward lower ischemic event rates compared with conventional therapy. However, adding cilostazol to clazosentan did not improve outcomes over clazosentan alone. IPTW analyses yielded consistent results.

### Conclusions:

Clazosentan-based strategies showed a favorable trend compared with the conventional cilostazol-plus-fasudil regimen. However, adding cilostazol to clazosentan was not associated with additional clinical benefit.

O9-2

## Microsurgical Clipping for Small Ruptured Intracranial Aneurysms: Treatment Outcomes and Durability in 126 Cases

Yoshimichi SATO<sup>1</sup>, Atushi KANOKE<sup>1</sup>, Yuto SHINGAI<sup>1</sup>, Arata NAGAI<sup>2</sup>, Yuya KATO<sup>2</sup>,  
Shunsuke OMODAKA<sup>2</sup>, Hidenori ENDO<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Kohnan Hospital, Sendai, Japan, <sup>2</sup>Department of Neuroendovascular Therapy, Kohnan Hospital, Sendai, Japan, <sup>3</sup>Department of Neurosurgery, Tohoku University Graduate School of Medicine, Sendai, Japan

**Background:** Small ruptured intracranial aneurysms ( $\leq 5$  mm) are technically challenging lesions because of limited working space and fragile aneurysm walls, carrying risks of intraoperative rupture and perforator injury. Although microsurgical clipping is expected to achieve durable aneurysm obliteration, evidence regarding its safety and treatment durability in small ruptured aneurysms remains limited. This study aimed to evaluate the treatment outcomes, safety, and retreatment rate of microsurgical clipping for small ruptured intracranial aneurysms.

**Methods:** Among 899 consecutive patients treated for aneurysmal subarachnoid hemorrhage caused by ruptured saccular aneurysms at our institution between April 2015 and March 2025, 126 patients who underwent microsurgical clipping for small ruptured saccular aneurysms ( $\leq 5$  mm) were retrospectively analyzed. Patient demographics, aneurysm location, morphological characteristics, surgery-related complications, and retreatment rates were assessed.

**Results:** The median age was 56 years (IQR, 48-67.8 years), and 84 patients (66.7%) were female. The median maximum aneurysm diameter was 3.4 mm (IQR, 2.9-4.1 mm), with 41 aneurysms (32.5%) measuring  $\leq 3$  mm. The most common aneurysm locations were the anterior communicating artery (34.9%), middle cerebral artery (27.0%), and posterior communicating artery (15.1%). A bleb was identified in 57.1% of aneurysms. Intraoperative rupture occurred in 14 patients (11.1%). Surgery-related complications, excluding asymptomatic cerebral infarction, occurred in 32 patients (25.3%), whereas retreatment was required in only 1 patient (0.8%).

**Conclusions:** Despite substantial technical complexity, microsurgical clipping for small ruptured intracranial aneurysms demonstrated an extremely low retreatment rate, suggesting excellent treatment durability and supporting its role as an important treatment option.

## Age-dependent association between concomitant cilostazol use and delayed ischemic events in clazosentan-treated aneurysmal subarachnoid hemorrhage: a multicenter prospective registry

Taku SUGIYAMA<sup>1</sup>, Asuka NAKAZAKI<sup>1</sup>, Daisuke SHIMBO<sup>2</sup>, Masaki ITO<sup>3</sup>, Yusuke SHIMODA<sup>4</sup>, Masaaki HOKARI<sup>2</sup>, Ryota TATEZAWA<sup>1</sup>, Yasuhiro ITO<sup>1</sup>, Masayuki GEKKA<sup>5</sup>, Haruto UCHINO<sup>1</sup>, Miki FUJIMURA<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Hokkaido University Graduate School of Medicine, Sapporo, Japan, <sup>2</sup>Department of Neurosurgery, Teine Keijinkai Hospital, Sapporo, Japan,

<sup>3</sup>Department of Neurosurgery, Otaru General Hospital, Otaru, Japan, <sup>4</sup>Department of Neurosurgery, Sapporo Azabu Neurosurgical Hospital, Sapporo, Japan, <sup>5</sup>Department of Neurosurgery, Tomakomai City Hospital, Tomakomai, Japan

Background: Delayed ischemic events remain important in aneurysmal subarachnoid hemorrhage (aSAH) despite clazosentan treatment. Concomitant cilostazol may reduce these events, but age-specific associations and safety remain unclear.

Methods: We analyzed 164 clazosentan-treated aSAH patients from a multicenter prospective registry (cilostazol n=135; no cilostazol n=29). Primary endpoints were delayed ischemic events (delayed ischemic neurological deterioration, imaging vasospasm, or delayed cerebral infarction) and non-ischemic adverse events; secondary endpoint was favorable outcome (modified Rankin Scale 0-2). Models included age and WFNS grade. Age-cilostazol interaction at 75 years and propensity-score weighting were examined.

Results: Delayed ischemic events occurred in 26/135 (19.3%) cilostazol-treated versus 12/29 (41.4%) untreated patients. Cilostazol was associated with fewer such events (adjusted OR 0.28, 95% CI 0.11-0.69). The association was strongest in patients aged 75 years or older (OR 0.10, 95% CI 0.02-0.63) but not evident in younger patients (OR 0.56, 95% CI 0.19-1.63; interaction p=0.042). It persisted after propensity-score weighting (OR 0.38, 95% CI 0.16-0.91). Cilostazol was not associated with increased non-ischemic adverse events, pulmonary edema, or altered favorable outcome.

Conclusions: Concomitant cilostazol was associated with fewer delayed ischemic events in clazosentan-treated aSAH, particularly in patients aged 75+, without increased non-ischemic adverse events.

O9-4

## **Plasma sCLEC-2 as an Early Biomarker of Platelet Activation and Disease Severity in Aneurysmal Subarachnoid Hemorrhage**

Hideyuki YOSHIOKA<sup>1</sup>, Koji HASHIMOTO<sup>1</sup>, Norito FUKUDA<sup>1</sup>, Ryo HORIUCHI<sup>1</sup>,  
Katsue SUZUKI-inoue<sup>2</sup>, Hiroyuki KINOUCHI<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, University of Yamanashi, Yamanashi, Japan,

<sup>2</sup>Department of Clinical and Laboratory Medicine, University of Yamanashi

**Background:** Growing evidence indicates that platelet activation contributes to microthrombosis, early cerebral hypoperfusion, and delayed cerebral ischemia (DCI) after aneurysmal subarachnoid hemorrhage (SAH), suggesting an important role in determining SAH severity and clinical outcomes. However, no reliable biomarker has been established to quantify platelet activation in SAH. Soluble C-type lectin-like receptor-2 (sCLEC-2), a specific marker of platelet activation, has recently emerged as a biomarker in arterial thrombosis, yet its relevance in aneurysmal SAH remains unclear. This study aimed to evaluate plasma sCLEC-2 levels at onset and their associations with neurological severity, in-hospital complications, and functional outcomes.

**Methods:** Forty-four consecutive patients with aneurysmal SAH who underwent surgical treatment within 48 hours of onset were prospectively enrolled. Associations between plasma sCLEC-2 levels at onset and clinical variables, including WFNS grade, hematoma volume, angiographic vasospasm, DCI, hydrocephalus, and functional outcomes at discharge, were analyzed.

**Results:** Mean plasma sCLEC-2 levels at onset were markedly elevated (377.1 pg/mL), exceeding the normal reference range (57.4-150.6 pg/mL). Plasma sCLEC-2 levels were positively correlated with hematoma volume ( $p=0.011$ ). Patients with severe SAH (WFNS 4-5) exhibited significantly higher sCLEC-2 levels than those with mild to moderate SAH (WFNS 1-3), with an optimal cutoff of 433 pg/mL. Plasma sCLEC-2 levels were significantly associated with hydrocephalus ( $p=0.032$ ), whereas no significant associations were observed with angiographic vasospasm or DCI. Higher sCLEC-2 levels at onset were also associated with poor functional outcome at discharge (mRS 3-6), with a cutoff value of 411 pg/mL.

**Conclusion:** Plasma sCLEC-2 levels are markedly elevated in the acute phase of aneurysmal SAH and are associated with neurological severity, hydrocephalus, and poor functional outcomes. These findings suggest that sCLEC-2 may serve as a novel biomarker reflecting platelet activation and disease severity in SAH. Larger studies are warranted to validate its prognostic value and clinical utility.

## Anesthetic Perturbation Reveals Attenuated Ipsilesional Slow-Wave Reactivity After Aneurysmal Subarachnoid Hemorrhage: A Frontal Two-Channel EEG Study

Seung Young CHUNG, Hyun Dong YOO

Department of Neurosurgery, Daejeon EULji Medical Center, Daejeon, ROK

**Background:** SAH may induce neurophysiological alterations. However, it remains unclear whether limited frontal EEG acquired in anesthesia setting can capture lesion-referenced differences in brain function related to rupture status. We investigated ipsilesional slow-wave activity and EEG reactivity to anesthetic induction with ruptured and unruptured aneurysms using 2-channel frontal EEG.

**Methods:** 20 patients with aneurysms who met signal-quality criteria were included in final analysis. The ruptured and unruptured groups each included 10 patients. EEG was recorded from Fp1 and Fp2 and segmented into an awake state and an anesthetized state after induction. Ipsilesional absolute power in Delta and Theta bands was computed, and ipsilesional anesthetic reactivity was defined as difference in absolute power between anesthetized and awake states. Between-group differences were assessed using linear mixed-effects models and Lesionside-stratified permutation tests. To explore patient-level informativeness of lesion-referenced EEG features, leave-one-subject-out cross-validation was performed using ridge-regularized logistic regression and a linear support vector machine.

**Results:** Ipsilesional Delta and Theta absolute power did not differ significantly in either the awake or anesthetized state. In contrast, ipsilesional anesthetic reactivity showed a significant main effect of group ( $p = 0.015$ ). Band-specific comparisons also showed lower ipsilesional anesthetic reactivity in the ruptured, both in Delta band (FDR-adjusted  $p = 0.034$ ) and in Theta band (FDR-adjusted  $p = 0.034$ ). In exploratory classification, the feature set containing only ipsilesional anesthetic reactivity achieved the best performance with ridge-regularized logistic regression, with an accuracy of 0.70, balanced accuracy of 0.70, and AUC of 0.64. Balanced accuracy reached nominal significance in the LesionSide-stratified permutation test ( $p = 0.049$ ).

**Conclusions:** Patients with ruptured aneurysms showed reduced ipsilesional Delta/Theta slow-wave reactivity to anesthetic induction compared with patients with unruptured aneurysms. These findings suggest that ipsilesional anesthetic reactivity may contain functional EEG information related to aneurysm rupture, even when measured using limited 2-channel frontal EEG.

09-6

## **Clipping versus Endovascular Coil Embolization for Ruptured PICA Aneurysms: A Bi-Institutional Propensity Score-Adjusted Retrospective Cohort Study**

Jong Young LEE<sup>1</sup>, Il-young SHIN<sup>2</sup>, Jung Hyun PARK<sup>2</sup>, Hong Suk AHN<sup>1</sup>

<sup>1</sup>Department of Neurosurgery, Hallym University Gangdong Sacred Heart Hospital, Seoul, ROK, <sup>2</sup>Department of Neurosurgery, Hallym University Dongtan Sacred Heart Hospital, Hwasung, ROK

**Background:** Posterior inferior cerebellar artery (PICA) aneurysms are rare, and the optimal treatment for ruptured cases remains undefined because existing evidence is derived mainly from mixed or unruptured cohorts with very low certainty.

**Objective:** To compare clinical outcomes between surgical clipping and endovascular treatment (EVT) for ruptured PICA aneurysms, with particular attention to treatment-related morbidity and clinical outcomes.

**Methods:** This retrospective bi-institutional cohort study included 36 consecutive patients with ruptured PICA aneurysms treated between January 2017 and February 2025 (Clip = 11, EVT = 25). Outcomes were compared in unmatched, inverse probability of treatment weighting (IPTW), and 1:1 propensity score matching (PSM) cohorts. The primary endpoints were modified Rankin Scale (mRS) scores at discharge, 1-year follow-up, and last follow-up. Secondary endpoints included periprocedural complications, angiographic outcomes, and clinical outcomes according to PICA patency.

**Results:** Traction injury (63.6% vs 8.0%,  $p < 0.001$ ) and lower cranial nerve palsy (45.5% vs 4.0%,  $p < 0.001$ ) occurred significantly more often in the Clip group in the unmatched and IPTW cohorts, with a similar directional trend in the PSM cohort. The EVT group showed superior long-term functional outcomes (median mRS 0 vs 2; IPTW  $p < 0.001$ ). PICA occlusion was associated with worse discharge mRS scores (4.5 vs 1.5,  $p = 0.016$ ) and a numerically higher in-hospital mortality rate (37.5% vs 7.1%,  $p = 0.061$ ).

**Conclusion:** EVT was associated with superior long-term functional outcomes for ruptured PICA aneurysms, mainly by avoiding treatment-related morbidity, including traction injury and lower cranial nerve palsy. Preservation of PICA flow should be prioritized, and when PICA-sparing embolization or clipping is not feasible, revascularization strategies should be considered.

## Sequential Decision-Making in Bilateral Distal Internal Carotid Artery SAH with Suspected Dissecting Pathology

Hun HEO, Young-min HAN

Department of Neurosurgery, Naeun Hospital, Incheon, ROK

**Background.** Complex aneurysmal subarachnoid hemorrhage (SAH) may demand repeated therapeutic decisions under persistent diagnostic uncertainty rather than a single definitive intervention. We report a case in which rapid interval enlargement of a contralateral lesion fundamentally changed the diagnostic hypothesis and the entire treatment strategy.

**Case.** A 44-year-old woman presented with Hunt-Hess III, Fisher 3 SAH from a left paraclinoid ICA aneurysm, treated by stent-assisted coiling. A right distal ICA lesion then enlarged markedly over days, raising suspicion of an underlying dissecting pathology rather than a conventional saccular aneurysm, which remained unconfirmed in the absence of vessel-wall imaging and follow-up angiography. After urgent coiling, she re-deteriorated with new right-sided SAH; emergent angiography showed regrowth and hemodynamically stable intra-procedural extravasation consistent with dissecting wall failure. We chose reversible options before irreversible ones: additional coiling escalating to parent-artery occlusion, with collateral sufficiency confirmed, for immediate hemostasis, favored over telescoping flow diversion given vasospastic M1 and dual-antiplatelet burden in acute SAH. A demonstrated hemorrhagic tendency, manifest as recurrent drain-tract bleeding, was balanced against stent-surface thrombosis by converting aspirin to cilostazol. Shunt dependence was established objectively through a structured ventricular-drain weaning challenge using intentional under-drainage below physiologic production, and a ventriculoperitoneal shunt was completed through a staged, consent-guided course. The patient recovered to an alert, ambulatory state with preserved motor function despite a completed right middle cerebral artery infarction.

**Conclusion.** Choosing reversible options before irreversible ones repeatedly proved decisive throughout this complex course. Short-interval aneurysm growth in a young patient should prompt suspicion of dissecting pathology and reshape the choice among coiling, flow diversion, and occlusion; sequential, safe-fail decision-making anchored by objective physiological endpoints can navigate uncertainty in highly complex SAH.

P1-1

## **A Recurrent MCA Aneurysm After Clipping Requiring Reconsideration of Definitive Surgical Treatment**

Mai FUJIOKA, Tetsuo OTA, Shihori HAYASHI

Department of Neurosurgery, Tokyo Kita Medical Center, Tokyo, Japan

### Background

Surgical treatment for recurrent aneurysms after clipping is technically challenging because of adhesions around the aneurysm and the presence of previous clips. We report a recurrent middle cerebral artery (MCA) aneurysm after clipping and discuss optimal treatment strategies based on recurrence patterns.

### Case Presentation

A 53-year-old woman was diagnosed with an unruptured left M2 segment aneurysm 17 years before presentation. Enlargement of the aneurysm was observed, and clipping was performed 9 years ago. Follow-up imaging showed no recurrence for 5 years; however, recurrence was detected 2 years ago and gradually enlarged.

Preoperative imaging demonstrated regrowth along the M2 segment with fusiform changes of the parent artery. Endovascular treatment was deemed difficult because of the small caliber of the involved M2 branch. Reoperation was therefore performed through the previous craniotomy. Due to severe adhesion, it was difficult to remove the previous clip. Additional clipping was achieved without ischemic complications, and postoperative imaging demonstrated no apparent residual aneurysm. The patient was discharged without neurological deficits.

### Discussion

Retrospective review suggested that the recurrence pattern corresponded to Type 4 in the classification proposed by Kobayashi et al., in which identification of a new closure line is difficult and definitive clipping may be challenging. In such cases, because the lesion involves the entire parent artery, bypass-assisted trapping should be considered as alternative treatment strategies. Recognition of recurrence patterns before surgery may facilitate selection of a more definitive treatment approach.

### Conclusion

For recurrent MCA aneurysms after clipping, treatment planning should be based not only on technical feasibility of reclipping but also on recurrence morphology and long-term durability. Bypass-assisted strategies may be important options in selected cases.

## Occult Rupture of Presumed Unruptured Intracranial Aneurysms Revealed During Elective Microsurgical Clipping

Wan PARK, Yong-jun LEE, You-sub KIM, Sung Pil JOO, Tae Sun KIM

Department of Neurosurgery, Chonnam National University Hospital & Medical School, ROK

### Background

Intracranial aneurysms are generally classified as ruptured or unruptured based on clinical and radiological findings. However, minor hemorrhagic events may remain clinically silent and undetectable on routine imaging. We report two presumed unruptured intracranial aneurysms in which unexpected intraoperative hemorrhagic findings suggested previous occult rupture during elective microsurgical clipping.

### Case Description

Case 1 was a 73-year-old woman with a 3.5-mm left posterior communicating artery aneurysm diagnosed as unruptured on preoperative evaluation. Computed tomography showed no evidence of subarachnoid hemorrhage (SAH). Following dural opening, diffuse SAH and severe brain swelling were unexpectedly encountered. Progressive swelling required decompressive craniectomy and external ventricular drainage for brain relaxation. The aneurysm was successfully clipped, although no definite rupture point was identified.

Case 2 was a 55-year-old man with a 3-mm right middle cerebral artery bifurcation aneurysm scheduled for elective clipping. Preoperative computed tomography demonstrated no evidence of hemorrhage. After dural opening, diffuse SAH and significant brain swelling were observed. External ventricular drainage facilitated brain relaxation and sylvian fissure dissection. A thick perianeurysmal hematoma surrounding the aneurysm was identified intraoperatively. Complete clipping was achieved, but no definite rupture site was found.

### Conclusion

These cases suggest that some aneurysms classified as radiologically unruptured may actually represent previously ruptured lesions with spontaneous sealing of the rupture site. Unexpected intraoperative findings, including diffuse SAH, brain swelling, and perianeurysmal hematoma, should raise suspicion for occult previous rupture even when preoperative imaging is negative. In such situations, cerebrospinal fluid diversion and gradual brain relaxation can facilitate safe microsurgical dissection and successful clipping. The absence of an identifiable rupture point may be explained by spontaneous thrombosis, fibrin sealing, or healing of a prior micro-rupture.

P1-3

## **A Landmark-Based Ultramini-Pterional Approach Centered on the Anterior Sylvian Point for Anterior Circulation Aneurysm Clipping: Initial Consecutive Series**

Young Hoon CHOI, Dong-kyu JANG, Byung Rae CHO, Dong Sub KIM

Department of Neurosurgery, Incheon St. Mary's Hospital, College of medicine, The Catholic University of Korea, Incheon, ROK

**Background:** Minimally invasive pterional variants reduce soft-tissue injury and improve cosmesis, but excessive reduction of incision length and bone flap size may posteriorly displace the craniotomy center and compromise proximal Sylvian exposure and early vascular control. A reproducible, anatomy-anchored ultramini strategy that preserves proximal corridor geometry has not been systematically defined.

**Objective:** To introduce an anterior Sylvian point (ASP)-centered ultramini-pterional (uMP) approach and assess its feasibility, operative efficiency, and early angiographic outcomes.

**Methods:** Twenty-one consecutive patients with 26 unruptured anterior circulation aneurysms underwent microsurgical clipping using an ASP-centered uMP approach by a single surgeon between May 2025 and February 2026. The craniotomy was initiated with burr-hole trephination at the anterior squamosal point (ASqP), a bony surface correlate of the ASP, followed by tailored limited craniectomy and sphenoid ridge drilling to optimize the proximal transsylvian trajectory. Outcomes included bone-work time, conversion to extended craniotomy, procedure-related complications, and postoperative computed tomographic angiography (CTA)-confirmed occlusion.

**Results:** All aneurysms were unruptured; four patients had multiple aneurysms. Locations included middle cerebral artery bifurcation ( $n = 11$ ), M1 segment ( $n = 2$ ), anterior choroidal artery ( $n = 9$ ), posterior communicating artery ( $n = 3$ ), and A1 segment ( $n = 1$ ). Conversion to a larger craniotomy was required in one patient (4.8%). Mean bone-work time was  $24.6 \pm 2.2$  minutes. One intraoperative premature rupture was controlled without neurological sequelae. One transient facial nerve palsy resolved within 1 month. Complete occlusion was achieved in all aneurysms on postoperative day 1 CTA.

**Conclusion:** The ASP-centered uMP approach may preserve proximal Sylvian corridor alignment while limiting surgical exposure. By prioritizing anatomic geometry rather than cosmetic downsizing alone, this technique may facilitate early parent-vessel identification and proximal control without increasing operative complexity. It represents a geometric refinement of mini-pterional surgery rather than a simple reduction in incision length.

## The Usefulness of Extradural Anterior Clinoidectomy for Lower-Lying Posterior Communicating Artery Aneurysms : A Cadaveric Study

Hyoungsoo BYOUN<sup>1</sup>, Kyu-sun CHOI<sup>2</sup>, Min Kyun NA<sup>2</sup>, Sae Min KWON<sup>3</sup>, Yong Seok NAM<sup>4</sup>

<sup>1</sup>Department of neurosurgery, Chungbuk National University Hospital, Chungbuk National University College of Medicine, Cheongju, ROK, <sup>2</sup>Department of Neurosurgery, College of Medicine, Hanyang University, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Dongsan Medical Center, Keimyung University School of Medicine, Daegu, ROK, <sup>4</sup>Department of Anatomy, College of Korean Medicine, Dongshin University, Naju, ROK

**Objective :** To confirm the usefulness of the extradural anterior clinoidectomy during the clipping of a lower riding posterior communicating artery (PCoA) aneurysm through cadaver dissection.

**Methods :** Anatomic measurements of 12 adult cadaveric heads (24 sides total) were performed to compare the microsurgical exposure of the PCoA and internal carotid artery (ICA) before and after clinoidectomy. A standard pterional craniotomy and transsylvian approach were performed in all cadavers. The distance from the ICA bifurcation to the origin of PCoA (D1), pre-anterior clinoidectomy distance from the ICA bifurcation to tentorium (D2), post-anterior clinoidectomy distance from the ICA bifurcation to tentorium (D3), pre-anterior clinoidectomy distance from the tentorium to the origin of PCoA (D4) and post-anterior clinoidectomy distance from the tentorium to the origin of PCoA (D5) and the distance of the ICA obtained after anterior clinoidectomy (D6) were measured.

**Results :** Twenty-four sites were dissected from 12 cadavers. The age of the cadavers was 79.83 $\pm$ 6.25 years. The number of males was the same as the females. The space from the proximal origin of the PCoA to the preclinoid-tentorium (D4) was [1.45 $\pm$ 1.08] mm (max: 4.01, min: 0.56). After the clinoidectomy, the space from the proximal origin of the PCoA to the postclinoid-tentorium (D5) was 3.612 $\pm$ 1.15 mm (max: 6.14, min: 1.83). The length (D6) of the exposed proximal ICA after the extradural clinoidectomy was 2.17 $\pm$ 1.04 mm on the lateral side and 2.16 $\pm$ 0.89 mm on the medial side. The thickness of the Yasargil clip blade used during the clipping surgery was 1.35 mm measured with a digital precision ruler.

**Conclusion :** The proximal length obtained by performing an external anterior clinoidectomy is about 2 mm, sufficient for proximal control during PCoA aneurysm surgery, considering the thickness of the aneurysm clips.

P1-5

## **Postoperative Patient Experience Following Different Minimally Invasive Surgical Approaches for Unruptured Intracranial Aneurysms: Superciliary Approach versus Trans-scalp Lateral Supraorbital Approach**

Sangmin LEE<sup>1</sup>, Sangmin LEE<sup>1</sup>, Myungsoo KIM<sup>2</sup>

<sup>1</sup>Department of neurosurgery, Kyungpook national university hospital, Daegu, ROK, <sup>2</sup>Department of Neurosurgery, Kyungpook national university Chilgok hospital, Daegu, ROK

**OBJECTIVE:** This prospective study performed a comparative study between the superciliary approach with a supra-eyebrow skin incision and the lateral supraorbital approach with a scalp incision. It compared patient experience including postoperative pain and general symptoms following the approaches.

**METHODS:** Patients (n = 111) who underwent a superciliary approach or trans-scalp lateral supraorbital approach for unruptured aneurysms in the anterior circulation completed a six-item daily symptom questionnaire using the visual analogue scale (VAS) and underwent neurological examinations for 5 days after surgery. The symptoms in the questionnaire included surgical wound-related pain, generalized headache, depressed mood, fatigue, decreased appetite, and nausea.

**RESULTS:** On postoperative day (POD) 5, the patients with a superciliary approach reported significantly less severe symptoms including surgical wound-related pain (VAS score  $3.34 \pm 2.26$  vs.  $4.70 \pm 2.49$ ,  $p=0.003$ ), generalized headache ( $3.54 \pm 2.23$  vs.  $5.16 \pm 2.85$ ,  $p=0.001$ ), depressed mood ( $2.33 \pm 1.95$  vs.  $3.44 \pm 2.73$ ,  $p=0.018$ ), fatigue ( $3.11 \pm 2.17$  vs.  $4.46 \pm 2.98$ ,  $p=0.009$ ), and decreased appetite ( $3.61 \pm 2.43$  vs.  $5.00 \pm 2.93$ ,  $p=0.007$ ) in comparison to the patients with a lateral supraorbital approach. The surgical technique (trans-scalp lateral supraorbital approach) was selected as a dominant variable for surgical wound-related pain, generalized headache, depressed mood, and fatigue with a positive  $\beta$  coefficient and statistical significance of variable. Meanwhile, significant mood depression with a VAS score  $\geq 5$  was reported in 10 patients (16.4%) in the superciliary approach group and 17 patients (34.0%) in the trans-scalp approach group on POD 5. **CONCLUSIONS:** The patients who underwent the superciliary approach reported less symptoms and discomfort compared to those who underwent a trans-scalp lateral supraorbital approach in the early postoperative period following successful clip placement for unruptured intracranial aneurysms.

## Successful Single Flow-Diverter Treatment for Four Clustered Internal Carotid Artery Aneurysms: A Case Report

Juwhan LEE<sup>1</sup>, Jin LEE<sup>1</sup>, Hae Woong JEONG<sup>2</sup>

<sup>1</sup>Department of Neurosurgery & Neurointervention, Inje University Busan Paik Hospital, Busan, ROK, <sup>2</sup>Department of Radiology & Neurointervention, Inje University Busan Paik Hospital, Busan, ROK

Multiple clustered aneurysms involving a single intracranial artery are uncommon and may be difficult to treat completely with conventional microsurgical or endovascular techniques. Flow diversion can be an effective option in selected such complex cases.

We report a patient with four clustered aneurysms of the left internal carotid artery, initially detected on magnetic resonance angiography and confirmed by transfemoral cerebral angiography. The lesions were distributed along the intracranial ICA, with a combined maximal diameter exceeding 10 mm. Considering the aneurysm configuration and South Korean national health insurance criteria, we planned single-session flow diversion to cover all four aneurysms.

A 6-Fr Shuttle sheath and 6-Fr Sofia distal access catheter provided distal guiding support. A Surpass Elite 5.0 mm / 20 mm flow diverter (Stryker) was deployed through an Excelsior XT-27 microcatheter. Due to the tortuous intracranial ICA, accurate deployment at the intended distal landing zone was technically challenging. However, the stent was successfully deployed with 30 mm total coverage, confirmed by 20-second cone beam CT. The patient tolerated the procedure well and was discharged without neurologic deficits. Dual antiplatelet therapy with aspirin and clopidogrel was maintained for 6 months. Follow-up magnetic resonance angiography demonstrated complete occlusion of all four aneurysms without recurrence and preserved stent stability without braid deformation.

This case highlights the expanding role of endovascular devices in treating complex intracranial aneurysms and suggests that single device flow diversion can achieve favorable outcomes in carefully selected patients.

P1-7

## **Isolated Horner's Syndrome as the Sole Presentation of Vertebral Artery Dissecting Aneurysm Treated with Flow Diversion and Coil Embolization**

Wonsoo SON

Department of Neurosurgery, Kyungpook National University Hospital, Daegu, ROK

**Background:** Vertebral artery (VA) dissecting aneurysm typically presents with brainstem or cerebellar deficits. Horner's syndrome, when present, is almost always accompanied by lateral medullary syndrome or other neurological abnormalities. Isolated Horner's syndrome as the sole manifestation is exceptionally rare. We report such a case successfully treated with combined flow diversion and adjunctive coil embolization.

**Case Presentation:** A 48-year-old male presented with acute-onset right-sided ptosis, miosis, and facial anhidrosis consistent with Horner's syndrome. Neurological examination revealed no brainstem signs, cranial nerve dysfunction, or cerebellar deficits. Magnetic resonance imaging demonstrated a partially thrombosed dissecting aneurysm of the left V4 segment with mass effect on the right dorsolateral medulla. Diffusion-weighted imaging showed no infarction. Digital subtraction angiography confirmed irregular luminal narrowing with focal dilatation.

**Treatment and Outcome:** Endovascular treatment was performed under general anesthesia. A flow diverter (Surpass EVOLVE, 4.5 x 30 mm) was deployed across the dissected segment, followed by adjunctive coil embolization using five coils via a semi-jailing technique. Final angiography confirmed contrast stasis with preserved parent artery patency. The procedure was completed without complications. At 1-month follow-up, ptosis and miosis had markedly improved. By 3 months, Horner's syndrome had completely resolved, despite follow-up imaging showing persistent aneurysmal size with minimal reduction.

**Conclusion:** This case expands the recognized clinical spectrum of VA dissecting aneurysms by demonstrating isolated Horner's syndrome as a sole presentation. The dissociation between complete symptom resolution and persistent aneurysm morphology underscores that hemodynamic stabilization, rather than structural regression, drives early clinical recovery. Acute isolated Horner's syndrome warrants vascular imaging to exclude posterior circulation pathology.

## Red Blood Cell Transfusion in The Minimally Invasive Era of Unruptured Aneurysm Surgery

Donggyu SHIN<sup>1</sup>, Myungsoo KIM<sup>2</sup>

<sup>1</sup>Department of Neurosurgery, Kyungpook National University Hospital, Daegu, ROK,

<sup>2</sup>Chilgok Kyungbook national university hospital

Background Historically, red blood cell (RBC) transfusion rates during aneurysm surgery have been reported to range from 9.5% to 24.5%. With the widespread adoption of minimally invasive keyhole approaches, contemporary transfusion patterns require re-evaluation. Objective To determine the incidence and predictors of RBC transfusion in patients undergoing minimally invasive microsurgical clipping for unruptured intracranial aneurysms. Methods we retrospectively analyzed 587 consecutive patients who underwent keyhole clipping for unruptured anterior circulation aneurysms between 2017 and 2022. Because transfusion events were rare, Firth's penalized likelihood logistic regression was used to identify independent predictors. Sensitivity analysis was performed after excluding patients with severe preoperative anemia. Results Intraoperative and perioperative RBC transfusion occurred in 0.7% (n=4) and 2.6% (n=15) of patients, respectively. Lower preoperative hemoglobin level was the only independent predictor of both intraoperative (OR 0.32, 95% CI 0.16-0.54, p<0.001) and perioperative transfusion (OR 0.31, 95% CI 0.18-0.47, p<0.001). Sensitivity analysis confirmed the robustness of this association and additionally identified combined surgical approach as a predictor of perioperative transfusion. Conclusions RBC transfusion is exceedingly rare in contemporary minimally invasive aneurysm surgery. Preoperative hemoglobin level is the most important determinant of transfusion risk, highlighting the importance of perioperative anemia management.

P2-1

## Diagnostic Performance of an Integrated 3D Vascular Reconstruction and Aneurysm Detection AI Model using MR angiography

Sion KIM<sup>1,2</sup>, Taeyeong YANG<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Gumdang Top Hospital, Incheon, ROK, <sup>2</sup>CLARUS-N, Seoul, ROK, <sup>3</sup>Taeyeong Yang, Department of Nursing, Dongguk University-WISE Campus, Gyeongju, ROK

### Purpose

To develop and validate a deep learning based framework for automated cerebral aneurysm detection on MR angiography and compare its diagnostic performance with experienced neuroradiologists using an external validation cohort.

### Materials and Methods

A total of 3,036 MR-TOF datasets containing 4,360 annotated aneurysms were used to train the AI framework. The system consisted of MR-Vessel AI for high-resolution vascular reconstruction and MR-Aneurysm AI for lesion detection using 3D subvolume analysis and iterative refinement. External validation was performed on 100 cases with 150 DSA-confirmed aneurysms across 19 anatomical locations and compared with interpretations by three neuroradiologists.

### Results

The AI model achieved significantly higher sensitivity than the radiologist group (92.0% vs. 68.7%,  $p=0.0324$ ), while maintaining high specificity (97.8%). Negative predictive value was also superior in the AI model (99.3% vs. 97.4%). In subgroup analysis, the AI demonstrated excellent detection performance in the paraclinoid artery (96.0% vs. 65.3%) and anterior communicating artery aneurysms (87.5% vs. 79.2%,  $p=0.0062$ ).

### Conclusion

The proposed deep learning framework showed robust performance for automated cerebral aneurysm detection on MRA, particularly with high sensitivity and NPV. The system may serve as an effective clinical decision-support tool for neurovascular screening by reducing diagnostic oversight and inter-observer variability.

## **Influence of Fetal-Type Posterior Cerebral Artery on Morphological Characteristics and Rupture Risk of Posterior Communicating Artery Aneurysms: A Radiomics Approach**

Kunhee HAN<sup>1,2</sup>, Minu NAHM<sup>1,2</sup>, Hyeong-joong YI<sup>1</sup>, Sang Hyung LEE<sup>2,3</sup>, Jaiyoung RYU<sup>2,4</sup>,  
Simon SONG<sup>2,5</sup>, Kyu-sun CHOI<sup>1,2</sup>

<sup>1</sup>Department of Neurosurgery, Hanyang University Medical Center, Hanyang University College of Medicine, Seoul, ROK, <sup>2</sup>Center for Precision Medicine Platform Based-on Smart Hemo-Dynamic Index, Seoul, ROK, <sup>3</sup>Department of Neurosurgery, Jeju National University Hospital, Jeju National University College of Medicine, Jeju, ROK, <sup>4</sup>Department of Mechanical Engineering, Korea University, Seoul, ROK, <sup>5</sup>Department of Mechanical Convergence Engineering, Hanyang University, Seoul, ROK

**Background and Objectives:** The fetal-type posterior cerebral artery (fetal PCA) is an anatomical variant that may alter hemodynamics and influence rupture risk in posterior communicating artery (PCoA) aneurysms. This study aimed to evaluate the impact of fetal PCA on aneurysm morphology and rupture risk using a radiomics-based approach.

**Methods:** We retrospectively analyzed 87 patients with PCoA aneurysms, including 39 ruptured and 48 unruptured aneurysms, treated at a tertiary center between January 2017 and December 2022. Seventeen conventional morphological parameters and 18 radiomics features were extracted from each aneurysm. Subgroup analyses were performed according to the presence or absence of fetal PCA. Univariate and multivariate logistic regression analyses, along with receiver operating characteristic (ROC) curve analysis, were conducted to identify predictors of rupture.

**Results:** Among the 87 aneurysms, 38 were associated with fetal PCA, including 24 ruptured and 14 unruptured aneurysms, whereas 49 were not, including 15 ruptured and 34 unruptured aneurysms. Fetal PCA was significantly associated with rupture (odds ratio [OR], 3.28;  $p = 0.018$ ). A higher non-sphericity index (NSI) was also associated with rupture risk (OR, 3.35;  $p = 0.016$ ). In aneurysms without fetal PCA, size-related parameters, including height and area, were more strongly associated with rupture. In contrast, in aneurysms with fetal PCA, flow-related parameters such as vessel angle showed a stronger association with rupture. ROC analysis showed good discriminatory performance, with areas under the curve of 0.726 for fetal PCA and 0.706 for NSI.

**Conclusion:** Fetal PCA is associated with rupture risk and distinct morphological characteristics in PCoA aneurysms. NSI may serve as a useful marker of rupture, reflecting aneurysm shape irregularity. Integrating anatomical variants with morphological and radiomics-derived features may improve rupture risk assessment.

P2-3

## **Characteristics of Giant Thrombosed Aneurysms Treated by Conventional Aneurysmal Neck Clipping**

**Ikseong PARK, Seongrim KIM, Hoon KIM, Seonghan KIM, Hyoungjin LEE**

Bucheon Saint Mary's hospital, The catholic university of Korea, ROK

**Objective:** Giant thrombosed aneurysms are generally not easily treatable with direct aneurysmal neck clipping and are often managed with bypass and parent artery occlusion. Consequently, operation time increases and the risk of complications rises. However, not all giant aneurysms necessarily require such complex procedures. This study investigates factors that led to successful outcomes with conventional aneurysmal neck clipping in out institutional cases of giant aneurysms.

**Method:** From 2003 to 2023, patients with giant aneurysms with diameters of 2.5cm or larger who underwent craniotomy were investigated. Clinical statuses before and after treatment, as well as angiographic morphology, were examined, and characteristics of patients eligible for direct clipping were analyzed.

**Results:** A total of 12 patients underwent treatment, with 4 undergoing direct neck clipping and 8 undergoing bypass and parent artery occlusion. Among the 4 patients treated directly, 2 had ruptured aneurysms, while 2 had unruptured ones. All patients eligible for direct clipping had their aneurysm necks confirmed via angiography, enabling successful treatment. All 4 patients showed a favorable prognosis with an mRS score of 0.

**Conclusion:** Even in cases of giant thrombosed aneurysms, if hemodynamic analysis through transfemoral catheter angiography examination suggests that arterial necks can be secured, conventional aneurysmal neck clipping may be attempted.

## Single-Stage Microsurgical Treatment of a Coexisting Unruptured Aneurysm and an Incidental Dural Arteriovenous Fistula Through One Craniotomy: Feasibility and Cautions

Dongwook SEO, Sukh Que PARK

Soonchunhyang University Seoul Hospital, Seoul, ROK

**Background:** The coexistence of an unruptured saccular aneurysm and an incidental, non-flow-related dural arteriovenous fistula (dAVF) is uncommon. We report single-stage microsurgical treatment of both lesions through one craniotomy.

**Case:** A 75-year-old woman underwent MRI/MRA for dizziness, showing an unruptured right MCA bifurcation saccular aneurysm (approximately 5 mm, bilobulated). Catheter angiography additionally revealed an incidental right distal ACA-fed, superior sagittal sinus-draining dAVF (Borden type I, without cortical venous reflux) not seen on MRA. As the fistula lay within the planned operative corridor, both lesions were treated in one session.

**Operative strategy:** Through a single right frontotemporal craniotomy, the aneurysm was clipped using a staged technique (straight, curved, then mini-clip for an inter-clip remnant); patency was confirmed by micro-Doppler and indocyanine green (ICG) videoangiography. The dAVF was obliterated by clipping the arterialized draining vein at the frontal fistula point; ICG confirmed loss of the shunt, and temporary clip release reproduced it, confirming the fistula point before final clipping.

**Outcome:** No new neurological deficit occurred. Postoperative CT showed a 3.8 cm acute hemorrhage in the right basal frontal lobe with pneumocephalus, within the fistula-disconnection field; it was managed conservatively and resorbed while remaining asymptomatic. Follow-up angiography showed a tiny aneurysm dog-ear remnant and complete dAVF obliteration, but also revealed a previously undetected external carotid-fed indirect cavernous sinus dAVF.

**Conclusion:** Single-stage microsurgical treatment of a coexisting unruptured aneurysm and an incidental dAVF through one craniotomy is feasible. However, for a low-risk (Borden I) fistula the benefit of opportunistic treatment is limited and must be weighed against the added operative risk: here, the fistula-directed corridor was associated with a basal frontal hemorrhage. The newly identified second fistula further underscores the value of complete pre- and postoperative angiographic surveillance, including selective external carotid evaluation.

P2-5

## **Microsurgical clipping remains a viable option for the treatment of coilable ruptured middle cerebral artery aneurysms in the endovascular era**

In-Hyoung LEE, Jong-il CHOI, Sung-kon HA, Dong-jun LIM

Department of Neurosurgery, Korea University Ansan Hospital, Korea University College of Medicine, ROK

**Background:** Although many institutions increasingly perform endovascular coiling instead of microsurgical clipping as the primary treatment for ruptured aneurysms, there remains ongoing debate regarding the optimal treatment strategy for ruptured middle cerebral artery (MCA) aneurysms. Therefore, we compared the outcomes of clipping and coiling for treating ruptured MCA aneurysms.

**Methods:** A total of 155 ruptured MCA aneurysms that were deemed eligible for both clipping and coiling were retrospectively reviewed. We compared patient characteristics, radiological results, clinical outcomes, and perioperative complications between patients who received clipping and those receiving coiling. Furthermore, we analyzed the potential risk factors for perioperative complications that differed between the two groups.

**Results:** 59 (38.1%) aneurysms were treated using coiling, and 96 (61.9%) received clipping. The clipping group showed a significantly higher rate of immediate complete occlusion and a lower rate of neck remnants compared with the coiling group ( $p=0.006$ ). These radiological results persisted at the 12-month angiographic follow-up, with a significantly higher complete occlusion rate ( $p=0.038$ ) and a lower recanalization rate ( $p=0.033$ ) in the clipping group. The clinical outcomes were comparable between the two groups. Patients treated with coiling showed a higher rate of permanent shunting than those treated with clipping (18.6% vs. 8.3%,  $p=0.058$ ). Coiling was independently associated with shunt-dependent hydrocephalus in multivariate analysis.

**Conclusion:** Microsurgical clipping provides comparable clinical outcomes, better occlusion, and superior durability for treating ruptured MCA aneurysms compared with endovascular coiling. Therefore, clipping remains a viable option for treating ruptured MCA aneurysms, even in aneurysms suitable for coiling.

## **Strategic WEB-Based Inflow Control for Large and Giant Intracranial Aneurysms: Neck-Bridging and Parent Artery Flow Diversion**

Jiwon NAM, Jongmin LEE, Soonchan KWON

Department of Neurosurgery, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, ROK

The Woven EndoBridge (WEB) device was developed to treat wide-neck bifurcation aneurysms challenging for conventional coiling. However, its use in large and giant aneurysms remains uncommon, and its efficacy in such lesions is not well established. We describe a single-operator experience with two distinct WEB-based inflow-control strategies for these complex lesions.

Case 1 involved a 78-year-old man with multiple unruptured aneurysms, including a large left internal carotid artery (ICA) bifurcation aneurysm and an adjacent wide-neck posterior communicating artery (PComA) aneurysm. Stent-assisted coiling for the large aneurysm was expected to complicate subsequent access to the PComA aneurysm, and coiling of the large aneurysm carried a risk of recurrence. Therefore, the ICA bifurcation aneurysm was treated with WEB, and stent-assisted coiling was reserved for the PComA aneurysm. After deployment of the largest available WEB size, angiography showed persistent opacification of the aneurysm neck and sac. The device was proximally repositioned toward the neck and detached in a neck-bridging configuration. Residual filling was limited to the proximal portion of the WEB, without dome opacification. The PComA aneurysm was then managed with stent-assisted coiling, followed by an overlapping stent. Final angiography and postoperative day 1 CT angiography demonstrated no contrast filling in either aneurysm.

Case 2 involved a previously reported 62-year-old man with a symptomatic giant partially thrombosed aneurysm at the basilar tip. Given the risk of severe brainstem compression, definitive isolation and thrombosis of the aneurysm were required. Although neither coiling nor standalone WEB deployment was expected to achieve these goals, the combination of the WEB device with staged bilateral vertebral artery trapping successfully achieved both goals. Seven-month follow-up angiography showed no recanalization.

These cases suggest that, even in large or giant aneurysms beyond the standard WEB sizing range, WEB may achieve adequate flow disruption when combined with lesion-specific strategies.

P2-7

## **Complications of endovascular treatment for intracranial aneurysms: 2 cases report**

Taesik GONG

<sup>1</sup>Department of Neurosurgery, Presbyterian Medical Center, Jeonju, ROK, <sup>2</sup>Taesik Gong

Endovascular coiling for intracranial aneurysms has become an accepted treatment with good clinical results, providing adequate protection against the rebleeding and rupture of aneurysms. However, despite the experience, preparation, or skill of the physician, complications during endovascular treatment still occur. The main complications of endovascular coiling are thromboembolic events and procedural aneurysmal perforations by the microcatheter, micro-guidewire, or coil.

We report a case of a 65-year-old woman who experienced three intraprocedural ruptures during coil embolization for an unruptured posterior communicating (Pcom) artery aneurysm. Additionally, we report another case of delayed symptomatic thromboembolism in an ischemic stroke patient who had undergone coil embolization for an unruptured basilar tip aneurysm.

## Hemorrhagic Complications of Prasugrel- versus Clopidogrel-based Dual Antiplatelet Therapy in Endovascular Treatment of Intracranial Aneurysms: A Single-center Retrospective Non-inferiority Study

Muwan PARK<sup>1</sup>, Kangmin KIM<sup>1</sup>, Hyunseung KANG<sup>1</sup>, Youngdae CHO<sup>2</sup>, Donghyun YOO<sup>2</sup>,  
Taeyoon PARK<sup>1</sup>, Jinhwan KOO<sup>1</sup>

<sup>1</sup>the department of neurosurgery, Seoul national university hospital, Seoul, ROK, <sup>2</sup>the department of Radiology, Seoul national university hospital, Seoul, ROK

### Purpose

Clopidogrel-based dual antiplatelet therapy (DAPT) is widely used for stent- or flow-diverter-assisted treatment of unruptured intracranial aneurysms, but its efficacy may be reduced in East Asians due to the high prevalence of CYP2C19 loss-of-function alleles. This study assessed whether low-dose prasugrel-based DAPT is non-inferior to clopidogrel-based DAPT regarding peri-procedural bleeding and evaluated its effectiveness in preventing ischemic events.

### Methods

This single-center retrospective era-comparison study included 1,555 procedures performed for unruptured intracranial aneurysms. Patients received either aspirin plus clopidogrel (2009-2013; n=489) or aspirin plus low-dose prasugrel (2020-2025; n=1,066) for 30 days following treatment. The primary endpoint was 30-day BARC grade  $\geq 2$  bleeding, assessed using a predefined non-inferiority margin of 1.5 percentage points. Secondary outcomes included major bleeding (BARC  $\geq 3$ ), site-specific bleeding, ischemic events, device thrombosis, and net adverse clinical events (NACE). Propensity-score-adjusted analyses were performed.

### Results

The primary endpoint occurred in 1.23% of the clopidogrel group and 1.50% of the prasugrel group, yielding a risk difference of 0.27% (95% CI, -1.26 to +1.41), which met the criterion for non-inferiority. Major bleeding rates were similarly low (0.61% vs. 0.66%), and intracranial hemorrhage was rare in both groups. No fatal bleeding or deaths occurred. Although access-site bleeding was more frequent in the prasugrel era, this difference was likely related to changes in vascular closure devices. Ischemic stroke occurred less frequently with prasugrel (1.13% vs. 2.66%; RR 0.42, 95% CI 0.19-0.92), and adjusted analyses demonstrated consistent findings.

### Conclusions

Low-dose prasugrel-based DAPT was non-inferior to clopidogrel-based DAPT with respect to 30-day bleeding risk and was associated with fewer ischemic events. These findings support the use of low-dose prasugrel in East Asian patients undergoing endovascular treatment of unruptured intracranial aneurysms, although prospective validation is warranted.

P3-1

## **The emergent superficial temporal artery to middle cerebral artery bypass in the middle cerebral artery occlusion - CASE SERIES -**

Yuseok CHOI

Department of Neurosurgery, Dongrae bongseng hospital, Busan, ROK

### Introduction

The emergent superficial temporal artery to middle cerebral artery bypass is considered for in acute ischemic stroke with large vessel occlusion does not become a thrombolysis indication due to time window or symptom fluctuations despite maximum medical treatment or failure to the mechanical thrombectomy.

### Material and Methods

During the last 10 years, 57 STA-MCA bypass were performed in the middle cerebral artery stenosis or occlusion by a single surgeon. Among them, the emergent bypass was undergone in the four patients. Three patients were done after mechanical thrombectomy failure, one patient was done after symptom aggravation after maximum medical treatment.

### Results

The bypass patency was confirmed by the 3DCTA at postoperative one week and by the digital subtraction angiography at postoperative one year. The perfusion was confirmed by CT perfusion or MR perfusion at postoperative 2weeks. The last normal to the operation time interval was less than 24 hours. The postoperative outcome was improved in 3 patients. But one patient had aggravated symptom even though bypass due to severe brain swelling according to the occlusion site spread to the internal carotid artery.

### Conclusions

In a patient who had symptom aggravation after maximum medical treatment and after mechanical thrombectomy failure, emergent STA-MCA bypass is a useful option that allows for flow augmentation in acute infarction territory with a high rate of patency and for improvement of clinical outcome.

## Quality of life measured using the 36-Item Short Form Health Survey and the EuroQol 5-Dimension 5-Level in adults with moyamoya disease in Japan

Honoka TAMORI<sup>1,2</sup>, Toshiya OSANAI<sup>3</sup>, Katsuhiko OGASAWARA<sup>4</sup>, Miki FUJIMURA<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Graduate School of Medicine, Hokkaido University, Hokkaido, Japan,

<sup>2</sup>Center for Outcomes Research and Economic Evaluation for Health, National Institute of Public Health, Saitama, Japan, <sup>3</sup>Department of Neurosurgery, Faculty of Medicine, Hokkaido University, Hokkaido, Japan,

<sup>4</sup>Faculty of Health Sciences, Hokkaido University, Hokkaido, Japan

**Background:** Moyamoya disease (MMD) is a cerebrovascular disease with a relatively higher prevalence in East Asian countries, including Japan. It can cause stroke, which may affect patients' quality of life (QoL). However, to the best of our knowledge, no studies have investigated QoL in Japanese patients with MMD. This study aims to explore the QoL of Japanese patients with MMD.

**Methods:** Questionnaires and informed consent forms were mailed to patients with MMD aged  $\geq 18$  years who visited Hokkaido University Hospital between January 1, 2023, and March 31, 2025. The questionnaires used were Japanese versions of the 36-Item Short Form Health Survey (SF-36) and the EuroQol 5-Dimension 5-Level (EQ-5D-5L). Responses were primarily obtained from patients; however, proxy responses were used when self-reporting was not feasible. Patient characteristics were collected from electronic medical records.

**Results:** Questionnaires were mailed to 213 patients, and informed consent was obtained from 140 patients. A total of 136 SF-36 responses and 137 EQ-5D-5L responses were eligible for scoring. The mean (SD) age was 48.2 (14.6) years among self-reported patients and 66.3 (14.1) years among proxy-reported patients. The mean (SD) physical, mental, and role/social component summary scores of SF-36 were 49.3 (8.1), 53.3 (9.1) and 52.0 (8.9) in self-reported patients, and 24.2 (18.8), 50.1 (7.8) and 28.7 (15.4) in proxy-reported patients. A score of 50 represents the mean of the general population. The mean (SD) EQ-5D-5L score was 0.937 (0.090) in self-reported patients and 0.355 (0.297) in proxy-reported patients, where 0 represents death and 1 represents completely health.

**Conclusions:** In this study, QoL in self-reported patients was similar to that of the general population. In contrast, proxy-reported patients, who were unable to respond themselves, showed lower QoL scores, while the mental component summary were similar to those of the general population.

P3-3

## **One-staged multi-regional revascularization for moyamoya disease: territory-specific hemodynamic evaluation using quantitative SPECT**

Ryo HORIUCHI, Hideyuki YOSHIOKA, Norito FUKUDA, Koji HASHIMOTO,  
Toru TATEOKA, Hiroyuki KINOUCHI

Department of Neurosurgery, Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi,  
Yamanashi, Japan

### **Purpose:**

To quantitatively evaluate territory-specific hemodynamic changes using SPECT in patients with moyamoya disease undergoing one-staged multi-regional revascularization consisting of unilateral superficial temporal artery-middle cerebral artery (STA-MCA) bypass and bifrontal encephalo-duro-periosteal-synangiosis (EDPS).

### **Methods:**

Six patients with moyamoya disease (mean age 32.7 years) presenting with transient ischemic attacks due to hemodynamic compromise in the unilateral MCA and bilateral ACA territories were retrospectively analyzed. Combined revascularization procedures consisting of unilateral STA-MCA bypass with encephalo-duro-myo-synangiosis (EDMS) and bifrontal EDPS were performed. Digital subtraction angiography and <sup>123</sup>I-iodoamphetamine SPECT with acetazolamide challenge were obtained before and 3-6 months after surgery. Cerebral blood flow (CBF) and cerebrovascular reactivity (CVR) were quantified using the dual-table autoradiographic method. Pre- and postoperative values were compared using the Wilcoxon signed-rank test.

### **Results:**

All patients showed improvement or resolution of ischemic symptoms after surgery. Quantitative SPECT analysis demonstrated increases in CVR across all vascular territories, with mean changes ranging from approximately +17% to +36%. Significant improvements were observed in most regions, although statistical significance was not reached in the ipsilateral ACA territories. In contrast, resting cerebral blood flow (CBF) showed small and inconsistent changes across territories. At a mean follow-up of 61.5 months, all patients showed excellent functional outcomes (modified Rankin Scale score of 0).

### **Conclusion:**

One-staged multi-regional revascularization combining STA-MCA bypass and bifrontal EDPS achieved territory-specific improvement of cerebrovascular reactivity and favorable long-term clinical outcomes in selected patients with moyamoya disease.

## Cognitive Changes Following Revascularization Surgery in Pediatric Moyamoya Disease: Predictors of Postoperative Improvement

Yosuke ISHII, Shoko HARA, Motoki INAJI

The Department of Neurosurgery, Institute of Science Tokyo, Tokyo, Japan

### Background:

Although revascularization surgery effectively prevents ischemic events in pediatric moyamoya disease (MMD), its impact on cognitive function remains unclear. This study investigated longitudinal cognitive changes after surgery and factors associated with postoperative cognitive improvement.

### Methods:

We retrospectively analyzed 42 pediatric patients with MMD who underwent revascularization surgery and preoperative and postoperative cognitive assessments using the Wechsler Intelligence Scale for Children (WISC-III, IV, or V) between 2000 and 2025. The median age at surgery was 8 years (range, 4–14 years), and 28 patients were female. The postoperative WISC assessment was performed a mean of 2.0 years after surgery. Full-Scale IQ (FIQ) and six common WISC subtests across editions (Block Design, Similarities, Vocabulary, Coding, Symbol Search, and Digit Span) were compared between preoperative and postoperative evaluations. Multivariable linear regression analyses were performed to identify factors associated with cognitive changes, including age, follow-up duration, preoperative MRA score, posterior cerebral artery (PCA) involvement, and prior cerebral infarction.

### Results:

FIQ improved significantly from 93.9 preoperatively to 99.7 postoperatively (mean change +5.8 points,  $p < 0.001$ ; Cohen's  $d = 0.59$ ). Multivariable analysis demonstrated that greater improvement in FIQ was independently associated with lower preoperative MRA score ( $\beta = -3.64$ ,  $p = 0.005$ ) and older age at surgery ( $\beta = 1.59$ ,  $p = 0.014$ ). In contrast, PCA involvement, prior infarction, and follow-up duration were not significantly associated with postoperative cognitive changes. Exploratory analyses revealed that improvements in Similarities ( $\beta = 1.49$ ,  $p < 0.001$ ) and Coding ( $\beta = 0.95$ ,  $p = 0.024$ ) were independently associated with FIQ improvement.

### Conclusions:

Revascularization surgery was associated with moderate improvement in global cognitive performance in pediatric MMD. Cognitive gains were greater in patients with less advanced angiographic disease, suggesting that earlier surgical intervention may maximize postoperative cognitive benefit. Improvements in Similarities and Coding were most strongly associated with postoperative increases in FIQ.

P3-5

## **Clinical Validation of a Deep Learning Model for Automated Detection of Cerebrovascular Steno-occlusive Disease on MRA**

Sion KIM<sup>1,2</sup>, Taeyeong YANG<sup>3</sup>

<sup>1</sup>Department of Neurosurgery, Gumdan Top Hospital, Incheon, ROK, <sup>2</sup>CLARUS-N, Seoul, ROK, <sup>3</sup>Department of Nursing, Dongguk University-WISE Campus, Gyeongju, ROK

### Purpose

The screening for intracranial aneurysms often overlooks concurrent steno-occlusive disease, which carries significant risk for ischemic events. This study sought to develop and validate a deep learning-driven solution for the automated identification of cerebrovascular stenosis and occlusion using MR Angiography to mitigate diagnostic oversight.

### Methods

A robust neural network architecture was optimized using a large-scale, heterogeneous dataset of 1,722 TOF-MRA volumes, which included 1,366 stenotic segments and 524 total occlusions meticulously curated for high-fidelity training. The model's diagnostic performance was evaluated on an independent external validation (n=408), consisting of 165 confirmed pathological cases and 243 normative controls.

### Results

In the validation analysis, the AI framework demonstrated superior screening performance with a sensitivity of 95.8% (correctly identifying 158/165 patients) and a specificity of 86.4% (210/243 controls). The system exhibited high-throughput efficiency, with a mean inferential latency of approximately 26.5 seconds per case, facilitating rapid clinical integration.

### Conclusion

The proposed AI model serves as a high-sensitivity clinical decision support tool, effectively identifying steno-occlusive lesions that may remain occult during routine radiologic interpretation. While the current specificity is affected by spurious signals, iterative refinements in post-processing are expected to further optimize the diagnostic yield and streamline neurovascular workflows.

## Indirect Bypass for Perfusion-Defined High-Risk Adult Moyamoya Disease: Efficacy and Postoperative Stroke Compared with Combined Bypass

Ho Hyun NAM, Je Hun JANG, Sang Hyo LEE, Jae Seung BANG

Department of Neurosurgery, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam-si, ROK

### OBJECTIVE

Adult patients with moyamoya disease(MMD) and extensive preoperative perfusion delay may be at increased risk for postoperative complications after combined bypass(CB). We compared indirect bypass(IB) and CB in a perfusion-defined high-risk adult MMD cohort.

### METHODS

We retrospectively reviewed adult MMD hemispheres treated with CB or IB between January 2019 and December 2024. The cohort was restricted to hemispheres with preoperative time-to-maximum(Tmax)> 6 seconds(6s) volume of 59.5 mL or greater. Revascularization was assessed by 6-month angiography using the Matsushima grading system, and perfusion improvement was evaluated using postoperative CT perfusion. Baseline imbalance was addressed using overlap-weighted propensity score analysis. Factors associated with postoperative complications were evaluated using overlap-weighted logistic regression, with sensitivity analyses using patient-clustered robust standard errors and Firth penalized logistic regression.

### RESULTS

A total of 124 hemispheres were analyzed(CB, 88; IB, 36). Before weighting, PCA involvement was more frequent in the IB group(86.1% vs 61.4%; standardized mean difference=0.586), but all prespecified covariates were balanced after overlap weighting. Good revascularization was comparable between CB and IB before weighting(93.2% vs 94.4%,  $p=1.000$ ) and after overlap weighting (90.6% vs 98.1%,  $p=0.102$ ). Postoperative perfusion outcomes were also similar. Postoperative complications occurred less frequently after IB both before weighting(5.6% vs 23.9%,  $p=0.021$ ) and after overlap weighting(5.2% vs 34.6%,  $p<0.001$ ). In the overlap-weighted multivariable model, IB was associated with lower odds of postoperative complications, whereas larger preoperative Tmax> 6s volume was associated with higher odds. These findings remained significant after adjustment for intra-patient correlation and were directionally consistent in Firth analysis.

### CONCLUSIONS

In this perfusion-defined high-risk adult MMD cohort, IB achieved angiographic and perfusion outcomes comparable to CB, with a lower observed postoperative complication rate. IB may be a reasonable risk-adapted option for selected high-risk hemispheres, although non-randomized treatment allocation warrants cautious interpretation.

P3-7

## **The Bypass Patency Rate on MRA After STA-MCA Bypass Surgery Is Lower in Moyamoya Disease Than in Intracranial Atherosclerotic Disease**

Takeshi MIYAMOTO, Izumi YAMAGUCHI, Manabu ISHIHARA, Masaaki KORAI,  
Kenji SHIMADA, Yasushi TAKAGI

Department of Neurosurgery, Tokushima University Graduate School, Tokushima, Japan

**Introduction:** Superficial temporal artery to middle cerebral artery (STA-MCA) bypass surgery is performed for intracranial occlusive diseases, including intracranial atherosclerotic disease (ICAD) and moyamoya disease (MMD). Postoperative bypass patency is commonly evaluated using magnetic resonance angiography (MRA). In clinical practice, however, bypass visualization on MRA appears to be less frequent in patients with MMD than in those with ICAD.

**Objective:** To compare the postoperative bypass patency rate on MRA following STA-MCA bypass surgery between patients with ICAD and those with MMD.

**Methods:** We retrospectively reviewed 124 hemispheres that underwent postoperative MRA among 127 consecutive hemispheres treated with STA-MCA bypass surgery for intracranial occlusive disease at our institution between January 2011 and December 2023. Patient characteristics, disease type, bypass patency on postoperative MRA, and perioperative complications were analyzed.

**Results:** Of the 124 hemispheres, 42 had ICAD and 82 had MMD. The postoperative bypass patency rate on MRA was 98% (41/42 hemispheres) in the ICAD group and 71% (58/82 hemispheres) in the MMD group. The patency rate was significantly lower in patients with MMD than in those with ICAD ( $p = 0.0002$ ).

**Conclusions:** The bypass patency rate on postoperative MRA following STA-MCA bypass surgery was significantly lower in patients with moyamoya disease than in those with intracranial atherosclerotic disease. We discuss the possible mechanisms underlying this finding with reference to the literature.

## Cortical resection instead of decompressive craniectomy for malignant edema of brain infarction

Jun Seob LIM, Sung Min YOON, Jong Hyun MOON, Hyun Jin JUNG

Kwangju Christian Hospital, ROK

### Purpose

Brain infarction area is safe to remove because it is already dead tissue. Authors tried cortical resection for decreasing ICP in malignant edema of brain infarction.

### Materials and methods

- 1)MCA occlusion - 4 cases
- 2)Cerebellar infarction - 8 cases.

### Operative methods

Under local anesthesia

- 1)MCA occlusion :about 4\*4cm-sized Temporal craniotomy and subcortical resection of frontal and temporal cortex
- 2)PICA occlusion :Suboccipital burr hole trephination and cortical resection of cerebellar cortex and drainage catheter insertion

### Case presentation

- 1)case 1
  - 67/F Rt. MCA occlusion and infarction
  - local anesthesia
  - Rt. temporal craniotomy(4\*4cm-sized) and subcortical resection of frontal and temporal cortex.
- 2)case 2
  - 57/M Rt. PICA occlusion & infarction.
  - local anesthesia.
  - Rt. suboccipital burr hole trephination and cortical resection of cerebellar cortex

### Result

- 1)Revision: 1 of 4 cases MCA occlusion
- 2)All cases resulted in adequate decompression without any complications. 2)Cerebellar infarction 8 cases :all cases recovered without any complications.

### Conclusion

Cortical resection for malignant edema of cerebral infarction is more effective operation than decompressive craniectomy. It has few complications from decompressive craniectomy and does not require secondary cranioplasty

P4-1

## **New Paradigm for Overcoming Vascular Dementia: Lessons from Stem Cell and Pharmacotherapy Research**

**Dong-Hyuk PARK<sup>1</sup>, Jang-hun KIM<sup>1</sup>, Jong-hoon KIM<sup>2</sup>, Dong-jun LIM<sup>3</sup>**

<sup>1</sup>Department of Neurosurgery, Korea University Anam Hospital, Seoul, ROK, <sup>2</sup>Laboratory of Stem Cells and Tissue Regeneration, Department of Biotechnology, College of Life Sciences and Biotechnology, Korea University, Seoul, ROK,

<sup>3</sup>Department of Neurosurgery, Korea University Ansan Hospital

Vascular dementia (VaD) is the second most common form of dementia, yet no disease-modifying therapy has been established. Current pharmacological options produce only limited symptomatic benefit, underscoring the urgent need for novel therapeutic strategies. This study investigated the efficacy of iPSC-derived induced neural stem cell (iNSC) transplantation compared with choline alfoscerate pharmacotherapy in a preclinical model of subcortical ischemic vascular dementia (SIVD).

A SIVD model was established in C57BL/6 mice via bilateral common carotid artery microcoil stenosis. Animals were assigned to sham, vehicle, iNSC transplantation, or choline alfoscerate treatment groups. After three months, neurobehavioral function was assessed using the Y-maze and passive avoidance tests. Histological evaluation included hematoxylin and eosin staining for neuronal damage in the hippocampal CA1 region, and immunofluorescence staining with IBA-1 and GFAP to quantify microglial and astrocytic activation in the hippocampus and corpus callosum.

Both iNSC transplantation and choline alfoscerate treatment significantly improved spatial working memory and associative learning compared to the vehicle group. Histological analysis confirmed reduced neuronal injury in the CA1 region in both treatment groups. Neuroinflammatory markers were significantly suppressed, with decreased IBA-1-positive microglia and GFAP-positive astrocytes in the hippocampus and corpus callosum. Notably, iNSC transplantation demonstrated superior efficacy over choline alfoscerate across all behavioral and histological outcomes.

These findings demonstrate that both stem cell transplantation and pharmacotherapy can attenuate neuroinflammation and improve cognitive function in a SIVD model, with cell-based therapy showing greater therapeutic benefit. Our results provide preclinical evidence supporting the translational potential of iNSC transplantation and highlight the importance of multi-modal approaches in vascular dementia treatment.

## **Development and Validation of an Integrated Deep Learning Framework for 3D Carotid Artery Reconstruction and Stenosis Detection using MR angiography**

Taeyeong YANG<sup>1</sup>, Sion KIM<sup>2,3</sup>

<sup>1</sup>Department of Nursing, Dongguk University-WISE Campus, Gyeongju, ROK, <sup>2</sup>CLARUS-N, Seoul, ROK,

<sup>3</sup>Department of Neurosurgery, Gumdan Top Hospital, Incheon, ROK

### Purpose

This study aimed to develop and validate an integrated deep learning framework for high-fidelity 3D vascular reconstruction and AI-based detection of carotid artery stenosis using Time-of-Flight (TOF) Magnetic Resonance Angiography (MRA).

### Methods

The proposed framework consisted of two primary modules: (1) a volumetric segmentation network based on a 3D U-Net architecture, trained using 200 curated carotid MRA datasets for precise vascular reconstruction, and (2) a stenosis detection algorithm trained on an annotated dataset comprising 622 cases with varying degrees of stenosis and complete occlusion. Diagnostic performance was evaluated using 450 carotid MRA examinations (300 normal controls and 150 pathological cases), and AI-generated outputs were compared with expert reference standards.

### Results

The reconstruction module demonstrated high anatomical fidelity, achieving a Dice similarity coefficient of 0.916 with a mean processing time of 4.5 seconds per case. For the detection of clinically significant carotid stenosis and occlusion, the framework achieved a sensitivity of 85.3% (128/150 cases) and a specificity of 92.3% (277/300 cases), indicating strong diagnostic accuracy and reliability.

### Conclusion

The integrated AI framework significantly enhances diagnostic precision for neurovascular diseases by identifying subclinical or occult lesions, such as subtle stenotic segments, which are frequently susceptible to clinician fatigue or oversight. This solution serves as a potent clinical decision-support tool, optimizing diagnostic workflows and mitigating inter-observer variability in high-volume neurovascular practice.

## Early Transition to Intra-Arterial Alteplase and Reperfusion Quality in Thrombectomy-Refractory Stroke

Kyeongsik KIM<sup>1</sup>, Hyungon LEE<sup>2</sup>, Seunghwan KIM<sup>3</sup>, Minjae CHO<sup>4</sup>

<sup>1</sup>Department of Neurosurgery, Inje University Haeundae Paik Hospital, Busan, ROK, <sup>2</sup>Department of Neurosurgery, Dongnam Institute of Radiological & Medical Sciences, Busan, ROK, <sup>3</sup>Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine, Changwon, ROK, <sup>4</sup>Department of Neurosurgery, Seoul National University College of Medicine, Seoul National University Bundang Hospital, Gyeonggi-do, ROK

### Background

Mechanical thrombectomy (MT) is the standard treatment for acute ischaemic stroke due to large vessel occlusion (LVO), but a subset of lesions remains refractory or technically challenging despite repeated mechanical attempts. In such cases, intra-arterial (IA) alteplase may be used as a rescue strategy, although the optimal timing of transition from mechanical to pharmacological therapy remains unclear.

### Methods

We retrospectively reviewed 90 consecutive patients with large vessel occlusion treated with MT between July 2021 and December 2022. Sixteen patients received IA alteplase when further mechanical thrombectomy was considered ineffective or technically unfeasible. The primary outcome was excellent recanalisation, defined as modified Thrombolysis in Cerebral Infarction (mTICI) 2c-3. Secondary outcomes included successful recanalisation (mTICI  $\geq$  2b), 3-month modified Rankin Scale (mRS), and haemorrhagic complications.

### Results

Successful recanalisation was achieved in 15 patients (93.8%), including excellent recanalisation in 8 (50.0%). Procedure time was significantly shorter in the excellent recanalisation group than in the non-excellent group (median, 85 vs. 180 minutes;  $p = 0.019$ ), whereas baseline characteristics were comparable. Haemorrhagic complications were limited in severity, with no cases of devastating intracerebral haemorrhage. Good functional outcome (mRS  $\leq$  2) was observed in 2 patients (12.5%), likely reflecting the cumulative time required to achieve reperfusion in this rescue setting.

### Conclusions

Longer procedural duration was associated with a lower likelihood of excellent reperfusion following rescue IA alteplase. These findings suggest that prolonged MT may reduce reperfusion quality and that earlier transition to IA alteplase may improve procedural outcomes in selected cases.

### Keywords

Acute ischaemic stroke; large vessel occlusion; mechanical thrombectomy; thrombectomy-refractory; intra-arterial alteplase; procedural timing; reperfusion quality

## **Time-Dependent Bidirectional Effects of Endovascular Thrombectomy on Decompressive Craniectomy in Large Core Ischemic Stroke: A Trial-Level Meta-Regression Analysis**

Hyeon Yeong JEONG

department of neurosurgery, Samsung changwon hospital, ROK

### Background and Purpose:

Endovascular thrombectomy (EVT) improves outcomes in large core ischemic stroke, but its effect on decompressive craniectomy (DC) remains uncertain. We evaluated whether the effect of EVT on DC differs according to treatment time window.

### Methods:

We performed a systematic review and trial-level meta-regression of randomized controlled trials comparing EVT plus medical management with medical management alone in patients with large core stroke (ASPECTS 0-5 or ischemic core 50 mL or more). The primary outcome was the difference in DC rate. Time to treatment, imaging modality, and reperfusion rate were evaluated as potential moderators.

### Results:

Six randomized controlled trials including 1887 patients were analyzed. Time window was the strongest predictor of EVT effect on DC. The difference in DC rate increased by 1.29 percent for each additional hour of treatment delay ( $p = 0.002$ ). Early-window trials showed a lower DC rate, whereas late-window trials showed a higher DC rate ( $p = 0.001$ ). Despite increased DC use, late-window EVT was not associated with lower mortality. MRI-based patient selection was associated with lower DC rates than CT-based selection ( $p = 0.029$ ).

### Conclusions:

The effect of EVT on decompressive craniectomy is time dependent in large core stroke. Late-window EVT increases DC rates without reducing mortality, suggesting that reperfusion-related brain edema may not be sufficiently improved by decompressive surgery. Better patient selection using treatment time and biomarkers of blood-brain barrier injury may improve outcomes.

## **Prediction of Cardiovascular Disease Development in CEA Patients: A Vision-Language Approach Bridging Whole-Slide Images and Pathological Findings**

Hinata KONDO<sup>1</sup>, Kento MORITA<sup>1,2</sup>, Kinta HATAKEYAMA<sup>2</sup>, Nice REN<sup>2</sup>, Shogo WATANABE<sup>2</sup>,  
Syoji KOBASHI<sup>2,3</sup>, Koji IIHARA<sup>2</sup>, Tetsushi WAKABAYASHI<sup>1</sup>

<sup>1</sup>Graduate School of Engineering, Mie University, Mie, Japan, <sup>2</sup>National Cerebral and Cardiovascular Center, Osaka, Japan,

<sup>3</sup>Graduate School of Engineering, University of Hyogo, Hyogo, Japan

Carotid endarterectomy (CEA) is a well-established treatment for severe carotid artery stenosis. However, predicting long-term postoperative cardiovascular outcomes remains a significant clinical challenge. While the predictive potential of whole-slide images (WSI) of carotid plaques is highly anticipated, it has not been fully explored. This study aims to predict cardiovascular disease development within one year after CEA by proposing an interpretable multimodal learning framework that integrates WSI and pathological findings.

We used data from 71 patients who underwent CEA. Utilizing PLIP, a vision-language foundation model fine-tuned on a large-scale pathology dataset, we processed images and text in a shared embedding space. To further enhance interpretability, we developed a text-guided attention mechanism that calculates similarity scores between patch-level WSI features and pathology reports. This enables the model to selectively weight and extract features from patches that align with the pathologist's clinical focus.

In binary classification for predicting postoperative events, the proposed model achieved a maximum ROC-AUC of 0.707. Although the predictive accuracy currently lags behind conventional machine learning models, our method successfully generated attention heatmaps. These heatmaps visually highlight the specific pathological regions contributing to the prediction, providing a transparent rationale that directly bridges morphological features with pathological findings.

We present a proof-of-concept for an explainable AI framework in CEA prognosis. By visually grounding the AI's reasoning in established pathological findings, our text-guided heatmaps ensure high clinical transparency. While improving absolute accuracy remains a future objective, this trustworthy approach serves as an objective index that complements physicians' visual judgments, and holds the potential to help identify novel visual biomarkers for cardiovascular events.

## Efficacy of carotid artery stenting in patients with symptomatic low-grade carotid artery stenosis

Toshinori MATSUSHIGE, Masahiro HOSOGAI, Hiroto MISHIMA, Toshimitsu SUMII

Department of Neurosurgery and Interventional Neuroradiology, Hiroshima City North Medical Center Asa Citizens Hospital, Japan

### Background

In the past decade, best medical treatment has been standard for patients with symptomatic low-grade cervical carotid artery stenosis. To date, radiographic diagnosis detecting unstable plaque and endovascular treatments have been advanced. In our local real-world data, we investigated the efficacy of carotid artery stenting (CAS) and examined differences in the outcomes of medical treatments.

### Methods

Seventy-seven consecutive patients with ischemic stroke due to low-grade carotid artery stenosis (NASCET<50%) were analyzed. Forty-four patients received medical therapy alone and 33 underwent CAS. All CAS were performed using closed cell stents under flow reversal method. We investigated patient profiles and plaque features using multiple modalities. The incidence of recurrent ischemic stroke in each treatment and factors were evaluated.

### Results

In the medical treatment group, 27 of 44 patients (61%, 26%/patient-year) had new DWI lesions, including 20 (45%, 21%/patient-year) with recurrent symptomatic stroke in the mid-term follow-up (mean 23, 7.9-51 months). Factors associated with recurrent stroke included dyslipidemia (HR:5.1) and intraplaque hemorrhage (HR:5.5).

Among 33 patients in the CAS group, 1 had a stroke due to an in-stent plaque 4 years after CAS (3.0%, 0.8%/patient-year). CAS showed a significantly lower recurrent rate than the medical control group ( $p < 0.001$ ).

### Conclusion

Although patient profile was different from previous large studies, CAS has potential as a safe and valid treatment option for elderly symptomatic low-grade carotid artery stenosis.

P4-7

## Unexpected Challenges and Complications During Carotid Artery Stenting: A Single-Center Experience

Hyun-Jean JEONG, Jun Sub LIM

Kwangju Christian Hospital, Gwangju, ROK

### Background

Carotid artery stenting (CAS) is an established treatment for carotid artery stenosis. However, unexpected procedural challenges and complications may arise and influence treatment strategies and clinical outcomes.

### Methods

We retrospectively reviewed 55 consecutive patients who underwent CAS between 2019 and 2025. Treatment timing was individualized according to whether the ischemic stroke represented an initial or recurrent event. In selected cases, CAS was performed immediately after diagnostic evaluation. Standard guiding catheters, distal embolic protection devices, balloon pre-dilation, and self-expanding carotid stents were used. Additional microcatheter support was employed when necessary.

### Results

Procedure failure or modification of the initial treatment strategy occurred in 4 patients (7.3%) because of unexpected anatomical or technical challenges. Although all procedures were performed with careful monitoring for baroreceptor-mediated bradycardia and cardiac arrest, no episodes of significant bradycardia or cardiac arrest occurred. One patient (1.8%) developed distal embolic occlusion of the middle cerebral artery requiring rescue mechanical thrombectomy. Another patient (1.8%) developed a watershed-zone cerebral infarction attributed to postprocedural hypoperfusion despite technically successful revascularization. No cases of intracerebral hemorrhage were observed. Technical complications, including stent malposition beyond the intended treatment zone (distal or proximal) and adverse events during device retrieval, occurred in 5 patients (9.1%). During follow-up, restenosis of the treated lesion was identified in 1 patient (1.8%), and no cases of stent migration were observed.

### Conclusions

Recognition of potential procedural pitfalls and prompt adaptation of endovascular strategies are essential for minimizing complications and optimizing outcomes during CAS.

## Safety and Efficacy of Conscious Sedation During Coil Embolization

Jung-Soo KIM<sup>1</sup>, Hyungon LEE<sup>2</sup>

<sup>1</sup>Dongnam Institute of Radiological & Medical Sciences, Busan, ROK,

<sup>2</sup>Department of Neurosurgery, Samsung Changwon Hospital, Sungkyunkwan University School of Medicine

**Purpose:** Coil embolization is commonly performed under general anesthesia, but conscious sedation may offer a feasible alternative in selected patients. This study evaluated the safety and efficacy of conscious sedation during coil embolization.

**Methods:** We retrospectively reviewed 46 patients who underwent coil embolization under conscious sedation between January 2022 and December 2023. Sedation was induced with dexmedetomidine 1.0 mcg/kg over 10 minutes, followed by continuous infusion at 0.4-0.8 mcg/kg/hr, with remifentanyl 0.02 mcg/kg/min. Bispectral index score (BIS) was used to assess sedation depth. Systolic blood pressure (SBP), heart rate (HR), and oxygen saturation were recorded every 5 minutes. Successful embolization was defined as Raymond-Roy occlusion classification class 1.

**Results:** The median patient age was 66 years (interquartile range [IQR], 56.00-72.25), and 6 patients (13.04%) were male. Four patients (8.70%) presented with subarachnoid hemorrhage. The median baseline BIS was 92.5 (IQR, 89.75-96.00). Sixteen patients required additional midazolam 1.25 mg because BIS remained 80 or higher after dexmedetomidine and remifentanyl. Patients requiring midazolam were significantly younger than those not requiring it (58.75 vs 67.85 years,  $p=0.034$ ). At maximum sedation, the median BIS was 62.00 (IQR, 52.75-66.25), SBP was 119 mmHg (IQR, 105.75-131.00), and HR was 55.00 beats/min (IQR, 48.00-61.00). Hypotension requiring vasopressors occurred in 1 patient (2.17%), and hypoxia requiring oxygen reservoir mask support occurred in 4 patients (8.69%). Raymond-Roy class 1 occlusion was achieved in 31 patients (67.39%).

**Conclusion:** Conscious sedation during coil embolization appears to be a feasible and relatively safe anesthetic strategy in selected patients.

P5-2

## **Reliability of Artificial Intelligence in ICH Volume Measurement: Comparison with Conventional Methods**

Junwon KIM, Yonghwan CHO, Jaehyung CHOI

Department of Neurosurgery, Dong-A University Hospital, Busan, ROK

### **Purpose:**

Intracerebral hemorrhage (ICH) volume is a key determinant of surgical intervention. Several methods are available for estimating ICH volume, including the ABC/2 method, which is simple but prone to over- or underestimation; the manual planimetric method, which is the most accurate but time-consuming; and, more recently, automated AI-based volume estimation. This study aimed to evaluate whether AI-based volume measurements are sufficiently reliable for determining surgical indications in clinical practice.

### **Methods:**

Patients with spontaneous ICH without intraventricular hemorrhage (IVH) from a single center were analyzed. Three different volume measurement methods were compared with manual planimetric measurement as the reference standard: the ABC/2 method, AI analysis 1, which was designed to provide ROI-based volumetric quantification, and AI analysis 2, which was designed to provide triage and coarse volume estimation. Subgroup analyses were additionally performed for deep and lobar hemorrhages.

### **Results:**

All methods showed strong correlations with manual planimetric measurements ( $r > 0.98$ ). The ABC/2 method tended to overestimate hemorrhage volume. AI analysis 2 showed the closest agreement with planimetric measurement. In subgroup analysis, AI analysis 1 exhibited the lowest correlation in deep hemorrhage. AI analysis 2 showed the lowest mean absolute error and the highest overall accuracy (95%) based on a 30 mL volume threshold.

### **Conclusion:**

AI analysis 2 showed the lowest deviation from manual planimetric measurement and provided volume estimates consistent with clinically relevant measurement. Although differences existed among AI-based analyses, they showed consistent trends in volume estimation. These findings suggest that AI-based volume estimation may be used as a supportive decision-making tool in clinical practice.

## Basilar Artery Angulation as an Imaging Marker of Transtentorial Herniation after Lumbar Drainage: Two Case Reports

Yong-Hwan CHO, Jae Hyung CHOI

The department of Neurosurgery, Dong-A university, Busan, ROK

**Background:** Lumbar drainage is commonly used in aneurysmal subarachnoid hemorrhage to achieve brain relaxation during clipping surgery. However, excessive cerebrospinal fluid drainage may cause intracranial hypotension and transtentorial herniation. Early diagnosis can be difficult because conventional imaging findings may be subtle or obscured in patients with subarachnoid hemorrhage. We describe two cases in which basilar artery angulation on computed tomography angiography was useful as an intuitive imaging marker of transtentorial herniation.

**Case Description:** Case 1 was a 65-year-old woman with subarachnoid hemorrhage from a ruptured anterior cerebral artery aneurysm. She underwent clipping with preoperative lumbar drainage. On postoperative day 4, she developed deep stupor and bilaterally fixed pupils. Sagittal maximum intensity projection images of computed tomography angiography showed a decrease in the basilar artery angle from 133 to 87 degrees. Her neurological status improved after lumbar drainage removal. Case 2 was a 56-year-old woman with subarachnoid hemorrhage from a ruptured posterior communicating artery aneurysm. On postoperative day 5 after clipping with lumbar drainage, she became stuporous. The basilar artery angle decreased from 153 to 91 degrees and returned toward its original configuration after lumbar drainage removal, followed by neurological recovery.

**Conclusion:** Basilar artery angulation on computed tomography angiography may help detect transtentorial herniation caused by lumbar drainage overdrainage. Serial sagittal maximum intensity projection images can provide a rapid and accessible diagnostic clue.

P5-4

## **Incidence and Disability Outcomes in Patients with Spinal Vascular Lesions in South Korea**

**Dong-Kyu JANG<sup>1</sup>, Minkyung HAN<sup>2</sup>, Doo-yong CHOI<sup>1</sup>**

<sup>1</sup>Department of Neurosurgery, Incheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Incheon, ROK, <sup>2</sup>Biostatistics Collaboration Unit, Department of Biomedical Systems Informatics, Yonsei University College of Medicine, Seoul, ROK

**Purpose:** Spinal vascular lesions (SVLs), including spinal vascular malformations and spinal dural arteriovenous fistulas, are rare. This study evaluated the nationwide incidence and treatment outcomes of SVLs after embolization or surgical occlusion in South Korea.

**Materials and Methods:** Using the National Health Insurance Service database (2002-2023), patients newly diagnosed with SVLs (ICD-10: Q28.2, Q28.3) who underwent spinal angiography and subsequent embolization or surgical occlusion were identified. A washout period (2002-2005) was applied. The primary outcome was the physical disability rate at 1-year follow-up. Predictors for disability and retreatment rates were analyzed.

**Results:** Over 18 years, the annual incidence of SVLs increased from 0.23 to 0.8 per million people. Among 587 patients (mean age: 51.5 years; male-to-female ratio: 2.5:1), 151 (25.7%) experienced physical disabilities at 1 year, and 98 (16.7%) developed new or aggravated disabilities. Surgical occlusion was a significant predictor for both 1-year disability (OR: 1.76; 95% CI: 1.13-2.76; p=0.013) and new/aggravated disability (OR: 1.71; 95% CI: 1.09-2.68; p=0.019). Retreatment was required in 89 cases (15.1%), predominantly following initial embolization, and managed via surgery (45 cases) or repeat embolization (38 cases).

**Conclusion:** This nationwide study provides essential epidemiological data on SVLs in Korea. Given the significant disability burden and retreatment rates, optimizing management strategies is crucial to improving clinical outcomes.

## **A study for comparative efficacy of urokinase and recombinant tissue-type plasminogen activators (r-TPA) in patients with intraventricular hemorrhage (IVH)**

Hyeon-Song KOH, Kiyeon YANG, Kyung Hwan KIM, Eun-oh JEONG, Hyon-jo KWON

Department of Neurosurgery, Chungnam National University Hospital, Daejeon, ROK

**Objective:** Spontaneous intracerebral hemorrhage (ICH) with intraventricular hemorrhage (IVH) is associated with high mortality and severe disability. This study aimed to compare the effects of urokinase and recombinant tissue-type plasminogen activator (r-tPA) on functional outcomes and IVH clearance in patients with IVH.

**Methods:** A retrospective analysis was conducted on 97 patients with IVH treated from January 2014 to February 2024. Patients received either urokinase or r-tPA via external ventricular drainage (EVD) and were assessed using the modified Rankin Scale (mRS) at 180 days. Prognostic factors were analyzed to evaluate the treatment effects.

**Results:** The 180-day mRS outcomes were similar between the urokinase and r-tPA groups ( $P = 0.817$ ). However, r-tPA achieved faster IVH clearance ( $P = 0.022$ ) with shorter dosing and drain durations. By postoperative day 3, the IVH volume significantly decreased in the r-tPA group, allowing earlier intraventricular fibrinolysis cessation. ICU stays were shorter and infection rates lower in the r-tPA group, but these differences were not statistically significant. Multivariate analysis identified the NIHSS and initial ICH volume as key outcome predictors ( $P = 0.048$ ,  $P = 0.035$ ).

**Conclusion:** While r-tPA facilitated faster IVH clearance, it did not improve long-term functional outcomes. Faster clearance with r-tPA may help reduce ICU stays and infection rates, but initial neurological status remains a primary prognostic factor. Larger studies are needed to confirm these findings and evaluate the potential benefits of r-tPA in IVH management.

P5-6

## **Case series ; The Putaminal Hemorrhage Evacuation via Minipterional craniotomy and Transylvian-transinsular Approach**

Hansan OH

The department of neurosurgery, Gil medical center, Gachon University College of Medicine, ROK

### Background

Putaminal intracerebral hemorrhage (ICH) can result in hemiparesis and impaired consciousness. Although recent studies have suggested benefits of surgical evacuation in selected patients, the impact of corticospinal tract (CST) involvement on neurological recovery remains unclear. We report three cases of small putaminal hemorrhage treated via a mini-pterional transsylvian-transinsular approach and evaluated outcomes according to CST involvement.

### Methods

Between January and March 2026, three patients with putaminal hemorrhage <30 mL and neurological deficits underwent hematoma evacuation through a mini-pterional transsylvian-transinsular approach. Hemorrhages extending above the superior margin of the lateral ventricle were classified as corona radiata involvement. Posterior limb of the internal capsule (PLIC) involvement was categorized as compression or destruction. Hematoma volume, NIHSS score, surgical complications, and 3-month modified Rankin Scale (mRS) outcomes were analyzed.

### Results

The mean age was 55.3 years and the mean hematoma volume was 25.6 mL. One patient demonstrated corona radiata involvement, one showed PLIC destruction, and one exhibited PLIC compression. The mean residual hematoma volume was reduced to 5 mL after surgery. No procedure-related complications were observed.

At 3-month follow-up, the patient with corona radiata involvement improved from Medical Research Council (MRC) grade II to IV and achieved an mRS score of 2. The patient with PLIC destruction recovered to MRC grade III with an mRS score of 3. In contrast, the patient with PLIC compression achieved complete neurological recovery (mRS 0).

### Conclusions

Mini-pterional transsylvian-transinsular evacuation was a feasible and safe technique for selected patients with small putaminal hemorrhage. Functional recovery appeared to correlate with the degree of CST involvement, with the best outcome observed in the patient with PLIC compression.

## Internal Carotid Artery Occlusion after Transvenous Embolization of a Direct Carotid-Cavernous Fistula

Dabeom KIM, Seung Hwan KIM

Department of Neurosurgery, Samsung Changwon Hospital, ROK

**Background:** Transvenous embolization is an established treatment for carotid-cavernous fistula (CCF), but internal carotid artery (ICA) occlusion is a rare and potentially devastating complication.

**Case Description:** A 73-year-old woman presented with left periorbital pain, chemosis, and proptosis after head trauma 2 months earlier. Cerebral angiography demonstrated a direct left CCF with high-flow shunting from the ICA to the cavernous sinus. Transvenous coil embolization was performed through the left inferior petrosal sinus. Immediate control angiography showed complete obliteration of the fistula; however, delayed final angiography revealed occlusion of the left ICA.

Because ICA compromise related to the coil mass was suspected, rescue stenting of the petrous ICA was attempted. Despite multiple attempts, the microcatheter could not be advanced across the angulated petrous segment, and the dense coil mass within the cavernous sinus obscured visualization of the ICA. Consequently, stent placement was unsuccessful.

Emergency superficial temporal artery-to-middle cerebral artery bypass was subsequently performed. Although bypass patency was confirmed, the patient developed a large left middle cerebral artery territorial infarction. At 3-month follow-up, she had persistent severe neurological deficits, including right hemiparesis and aphasia.

**Conclusion:** ICA occlusion should be recognized as a rare but catastrophic complication of transvenous embolization for direct CCF. Careful assessment of coil mass effect, repeated angiographic evaluation, and preparation for prompt endovascular or surgical revascularization are essential, particularly in large high-flow fistulas.

P5-8

## **Successful Treatment of a Ruptured Brain Arteriovenous Malformation in a Pregnant Patient by Endovascular Embolization followed by Normal Delivery: Case Report**

Sung Kyun HWANG

Department of Neurosurgery, Ewha Womans University Hospital, Seoul, ROK

We report a case of successful treatment of a ruptured brain arteriovenous malformation (AVM) in a pregnant patient by endovascular embolization followed by normal delivery. A 34-year-old woman presented at 35 weeks of gestation with a history of severe headache followed by severe consciousness disturbance. Brain computed tomography showed a sub-cortical hemorrhage in the left frontal lobe along with bilateral intraventricular hemorrhage. A cerebral angiography was performed to confirm the diagnosis, which revealed left frontal AVM. At 35 weeks of gestation, endovascular embolization of the AVM was attempted under general anesthesia. The feeding artery and the nidus were simultaneously obliterated by injection of Onyx (Medtronic). As a result, the blood flow into the nidus was drastically decreased and the risk of re-bleeding was substantially reduced. At 1 week later, normal delivery was performed under combined spinal-epidural anesthesia. The mother had no further neurological deficit and the infant was confirmed as not having any congenital anomalies. The patient and the infant were discharged home without any medical problems. Endovascular treatment in pregnant women is associated with various unique concerns, such as the effects of radiation and diagnostic/therapeutic agents on the fetus. However, it can be carried out safely and effectively and is useful not only for saving the mother's life but also for allowing the pregnancy to continue to term.