

Symposium



S1-1

The evolution of giant Aneurysm treatment

Jafar J. Jafar
NYU Neurosurgery Associates

TBA

S1-2

Flameless stereotactic endoport-assisted microsurgery of a ruptured posterior lateral choroidal artery aneurysm

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Ruptured periventricular aneurysms associated with moyamoya disease represent challenging pathologies. Its natural history is unknown and methods of treatment are still controversial. Disappearance after bypass surgery, microsurgical resection and endovascular embolization are reported as the surgical treatment, however rare cases arise in which the location and anatomy of the aneurysm make these treatment modalities challenging.

We report a case of 60-year-old female with moyamoya disease who presented with intraventricular hemorrhage. CT angiography and digital subtraction angiography revealed the gradual growing of the aneurysm of the posterior lateral choroidal artery located in the lateral wall of the atrium of the right lateral ventricle. We resected this aneurysm successfully using flameless navigated biopsy system (VarioGuide, Brainlab AG, Germany) and tuber retractor (ViewSite, Vycor medical Inc., FL).

We demonstrate the efficacy of flameless stereotactic endoport-assisted microsurgery for the treatment of this uncommon deep seated aneurysm.

S1-3

Surgical Technique and Variations of the Occipital Artery-to-Posterior Inferior Cerebellar Artery Bypass

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(Objective) Occipital artery (OA) to posterior inferior cerebellar artery (PICA) bypass is indispensable for the management of complex aneurysms involving the PICA that cannot be reconstructed with surgical clipping or coil embolization. Although OA-PICA bypass is a comparatively standard procedure, the bypass is difficult to perform in some cases because of the location and situation of the PICA. We report the variation and surgical strategy of the OA-PICA bypass

(Methods) Between 2009 and 2017, 36 OA-PICA bypasses were performed for patients with Vertebral Artery (VA) or PICA aneurysm at our institution. Surgical procedures and medical records of all patients were retrospectively reviewed.

(Results) The mean age was 60 years old (32 to 89 years old). Primary diseases were VA-PICA aneurysms in 13 cases, PICA aneurysms in 12 cases and VA aneurysms in 11 cases. The sites of anastomosis were lower position of the caudal loop of PICA in 13 cases, high position of the caudal loop or cranial loop of the PICA (located at upper part of the cerebellomedullary fissure (CMF)) in 18 cases, and cortical branch of the PICA in 5 cases. Postoperative angiogram showed good patency of OA-PICA bypasses in 34 cases. There was no major complication caused by OA-PICA bypass procedure.

(Conclusion) Although previous articles have showed that lower position of the caudal loop of the PICA was recommended as recipient artery of OA-PICA anastomosis, we performed these anastomosis at lower part of the PICA in only 13 cases (36%). When the recipient artery was located in the upper part of the CMF, the unilateral trans-CMF approach provided a sufficient operative field for OA-PICA anastomosis.

S2-1

Prehospital and preprocedural management for acute ischemic stroke on superacute phase

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<Background>

The evidence of thrombectomy with or without intravenous thrombolysis for acute ischemic stroke is recently well-established. The main strategy of the treatment for acute ischemic stroke is 'rapid estimation and rapid recanalization'. We report our tips and management for shortening time from onset to recanalization on superacute phase of acute ischemic stroke.

<Patients and methods>

46 patients who received thrombectomy for acute ischemic stroke were registered from 2014-2017. The door-to-puncture time, good-recanalization rate, and clinical outcome for the former 2 years and the latter 2 years were compared. Especially, our effectiveness of the management for acute ischemic stroke these 2 years were analyzed.

<Results>

The mean door-to-puncture time was 132 minutes from 2014 to 2015, but was 55 minutes from 2015 to 2017. The rate of good recanalization rate (TICI IIB-III) was 78.1% from 2014 to 2015, and was 81.2% from 2016 to 2017. Good clinical outcome was 28% and 42%.

<Discussion>

Great efforts achieved better outcome because of saving time for recanalization on acute ischemic stroke. For example, stroke management course was held for co-medicals, new workflow systems were established across multidisciplinary staffs, and prehospital air transportation systems were ongoing.

<Conclusion>

We know that rapid recanalization allows to achieve good clinical outcomes, but great efforts is necessary. The best systems for acute ischemic stroke depends on the characteristics of the institute.

S2-2

Experiences and improvements of endovascular clot retrieval in Kariya Toyota General Hospital

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The optional endovascular approach for acute ischemic stroke is unclear. A stent clot retriever and clot aspirator can be used as first-line treatment for fast mechanical recanalization. We struggled and developed a treatment protocol for acute ischemic stroke. We divided our clinical experiences into 3 terms according to devices and techniques. The 1st period was commonly used a Merci clot retriever for 10 consecutive cases. The 2nd period was used Trevo stent retriever for first-line treatment. Clot quality was assessed on the basis of the perfusion status after deployment of the Trevo. Twenty-five consecutive patients were analyzed. The 3rd period was induced a corkscrew penetrating method, and A Stent-retrieving into an Aspirator with Proximal balloon (ASAP) technique. We found the corkscrew penetrating method was effective for hard clots. We got the information of clot quality when the pigtail shaped tip of the microguidewire became stuck or not against a clot during penetration. The ASAP technique was aimed at a series of thrombus extraction by withdrawing the stent retriever into the aspiration catheter, and continuous aspiration in the first attempt without waiting. Forty-two consecutive patients were analyzed. We discuss the clinical data and endovascular techniques of each periods.

S2-3

Treatment Result of Kanazawa Mobile Embolectomy Team for Acute Ischemic Stroke

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Five recent multicenter randomized controlled trials (RCTs) have clearly shown the superiority of mechanical thrombectomy in large vessel occlusion acute ischemic stroke compared to systemic thrombolysis. Although 14 hospitals in Ishikawa prefecture have uninterrupted availability of systemic thrombolysis, mechanical thrombectomy is not available at all of these hospitals. Therefore, we established a Kanazawa mobile embolectomy team (KMET), which could travel to these hospitals and perform the acute reperfusion therapy. In this article, we report early treatment outcomes and validate the effectiveness of a network between affiliated hospitals and KMET. Between January 2014 and May 2017, 100 patients, aged 45 to 92 years (mean: 71.8 years), underwent acute reperfusion therapy provided by KMET in 13 affiliated hospitals of Kanazawa University Hospital. The pre-treatment NIHSS scores ranged from 5 to 39 (mean: 19.5). ASPECTS+W ranged from 0 to 11 (mean: 7.1). Successful revascularization, defined as thrombolysis in cerebral infarction (TICI) 2b or 3, was achieved in 79/100 cases (79%), and a good outcome, defined as modified Rankin Scale (mRS) score from 0 to 2 at 90 days after the treatment, was achieved in 51/100 cases (51%). There were 4 cases of intracranial bleeding (4%). Mean time from onset to recanalization was 284 min. These results, which are similar to those of five previous RCTs, suggest that a collaborative network between affiliated hospitals and KMET is effective for acute reperfusion therapy in local areas wherein experienced neuroendovascular specialists are insufficient.

S3-1

Wrap-clipping for Ruptured Blood Blister-like Aneurysms

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[Object] Wrap-clipping is one of the recommended treatments for ruptured blood blister-like aneurysms (BBAs) of the internal carotid artery (ICA), and has a big advantage in preserving the anterograde blood flow of the ICA. However, clinical and angiographic long-term evaluation of this simple procedure has not been elucidated. In this study, we evaluated the long-term efficacy of wrap-clipping using polytetrafluoroethylene (PTFE) membrane, an ideal wrapping material, for ruptured BBAs.

[Methods] We analyzed the clinical and radiological data of 9 patients with ruptured BBAs treated at our institutes between 2007 and 2016. Wrap-clipping using PTFE membrane was performed under modern monitoring techniques including fluorescence video angiography, intraoperative digital subtraction angiography (DSA) and neuroendoscope. Postoperative DSA was routinely carried out during hospitalization, and angiographic follow-up was executed by three-dimensional computed tomography angiography (3DCTA) or DSA to detect possible regrowth of the aneurysm or patency of the ICA. Clinical outcomes were assessed by the modified Rankin scale (mRS).

[Results] All BBAs located at the anterolateral to medial wall of the supraclinoid ICA. Wrap-clipping with PTFE membrane was performed without any permanent morbidity in all patients. Neuroendoscope was useful to observe the position of the medial blade of the clip and the surrounding perforators in the dead angle of the microscope. The effectiveness of fluorescence video angiography for the visualization of the blood flow of the ICA and the surrounding arteries was reinforced by intraoperative DSA, which revealed the blood flow in the wrapped lesion. The mRS was 0 in all patients at the time of the final clinical follow-up evaluation. There were neither reruptures nor ischemic complications in the mean clinical follow-up period of 58 months. Regrowth of the BBAs or progression of ICA stenosis was not observed in the mean angiographic follow-up period of 36 months.

[Conclusions] Wrap-clipping using PTFE membrane for ruptured BBAs is a useful and acceptable procedure promising long-term effectiveness. The durability of this method can be strengthened by the aid of modern technologies.

S3-2

Surgical strategy using high flow bypass for ruptured blister-like internal carotid artery aneurysm

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Aneurysms at non-branching sites in the distal internal carotid artery (ICA) can be classified as blood blister-like aneurysms (BBAs). The etiology of most cases is considered as dissection. In those cases, direct neck clipping is difficult because of ill-defined neck and fragile wall, and have substantial risk of periprocedural bleeding in the acute stage treatment. Also we cannot estimate whether direct neck clipping is possible or not from radiological examination. Although the optimal surgical procedure for ruptured BBAs in acute period remains controversial, we recommend the high flow bypass establishment before approaching aneurysms in every cases. Our strategy can completely avoid the risk of devastating intraoperative hemorrhage, also can achieve complete occlusion of the aneurysm safely by trapping. Furthermore, construction of high flow bypass might be reduce the ischemic complications due to vasospasm. We show the technical tips of our strategy by video presentation.

S3-3

Endovascular treatment for ruptured blister-like aneurysm

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【Introduction】 The blood blister-like aneurysms (BBAs) at the supraclinoid internal carotid artery (ICA) is usually small size, with wide neck and fragile wall. Therefore the treatment of the ruptured BBA at supraclinoid ICA has the high morbidity and mortality rate. We report a case of ruptured BBA with treated stent-assisted coil embolization by semi-jailing technique.

【Case】 A 41-year-old man presented with sudden onset headache and vomiting. CT showed subarachnoid hemorrhage and digital subtraction angiography (DSA) showed BBAs at right ICA, located distal to the posterior communicating artery and involved anterior choroidal artery. Initially, the patient kept under deep sedation for the stable blood pressure, since surgical invasion has high risk during acute phase. But aneurysm obviously enlarged on DSA after 6 days. Consequently, we determined to treat BBAs with stent-assisted coil embolization using semi-jailing technique.

【EVT】 The procedure was performed by general anesthesia, after Clopidogrel 300mg and aspirin 100mg were induced through the gastric tube. The initial microcatheter was navigated to distal the aneurysm, and then the second microcatheter was introduced into the aneurysm. After Enterprise VRD 4.5 × 22mm were partially deployed to narrow the aneurysmal neck through the first microcatheter, framing coil was placed in the aneurysms through the first microcatheter and the stent was fully deployed. Final control angiogram conformed occlusion of aneurysm. The procedure was completed finished without complication. The patient's postoperative course was favorable, and he was discharged to his home 28 days after symptom onset. However the patient had recurrence of aneurysm after three month and was in need of the additional coil embolization.

【Discussion】 Semi-jailing technique in the stent assisted coiling enables unrestricted movement of microcatheter and affects less to aneurysmal wall during the procedure. Because the wall of ruptured BBAs at supraclinoid ICA is usually thin and fragile, this technique is efficient to avoid the perforation during the procedure. Stent assisted coiling for BBAs during acute phase leaves concerns for recurrence of aneurysm and needs careful follow up examination, however, semi-jailing technique is still effective treatment option for ruptured BBA in acute phase.

S4-1

Tips, bases, and pitfalls in current AVM surgery in hybrid OR: operative nuances

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BACKGROUND AND AIMS: Management strategies of cerebral arteriovenous malformation (AVM) have undergone considerable evolution with the advent of surgical, endovascular, and radiosurgical technologies. This presentation will assess our current strategy for those complex lesions and illustrates recent futuristic technologies and techniques aiming to improve outcomes in AVM surgeries.

METHODS&RESULTS: At surgery, embolized AVMs were easily dissected from adjacent brain with minimal bleeding. Intraoperative selective 3D-angiography (and subsequent intraoperative embolization in selected cases) was very helpful for understanding of the microstructure of the complex lesions, and preserving passing normal vessels. In some patients, subclinical minor bleeding and/or necrotic tissue were noted within/around the nidus.

CONCLUSIONS: The hybrid suite is useful setup which allowed for unconstrained combined microsurgical and neuroradiological workflow. Significance of patient selection, preoperative and intraoperative endovascular treatment (hybrid surgery) will be discussed.

S4-2

Surgical treatment of Brain AVMs in the post ARUBA era

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After the result of ARUBA trial (A Randomized Trial of Unruptured Brain Arteriovenous Malformations) was published, surgical treatment of brain arteriovenous malformation (AVM) faces the new era. Here, the result of ARUBA trial is summarized and the criticisms against this study are reviewed. In this era, low mortality in the safe surgical treatment is important and necessary. The surgical skills for safe removal of AVM in our department are summarized. We emphasize the importance of intraoperative assessment of blood flow in the nidus of AVMs. We show the results of surgical treatment against AVMs in our institute, especially in unruptured and Spetzler and Martin Grade I-II cases. Since Jan. 2008 to Jun. 2017, total 95 cases of the patients with brain AVMs were admitted to our institute. Among them, 34 cases were surgically treated. Forty-five cases were Spetzler and Martin grade I-II cases. Twenty-five cases were non-hemorrhagic and 20 cases were hemorrhagic cases. Surgical morbidity in this series was 2.4%. Finally, current and future status of the surgery against AVM are discussed.

S4-3

Long-term outcomes of gamma knife radiosurgery for cerebral arteriovenous malformations with more than 10-year follow-up

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Gamma knife radiosurgery (GKRS) is one of the established therapeutic modalities for cerebral arteriovenous malformations (AVMs). Its efficacy and safety in short to middle period are well-understood. However, its long-term outcomes are not fully understood; as clinical experiences have advanced, recurrence, radiation-induced tumorigenesis, and late adverse events (cyst formation or encapsulated hematoma) have been revealed. In this report, we conducted a large retrospective study by reviewing our treatment data on consecutive patients who had AVMs and were treated with GKRS between 1990 and 2007.

A total of 598 patients were included in the study. The mean clinical follow-up period was 128 months (range, 1–320 months) and 280 patients (47%) were followed for ≥ 10 years. The median maximal diameter, volume, and prescribed margin dose were 21 mm, 2.3 ml, and 20 Gy, respectively. Intracranial hemorrhage was confirmed before GKRS in 362 patients (61%). Spetzler-Martin grade was I-II, III, IV-V, and VI in 320 (53%), 213 (36%), 40 (7%), and 25 (4%) patients, respectively.

Nidus obliteration after initial treatment was confirmed in 393 patients (66%) at a median of 26 months from the treatment; actuarial obliteration rates were 55%, 73%, and 79% at 3, 4, and 5 years, respectively. Post-GKRS hemorrhage rate was 1.2%/year and 0.4%/year before and after 5-year from GKRS, respectively, both of which were lower than the pre-GKRS hemorrhage rate (3.0%/year). Radiation-induced tumorigenesis, nidus recurrence, and late adverse events were confirmed in 1 (0.17%), 3 (0.5%), and 39 (6.5%) patients at 283, 25–241 (median, 163), and 13–312 (median, 140) months, respectively. Disease-specific mortality rates were 1.5%, 1.7%, and 2.2% at 5, 10, and 15 years, respectively.

Overall, GKRS could provide favorable long-term outcomes over ≥ 10 years with acceptably-low rates of late complications. Radiation-induced tumorigenesis and nidus recurrence, albeit extremely rare, could occur, and thus long-term follow-up would be important even after 10–20 years from the treatment.

S4-4

Role of Embolization for the treatment of Brain Arteriovenous Malformations

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Advancements in endovascular therapy have greatly expanded the treatment options for patients harboring brain AVMs. However, the complete obliteration rate of brain AVMs treated with endovascular therapy alone is still low with the relatively high rate of adverse events. On the other hand, adjunctive embolization prior to either surgery or radiosurgery may make the treatment safer and more feasible. For this purpose, the embolization must be done as safely as possible to ensure that the cumulative risks associated with embolization plus surgery or radiosurgery do not exceed the risk of treating the same AVM without embolization.

Thirty-two patients with brain AVMs were treated with endovascular embolization using NBCA, ONIX, and/or platinum coils in our institution from January 2014 to May 2017. Presurgical embolization was performed in 28 patients for the purpose of eliminating arterial feeders that were difficult to access surgically and/or gradual flow reduction to prevent devastating postprocedure hemorrhages. Seventeen patients were treated with embolization and surgery on the same day in the hybrid operation room. Preradiosurgical embolization was performed in three patients to eliminate intranidal aneurysms and the high-flow components. One patient was cured by embolization alone. Two symptomatic adverse events occurred; brain infarction with transient symptom and hemorrhage that was immediately treated in the hybrid operation room surgically.

As there is no established treatment algorithm, treatment strategy is determined for individual AVMs at the multidisciplinary conference in our institution. Adjunctive embolization is safe and effective for the treatment of selected patients with brain AVMs.

S5-1

Combined treatment of cerebral AVM----experience of Huashan Hospital

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TBA

S5-2

Therapeutic strategy and results of microsurgery for unruptured arteriovenous malformations (AVMs) in multimodal treatment / ARUBA aftermath era.

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Introduction: Current management strategies of cerebral arteriovenous malformations (AVMs) have undergone considerable evolution with the advent of surgical, endovascular, and radiosurgical technologies. However, controversy exists in the indication of invasive treatment, especially for unruptured lesions taking the results of a randomized trial of unruptured brain arteriovenous malformation (ARUBA) study.

Methods: Medical records of consecutive 66 patients who underwent microsurgical resection for unruptured AVMs were retrospectively reviewed. AVM characteristics closely matched to ARUBA trial (SMG-I/II;34, III;22, IV;10). Conversely, compared to ARUBA, much larger proportion of our patients suffered with seizures or progressive neurological deficit. Pre/intraoperative transarterial embolization was used in 46 patients.

Results: All surgeries were performed in the hybrid operation room (BRAIN OR), with assistance with intraoperative electrophysiological monitoring, ICG videoangiography, ultrasound, and catheter 3D-angiography. All AVMs were totally removed, and 65 patients (98.1%) had mRS score of 0-2 at 6 months follow-up.

Conclusions: Owing to recent futuristic technologies and techniques, clinical results of AVM surgery have been improved. Future grading scale should incorporate current innovation of imaging studies, pre/intraoperative management.

S5-3

Endovascular Management of Ruptured Brain Arteriovenous Malformations

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Objective: Modern treatment of ruptured brain arteriovenous malformations (BAVMs) is a multimodality endeavor, requiring a multidisciplinary approach including surgical resection, endovascular treatment, and radiosurgery. Endovascular treatment has become a major component of BAVMs management, either as a stand-alone curative method or more commonly as an adjunct to microsurgery or radiosurgery. The aim of this study was to report our experience with the treatment of ruptured BAVMs with endovascular treatment.

Methods: A retrospective series study was conducted at Soonchunhyang university hospitals between Jan 2011 and Aug 2017. Total 57 patients that underwent endovascular treatment were enrolled. Among them, we exclude 11 patients that performed endovascular treatment for unruptured BAVMs. 5 patients excluded by not reporting outcomes. 2 patients also excluded by previous endovascular treatment by outside hospital. Finally, 39 patients of rupture BAVMs enrolled to analysis with technical conditions, complications, clinical outcome (mRs) and angiographic results.

Results: In 39 patients, 44 embolization procedures were performed with 58 feeding arteries embolized, ranging from 1 to 4 per patient. Mean age were 34 years ranged 3-76 years. The estimated Spetzler-Martin grade was in the range of 1 to 4, average of 3. The incidence of symptoms was as following headache, hemiparesis, mental deterioration, amnesia, disturbed vision and language. Endovascular treatment was performed with curative intent with favorable angio-architecture in 13 patients with mean mRS score 2. Endovascular treatment as an adjunct to other modalities was performed in 26 patients. Preoperative embolization to render surgery technically simpler and possibly with less morbidity was performed in 16 patients with mean mRS score 1. Embolization to reduce the BAVMs size to make it more conducive to cure with radiosurgery performed in 10 patients with mean mRS score 1. Overall eighteen patients were recovered without neurologic deficits, but the other patients had a temporary or permanent deficits. There was one death. Angiographic assessment of the efficacy of the procedure was performed 1-120 months (mean 23months) after the procedure. Total BAVM obliteration was obtained in 29 patients (74.4%). Partial obliterations were observed with surgical (1 patient) and radiosurgical procedures (5 patients) on follow up.

Conclusion: Endovascular management with the careful selection of multimodality provides acceptable morbidity, mortality and good efficacy for ruptured BAVMs.

S5-4

Surgical and endovascular management for brain AVM

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Management of arteriovenous malformations (AVMs) in the brain cannot be generalized because of the wide variations in the location, size, and angioarchitecture of these lesions. The Spetzler-Martin grading scale is a simple and practical tool used to predict the risks associated with surgical resection of a brain AVM. Grade I, II, and III lesions were found to have low treatment-associated morbidity. However, grade IV and V lesions are at high-risk of treatment-associated morbidity. These facts are reflected in the treatment guidelines, which recommend surgery for grade I and II lesions. Grade III lesions should be treated on a case-by-case basis, while grade IV and V lesions require a multidisciplinary approach with individual analysis. Multimodality treatment is essential for the management of particularly high-grade brain AVMs. Preoperative embolization is a useful option to reduce surgical risks associated with use of neuroendovascular techniques and devices developed in recent years. We usually perform presurgical embolization even in patients with low-grade AVMs. In this paper, we describe our multimodal treatment strategy and treatment results for brain AVMs.

S6-1

“Non-moyamoya” intracranial arteriopathy in Japanese children

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Objective

Moyamoya disease accounts for approximately 80% of the pediatric arterial ischemic stroke (AIS) in Japan. However, there are cases of intracranial arteriopathy which do not fulfill the diagnostic criteria of moyamoya disease. Here the author presents the clinical characteristics of the “non-moyamoya” pediatric arteriopathy in Japan through the results of the multicenter survey.

Methods

Sixteen pediatric cases (<18y) of symptomatic “non-moyamoya” AIS were retrospectively detected in five neurosurgical institutes and their affiliate hospitals (1998-2011, mean age: 10.0 ± 4.7 y, male : female=3 : 2). Clinical features were cerebral infarctions in 40, TIAs in 7, intracranial hemorrhage with arterial stenosis in 3, and others in 10. The patients’ clinical courses and prognoses were analyzed (mean follow-up period: 4.7y).

Results

The ICAs and MCAs were involved in 50% and 65% of the cases, respectively. In 94% of the patients, the lesion was unilateral. Basal ganglia infarction was the most frequent clinical feature (73%). Prominent “moyamoya collateral vessels” were shown in none of the cases. Spontaneous remission of the stenosis was frequently observed (34%), and the angiographic deterioration was relatively uncommon (18%). Nonsurgical (conservative) treatment was selected in 83% of the cases, and the recurrent stroke was extremely rare (1.7%). The final mRS was 0 in 50%, 1-2 in 32%, 3-5: 7%, and unknown in 12%.

Conclusion

Some of the non-moyamoya AIS in Japanese children seem to correspond to the TGA (transient cerebral arteriopathy) or FTA (idiopathic focal cerebral arteriopathy), both of which have been advocated in US/Europe recently. Unlike moyamoya disease, their clinical courses are not progressive (i.e. self-limited). Although permanent neurological deficits are not uncommon, the prognoses are usually determined by the initial ischemic events. Because bypass surgery is not the adequate strategy in many of these cases, the differential diagnosis from moyamoya disease is crucial especially in Japan or East Asia.

S6-2

Endovascular therapy of pediatric intracranial arteriovenous shunts

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Intracranial arteriovenous shunts (ICAVS) in young children are characterized by frequent high-flow fistulas. In association with high-flow fistulas and the physiological condition of the developing brain and heart, each ICAVS type tends to present at a certain age with unique symptoms. Vein of Galen aneurysmal malformation (VGAM) and dural sinus malformation with arteriovenous (AV) shunt tend to present in the neonate with high output cardiac failure. Neonates are vulnerable to develop high output cardiac failure in the presence of high flow AVF because of drastic hemodynamic changes at birth and low cardiac reserve. In infancy, VGAM, pial arteriovenous fistula (AVF) and infantile dural AVF (DAVF) tend to present with hydrodynamic disorder such as macrocephaly, ventriculomegaly, prominent facial veins, and developmental delay. In neonates and infants, cerebrospinal fluid (CSF) is absorbed mainly through the medullary veins. Also, venous drainage of the brain converges to the torcula because of underdeveloped cavernous sinus at this age. Hydrodynamic disorder is caused by CSF malabsorption due to venous hypertension in the existence of high flow AVF. Pial AVF, AV malformation, and infantile DAVF can present with focal neurological signs such as seizure or hemorrhage at older ages. Endovascular treatment is currently the first choice of treatment for most pediatric ICAVS. Endovascular embolization for high flow ICAVS is best performed by transarterial embolization using NBCA under systemic hypotension or in combination with coils. Onyx may be used for multiple fistulas such as DSM or pial AVM. Complex lesions often require multistage treatment because of the limit in use of contrast materials. Although ultimate goal is complete cure, imminent treatment goal should be set according to the age of the patient. For neonates, recovery from heart failure should be the goal and if the patient can tolerate oral feeding with gaining weight, treatment should be delayed until 5 months of age if possible. For infants, normal development of the child avoiding shunt operation is the goal of treatment. For older children, cure should be aimed by the treatment. Experienced endovascular team with close collaboration with pediatricians is essential to obtain the best possible treatment results.

S6-3

Revascularization surgery for infant moyamoya disease

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Some reports have stated that ischemic symptoms in infant patients of moyamoya disease tend to be progressive rapidly. The direct bypass should play a leading role to prevent progressing ischemic stroke, however there have been few reports of direct bypass for infant patients of moyamoya disease. We describe the effectiveness and limits of superficial temporal artery (STA) - middle temporal artery (MCA) bypass for infant patients of moyamoya disease. Twenty-five patients, 45 sides with infant moyamoya disease continuously underwent STA-MCA bypass between January 2002 and December 2016. The patients were 8 males and 16 females ranging in age from 1 to 5 years (mean 3.3 years). Almost all cases were performed STA-MCA double bypasses with indirect revascularization. Perioperative complication rate was 4%. All were ischemic strokes with transient symptoms. Repeated infarction was occurred before operation in 40% cases presented infarction. Angiographical findings 6 months after operation showed blood supply in the whole MCA territory from the direct bypass and/or indirect revascularization in almost all patients. There were some hemispheres with good blood supply mainly from the direct bypass with poor blood supply from indirect revascularization, and vice versa. Preoperative progressive ischemic symptoms were well controlled immediately after operation. The incidence of postoperative symptomatic ipsilateral stroke and asymptomatic stroke in long-term follow-up (mean follow-up periods 3.5 years) were 11% and 11%, respectively. Postoperative stroke tended to present in cases with progression of the posterior cerebral artery stenosis. It can be said that direct bypass is effective immediately after operation to prevent progressive ischemia in cases of infant moyamoya disease. However, there have been still some uncontrollable cases. Preventing ischemic stroke as a perioperative complication should be mainly taken care. We could not estimate before operation which revascularization, direct or indirect played a central role in development of collateral blood supply in mid-to long-term in cases of infant moyamoya disease.

S6-4

The perfusion changes after bypass surgery in moyamoya disease.

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TBA

S7-1

Surgical management of pediatric moyamoya disease: microsurgical techniques and perioperative management

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The direct bypass should play a leading role to prevent progressing ischemic stroke for cases of pediatric moyamoya disease who tend to be progressive rapidly. However microsurgical technique of direct bypass for the cases is challenging and perioperative management is still remain controversial. We describe tips and pitfalls of surgical techniques of direct bypass and perioperative management for cases of pediatric moyamoya disease. Seventy-four patients, 131 operations with pediatric moyamoya disease continuously underwent revascularization between January 2002 and August 2017. The patients were 25 males and 49 females ranging in age from 1 to 15 years (mean 7.3 years). Almost all cases were performed superficial temporal artery - middle temporal artery double bypass. Direct bypass could reach to success and be confirmed patency of the graft intraoperatively in 129 of 131 operations. Postoperative complications, morbidity, and mortality were 6.9 % (6 infarctions, 2 epidural hematomas, 1 small thalamic hemorrhage), 0.8 %, and 0 %, respectively. To make successful bypass in condition of small fragile vessel, surgical tips and pitfalls are as follows, 1) loose stitches with wide interstitch intervals to facilitate expansion and ensure good patency of the orifice. 2) devices to help good visible of the orifice and to prevent tearing the fragile vessel wall of recipient artery, 3) careful dissection of the graft and keeping natural graft course. The main points of perioperative management are as below. The patients are instructed to take 1-3 mg/kg of acetylsalicylic acid (ASA) daily for at least one week prior to surgery, and to stop it on the day of the surgical procedure. During surgery, no intravenous boluses of heparin were administered, and the ASA was restarted 5 days postoperatively. Extubation is performed a few hours after operation. Intensive blood pressure monitoring is required to keep systolic blood pressure between 90-130 mmHg during 7 days after operation. It also should be paid attention for avoiding dehydration and anemia to prevent ischemic complication especially in infant cases.

S7-2

Long-term outcomes after combined revascularization surgery in adult moyamoya disease

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There have been few reports on the long-term surgical outcomes of adult moyamoya disease. We evaluate the long-term outcomes of combined revascularization surgery in adult moyamoya disease. This study included 132 cerebral hemispheres of 110 adult patients who underwent combined revascularization surgery with more than 5-year follow up period. We quantitatively evaluated the clinical, angiographic and hemodynamic outcomes in the short-term (within 6 months) and long-term (up to 5 years) periods after surgery. The mean follow-up period was 67.2 ± 11.2 months (range, 26-104 months).

There showed statistically significant improvement in clinical status up to 6 months after surgery and remained stable during follow-up, as assessed by the Karnofsky Performance Scale and modified Rankin Scale. The revascularization area in the supratentorial space showed a significant increase in the long-term period, compared to the short-term period (56.8% versus 46.2%; $p < 0.001$). Cerebral blood flow in the territory of middle cerebral artery improved immediately in the short-term period compared with that in the preoperative period (74.1% versus 67.8%; $p < 0.001$) and remained constant throughout the follow-up time (72.1% in the long-term; $p = 0.162$). The 5-year event free survival rate was 96.2%. In detail, 5-year hemorrhage free survival rate, and infarction free survival rate were 98.5%, and 97.7% respectively in the operated hemispheres.

Combined revascularization surgery improved clinical, angiographic and hemodynamic states during long-term follow-up. In addition, it also resulted in prevention of recurrent stroke.

S7-3

Efficacy of direct/indirect combined revascularization surgery for adult moyamoya disease: Significance of perioperative management based on hemodynamic study

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Moyamoya disease (MMD) is a unique cerebrovascular disease with unknown etiology characterized by progressive stenosis of the terminal portion of the internal carotid artery and abnormal vascular network formation at the base of the brain. Surgical revascularization not only prevents cerebral ischemic attack by improving cerebral blood flow, but also reduces the risk of re-bleeding in patients with intracerebral hemorrhage at posterior circulation territory. Regarding surgical procedure, recent study indicates the superiority of direct/indirect combined revascularization surgery such as superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis with indirect pial synangiosis for adult MMD. Despite its long-term favorable outcome, local cerebral hyperperfusion and cerebral infarction caused are potential complications of this procedure. Focal cerebral hyperperfusion could result in neurologic deterioration and/or delayed intracerebral hemorrhage, while paradoxical hypoperfusion could simultaneously occur at the cerebral cortex adjacent to the area of hyperperfusion, by the intrinsic mechanism of 'watershed shift phenomenon' in adult patients with MMD. To counteract this complex pathology during the acute stage after revascularization surgery, routine hemodynamic study and intensive perioperative management such as strict blood pressure control and administration of neuroprotective agents (edaravone, minocycline hydrochloride etc.) are essential to provide favorable outcome.

S8-1

Intraoperative computed tomography (iCT) for neurosurgery

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Intraoperative computed tomography (iCT) has gained increasing impact among modern neurosurgical techniques. We report our experience concerning feasibility, workflow and image quality using a multislice iCT (SIEMENS SOMATOM Definition AS Sliding Gantry) combined with CT compatible neuronavigation system (Stealth Air, Medtronic StealthStation) for neurosurgery.

Our short term experience confirms the feasibility of iCT for neurosurgical patients with various kinds of intracranial pathologies. It increases the safety for the patient and the surgeon. Imaging and updating of the navigation system can be performed at any time during surgery.

In the purpose to observe pathologic condition of the brain parenchyma, an image quality is inferior to MRI. However, CT has few necessary exclusive surgical instruments and the surgical procedure interruption is quite short. Therefore, we can perform a scan repeatedly easily. Because of few errors regardless of patient position, the auto-registration with neuronavigation system seemed to be in particular extremely useful.

S8-2

Continuous blood glucose monitoring may detect carotid occlusion intolerance during carotid artery stenting

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Objective: The frequency of the occurrence of adverse events associated with carotid artery stenting (CAS) is usually low, but serious adverse events such as cerebral hyperperfusion syndrome (CHS) may occur. Real-time monitoring is ideal for the early detection of adverse events during the surgical procedure. This study aimed to evaluate continuous blood glucose (BG) monitoring for the detection of adverse events during CAS.

Methods: Forty patients undergoing scheduled CAS were prospectively enrolled. An artificial pancreas was used for continuous BG monitoring (once per minute) using venous blood extracted at a rate of 2 ml/h during CAS. The primary endpoint was a correlation between BG change and adverse events.

Results: CAS was discontinued in one patient, and BG was not measured in 5 patients (12.5%) because of inability to extract blood. Among 34 patients, there was no patient having CHS, but 3 patients (9%) experienced carotid occlusion intolerance. During CAS, BG was significantly elevated in patients with carotid occlusion intolerance (median: 5 mg/dL) compared with patients without carotid occlusion intolerance (median: 0 mg/dL) ($P = 0.0221$). A cut-off value of $BG \geq 4$ mg/dL during CAS showed 100% sensitivity and 90% specificity for the detection of carotid occlusion intolerance. There was no significant correlation between BG change and other adverse events.

Conclusions: BG elevation ≥ 4 mg/dL during CAS may predict carotid occlusion intolerance. Further studies could elucidate whether continuous BG monitoring is able to detect adverse events using this cut-off value in further studies.

S8-3

Developing Technique for Peri-operative Assistance with Three-dimensional Virtual and Augmented Reality Images for cerebrovascular Surgery.

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Augmented reality (AR) is a combination technique of virtual reality (VR) and real-time interaction to real-world. Recently, AR-based surgical navigation is a promising technology for clinical applications in neurosurgery. It provides surgeons with direct perceptions the relation of normal anatomical structures and lesions, and assists them in pre- and intra-operative plans. However, commercial available VR and AR based navigation systems need high cost and provide only 2-dimensional images correlated to these structures.

Here, we will present and discuss the efficacy of our 3-dimensional (3-D)-AR and VR technique for peri-operative assistance in cerebrovascular surgeries.

For reconstruction of 3-D AR images, the preoperative DICOM (Digital Imaging and Communications in Medicine) formatted data of CT angiography (CTA), 3-D rotated angiography were used. These neuroimaging data were converted to STL (Standard Template Library) format which is generally compatible with AR devices. The data of 3-D images were converted again to FBX (Flimbox) data format by Blender™ software (Blender Foundation), following with loading into Unity® (Unity Technologies) for developing the AR application. The application was distributed to novel holographic computer device, HoloLens® (HL) (Microsoft Inc.), which is see-through head mounted display. The created 3D-virtual images were projected to the head model and observed through HL from arbitrary angles and magnification. The video-recorded operative findings were compared with the holographic AR images through HL retrospectively.

The 3-D AR images followed with the observed angle and magnification around the model. Additionally, the developed 3-D AR images in HL were well correlated to the real operative field. Our developed AR application have potential to use for not only preoperative assessments and intraoperative real time 3-D navigation for cerebrovascular surgeries, but also educational purpose for novice surgeons.

S9-1

Key hole approach for non-ruptured Acom aneurysms.

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The surgery for non-ruptured aneurysms needs less invasive techniques for the purpose of early come back to normal life of patients. We perform over 100 unruptured aneurysm surgeries in a year. We often use key hole techniques for Acom aneurysms.

We select approach from shape of Acom complex and aneurysm direction. For anterior and inferior dome projection type we use the supra orbital approach. In case Acom complex located high position or upper and posterior dome projection we use key hole unilateral interhemispheric approach. We introduce these two approaches with operative videos and examine about the operative techniques for key hole Acom aneurysm surgery.

For the key hole aneurysm surgery, microsurgical techniques to make enough operative fields around the aneurysm from small entrance are very important. Operative instruments are also important. We often use thin blade slightly curved micro scissors and small head angled clip applier, especially upper 10 degree type. In case of interhemispheric approach we use navigation system to locate craniotomy for good access entrance and preserving bridging vein.

Good operative results and high satisfaction of the patient were obtained by this operation method. The early come back to normal life is required with increasing patients from the brain checking center. We considered our less invasive operative method for unruptured aneurysms was very useful in such cases.

S9-2

Minimally invasive cerebrovascular surgery using superciliary keyhole approaches

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Neurosurgeons have been trying to reduce surgical invasiveness by applying minimally invasive keyhole approaches. A superciliary keyhole approach using a supraorbital mini-craniotomy, rather than a conventional pterional approach, provides many advantages, but is invariably limited due to the small cranial opening. Successful keyhole surgery requires an understanding of the limitations and the use of proper surgical techniques. Essentially, this means the effective selection of surgical indications, usage of the appropriate surgical instruments, and refined surgical techniques including straightforward access to the lesion and clean surgical dissection.

A 12-year experience with a superciliary keyhole approach for cerebrovascular diseases included unruptured intracranial aneurysms (n = 505), ruptured aneurysms (n = 32), and acute ischemic stroke involving intracranial internal carotid artery and middle cerebral artery (n = 10). For the patients with aneurysms (n = 537), there was no direct mortality from the surgery and only 3 patients (0.56%) developed significant morbidity adversely affecting the Glasgow Outcome Scale (GOS) score. Their GOS score was 2 in the 3 patients. Meanwhile, 10 patients underwent surgical embolectomy as rescue treatment following failed endovascular recanalization for acute ischemic stroke. A minimally invasive and rapid surgical embolectomy was applied and successful for recanalization.

Proper surgical indications for a superciliary keyhole approach are shown in this presentation. In addition, specialized surgical techniques for a keyhole surgery, including a clip-knotting technique for intracranial arterial suturing through deep and narrow surgical corridors, anchor screw technique for dural tenting sutures, and usage of a porous high density polyethylene implant for filling cranial gaps and burrholes.

S9-3

Validation of effectiveness of keyhole clipping in elderly patients with unruptured intracranial aneurysms: Lessons from 260 cases

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OBJECT Advanced age is known to indicate poor prognosis after surgical clipping of unruptured intracranial aneurysms (UIAs). This study compared the complications, and clinical and radiological outcomes after keyhole clipping between non-frail elderly patients (≥ 70 years) and non-elderly patients.

METHODS Keyhole clipping (either supraorbital or pterional) was performed to treat 260 cases of relatively small (≤ 10 mm) and anterior circulation UIAs, including 62 cases in the non-frail elderly group (72.9 ± 2.6 years) and 198 cases in the non-elderly group (59.5 ± 7.6 years). The study evaluated mortality and morbidity at 3 months and 1 year after the operation, the general cognitive function by MMSE at 3 months and 1 year, the anxiety and depressive mood by BDI and HAM-D at 3 months, and radiological abnormalities and recurrence at 1 year.

RESULTS Rates of other complications including stroke and epilepsy were not significantly different. Lacunar infarct occurred in 3.2% of the elderly group and 3.0% of the non-elderly group. No patient in the elderly group required retreatment or showed recurrence of clipped aneurysms. The MMSE at 3 months significantly improved in the non-elderly group but did not change in the elderly group. The BDI and HAM-D at 3 months were significantly improved in both groups. No patient died in either group. The morbidities at 3 months and 1 year in the elderly group (1.6%, 4.8%) were not significantly different from those in the non-elderly group (2.0%, 1.5%).

CONCLUSIONS Keyhole clipping to treat UIAs in the non-frail elderly is an effective and long-lasting treatment.

S9-4

Purely endoscopic port approach for clipping of anterior circulation aneurysms

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TBA

S9-5

Keyhole Approaches to Aneurysms

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Aneurysm surgery evolved dramatically after the introduction of the operating microscope. Approaches to specific aneurysms were established, with the pterional craniotomy (Pt) for most aneurysms around the circle of Willis, the orbitozygomatic-Pt for aneurysms at the basilar apex, the bifrontal craniotomy for anterior cerebral artery aneurysms, and the far lateral craniotomy for posterior inferior cerebellar artery (PICA) aneurysms. Perhaps the most significant advance in open aneurysm surgery is the embrace of minimalism. The mini pterional (MPt) craniotomy eliminates these areas from the craniotomy and hones in on the central surgical corridor. The craniotomy extends to the temporal side of the sphenoid ridge to expose the sylvian fissure and to the medial side of the superior temporal line to expose the pterion and orbital roof, shrinking the diameter of the flap to about 3 cm. The MPt approach is ideal for simple aneurysms that require a full sylvian fissure split: middle cerebral artery, internal carotid artery bifurcation, and ophthalmic artery aneurysms. The lateral supraorbital craniotomy differs from the MPt craniotomy in its lateral extent, stopping at the pterion/lateral sphenoid ridge rather than crossing to the temporal side. Consequently, only the frontal lobe is exposed, and the sylvian fissure lies at the edge of the exposure. The craniotomy measures <3 cm in diameter and is best suited to internal carotid artery aneurysms (posterior communicating artery and anterior choroidal artery) and simple anterior cerebral artery aneurysms (A1, anterior cerebral artery, and anterior communicating artery).

S10-1

Computational Fluid Dynamics for Assisting Neurosurgery: Basic Principles

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Computational Fluid Dynamics (CFD) is an engineering technique of simulating fluid flows, such as air and water, using computers. This day, the level of establishment of CFD in engineering worlds, such as automobiles and airplanes, has been fully practical and its routine use becomes indispensable for their design optimization. Simulating blood flow by CFD for assisting diagnostics and treatments of vascular diseases gather attention over the last decade. In a community of neurosurgery, cerebral aneurysms and carotid plaques are targets of interest. This presentation is intent to provide a basic knowledge of CFD for beginners. In the first place, CFD is overviewed on inputs and outputs. The inputs are (1) vascular geometry, (2) density and viscosity of blood, (3) boundary and (4) computational conditions, which are explained each by each. In order to ensure the quality of CFD, those inputs have to be standardized at a certain level where the outcome at least can be reproduced and sheared. Meanwhile, accompanying uncertainties should have been well managed. The outputs of CFD are an enormous amount of three-dimensional point-to-point pressure and velocity datasets, which are visually quantified by several characteristic value, such as wall pressure, wall shear stress and streamline. Until now, those quantities have been tested subject-by-subject on whether these have a capability of giving clinical significance, or flow marker. Typical applications of CFD are reviewed with a reference to potential pitfalls that need to be carefully assessed and tackled for enlarging the range of subjects.

S10-2

Clinical Application of Computational Fluid Dynamics in Cerebral Aneurysms

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During last 20 years, computational fluid dynamics (CFD) has been used for studying the basic mechanisms involved in the initiation and progression of vascular diseases. It has also been used for surgical and endovascular treatment planning. In neurosurgical field, the main target has been cerebral aneurysms. Most studies of CFD in cerebral aneurysms aimed to predict the rupture of the aneurysms; however, 'high-risk' aneurysms have not been determined yet. It is mainly because of the low incidence of rupture event (around 1% per year), thus it is difficult to confirm it prospectively.

To develop CFD as a useful tool for neurosurgery, we have tried to utilize CFD for surgical planning of cerebral aneurysms as follows. (1) Prediction of atherosclerosis of the aneurysm wall. Relative residence time was correlated with atherosclerosis of the aneurysm wall. It might be useful to avoid the risks for clipping. (2) Prediction of the recurrence after coil embolization. Aneurysm inflow rate coefficient was significantly correlated with the recurrence of basilar bifurcation aneurysms. It was useful to predict high-risk aneurysms for coiling. (3) Simulation of flow alteration for difficult aneurysms. Based on virtual occlusion of the parent arteries, we successfully constructed the surgical plan.

We think CFD is useful not only for predicting aneurysm rupture, but also for surgical planning, and will be important with the development of technologies.

S10-3

Endovascular management of cerebral aneurysms based on Flow dynamics

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More and more physicians are becoming on the side of endovascular treatment in the management of cerebral aneurysms since the ISAT trial proved the efficacy of embolization over the direct clipping in ruptured aneurysms.

Originally, the coil embolization was supposed to occlude the aneurysm by eliciting electrothrombosis. However, it is known that the embolization occludes aneurysms by reducing the flow to form thrombus. Thus, to know the flow dynamics further open the possibility of the endovascular treatment of cerebral aneurysms.

For a complex ruptured aneurysm that is difficult to cure both for the direct surgery and the endovascular intervention, changing the goals of management might be useful for the patient. In the aneurysm cavity, the flow velocity is slow inherently. The flow velocity in the outpouching cavity, that is bleb or rupture point, is further slow. With this knowledge, we can have a confidence that even a partial coiling will thrombose the rupture point of the aneurysm. We don't have to cure the aneurysm at a time. If we could delay the rupture, the aneurysm could safely be treated with more effective way such as a flow diversion surgery or a flow diverting stent in the chronic phase.

If we could understand the flow dynamics of cerebral aneurysms, it is becoming possible to control the recurrence of cerebral aneurysms after coiling. Now, the evidences are accumulating that the recurrence or the recanalization after coiling occur because of the high flow or the high velocity at the aneurysm orifice. We can control the flow velocity at the aneurysm orifice by putting stents. By calculating the flow before coiling, we can know we should put a stent or not in a specific case. Such flow dynamic simulation is useful in reducing the medical costs and the thrombotic complication inevitably associated with stents.

Flow dynamic simulation of cerebral aneurysm is pragmatically useful in the endovascular management of cerebral aneurysms.

S10-4

Hemodynamic features for offending vessels at neurovascular contact in patients with trigeminal neuralgia and hemifacial spasms; Application of Hemoscope

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OBJECTIVE: Offending vessels at the neurovascular contact (NVC) in patients with trigeminal neuralgia and hemifacial spasms may have specific hemodynamic features. In this study, the authors investigated the wall shear stress (WSS) at the NVC using computational fluid dynamics (CFD) analysis. **METHODS:** Twenty patients with trigeminal neuralgia and hemifacial spasms were evaluated by MR angiography and CT angiography, and hemodynamic parameters were calculated by using Hemoscope. 3D CFD images were directly compared with the NVC determined by 3D multifusion images of MR cisternogram and CT angiogram, and actual operative photos. Wall shear stress (WSS) at the proximal, just beginning, site, and distal areas of the NVC was analyzed, respectively, for magnitude (WSSm) and vector (WSSv), and their cycle variation (WSSm-var, WSSv-var). Ratio of WSSm for each area was assessed statistically. Areas of WSSv and WSSv-var were morphologically compared with the actual NVC confirmed by multifusion images and operation. **RESULTS:** Ratio of WSSm at the just beginning to the proximal area of the NVC (WSSm-just/proximal ratio) was higher to the site (WSSm-site/proximal ratio) and the distal (WSSm-distal/proximal ratio) areas. WSSv-var showed small variation along the NVC area confronted to the nerve. **CONCLUSIONS:** Relatively high WSSm may occur at the NVC. Small variation of WSSv-var detected along the contact side may be in consistent with the actual region of the NVC. Hemodynamic features of the offending vessels at NVC may be useful for diagnosis and treatment of trigeminal neuralgia and hemifacial spasms.