Dural arteriovenous fistulas (AVFs) are a rare clinical entity, which accounts for 12% of intracranial arteriovenous malformations (AVM).

Dural AVFs are considered as an acquired lesion. The etiology, however, still remains unknown in most cases. Clinical symptoms of the patients relate to the increased venous pressure as the essential pathophysiology of this disease.

Dural AVFs sometimes behave aggressively depending on the pattern of venous drainage, resulting in the intracranial hemorrhage and venous hypertension. Because the pathology of dural AVF is based on the venous side, physicians have to know well about the functional venous anatomy and to understand the venous draining pattern.

There are several important points to understand the hemodynamic state and to treat the patients.

[Locations of the shunt - sinus lesion]
cavernous sinus, transverse sinus, superior sagittal sinus, anterior condylar confluence

[Locations of the shunt - nonsinus lesion]
anterior cranial base, tentorium, craniocervical junction, convexity, spinal cord

[Draining patterns of the dural AVF]
1) antegrade sinus drainage
2) retrograde sinus drainage
3) retrograde leptomeningeal venous drainage

[Drainage patterns of cerebral veins and venous collateral channels]
1) antegrade drainage
2) venous stasis
3) retrograde drainage
[Classifications]
1) Cognard’s classification
2) Borden’s classification

[Treatment]
1) transarterial NBCA embolization
2) transarterial Onyx embolization (most updated method)
3) transvenous coil embolization
4) combined treatment
5) Surgical treatment
6) Radiosurgical treatment

[Complications of treatment]
TAE: cranial nerve palsy, glue migration through the dangerous anastomosis
TVE: cranial nerve palsy, hemorrhage (venous hypertension)
The removal of the deep seated cavernous malformations (CMs) located at the diencephalon is regarded as difficult not because the surgery itself but the unpredictable response of the target organ manipulation. The unanimous principle of surgical removal of CMs at these locations is the minimal manipulation of the target organ as possible.

7 CMs located at the diencephalon were operated by various approaches with the "shortest trajectory" principles. All the CMs were exposed subpially. Two cases of thalamic CMs were removed by occipital transtentorial approach and contralateral transcallosal route was used in removing the 2 CMs at the basal ganglia. Among 3 CMs from hypothalamus, 2 cases were removed using anterior interhemispheric translaminaterinalis approach and, in another one case, the anterior transcallosal subchoroidal route was selected to encompass the significant horizontal extension digging into the parenchyma of the hypothalamus. The results of surgery for CMs at basal ganglia and thalamus were uneventful. But, somnolence, diabetes insipidus, electrolyte imbalance and hydrocephalus were complicated in the surgery for the hypothalamic CMs.

Surgical strategy for deep seated CMs locating at the diencephalon is relatively simple and the outcome is not that awful as generally regarded. The "shortest trajectory" principle with appropriate surgical approaches and working strictly within the hemosiderin capsule for the CMs extending subpially will result in good surgical outcome. However, problems of parenchymal manipulation of hypothalamus must be expected in the postoperative management of hypothalamic CMs.
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 Kyoto University and Tokushima University. Since Jan. 2008 to Aug. 2017, total 102 cases of the patients with brain AVMs were admitted to Kyoto University. Among them, 40 cases were surgically treated. Forty-eight cases were Spetzler and Martin grade I-II cases. Twenty-five cases were non-hemorrhagic and 23 cases were hemorrhagic cases. Surgical morbidity in this series was 2.1%. During same period, 34 AVMs were treated in Tokushima University. Finally, current and future status of the surgery against AVM are discussed.
SYⅦ-4

Therapeutic strategies of Spetzler-Martin Grade III AVMs

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The Spetzler-Martin (SM) grading system is clinically useful because it is a simple and practical classification system. However, SM Grade III AVMs consist of largely heterogeneous components that may critically affect the treatment outcomes. In that context of SM grade III AVMs, a delicate subclassification of SM III group seems mandatory, such as 4 combinations depending on nidus size, location in the eloquent cortex, and presence of deep seated venous drainage.

Microsurgery of SM Grade III AVMs is generally known to be associated with 8.0-16.0% morbidity. From our experience and others, it seemed that the compactness of the nidus and degree of eloquence were the most influential components to the surgical exirpation of the lesion in the group of SM III AVMs. Therefore, small-sized AVM with eloquent and deep venous drainage may be the best candidate for microsurgery.

For the remaining SM III AVMs, a multimodal approach including endovascular embolization and radiosurgery should not be underestimated. Nevertheless, the selection of safe and effective therapeutic strategies for SMG III AVMs appeared to need a sophisticated consideration of whole circumstances around the patients themselves, level of expertise in each treatment options, and the expected natural course of the target lesions.
Lessons learned from 200 surgical battles against cerebral AVMs

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BACKGROUND
Management strategies of cerebral arteriovenous malformation (AVM) 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.

PURPOSE
This presentation will assess our current strategy and results of those complex lesions and illustrates recent futuristic technologies and techniques aiming to improve outcomes in AVM surgeries. Particularly, significance of patient selection, preoperative and intraoperative endovascular treatment (hybrid surgery) is discussed from author’s personal experiences with 200 surgical cases.

METHODS
Between 2007-2018, 200 patients with cerebral AVMs underwent direct surgery. Spetzler-Martin grade was I-II in 118, III in 51, and IV-V in 31. ARUBA-eligible AVM was found in 66.

RESULTS
Preoperative embolization was used in 76% of the patients. Majority of scheduled surgery was performed in hybrid suit. 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. After surgery, preoperative mRS was maintained in 91% of the patients.

CONCLUSIONS
Results of AVM management with our combined neurovascular team was satisfactory. Hybrid OR with multiple neurovascular intervention/monitoring is powerful tool for AVM resection. ARUBA shall not extirpate but centralize unruptured AVM surgical practice.
The treatment of cerebral arteriovenous malformation (cAVM) is very challenging and consists of microsurgery, radiosurgery, and embolization. With advancement of radiosurgery and onyx-based embolization, the role of microsurgery, the classical treatment, should be re-established. A retrospective analysis of 84 patients with cAVMs who were surgically treated was performed to evaluate the clinical outcomes. Forty-nine patients (58.3%) presented with hemorrhages and 78 (92.8%) had cAVMs of Spetzler-Martin (SM) grades ≤ 3. Complete obliteration was achieved in 82 (97.6%). The mean clinical follow-up duration was 44.3 months. Favorable clinical outcomes (mRS ≤ 2) were observed in 75 (89.3%) at the last follow-up. Seventy-three patients (86.9%) were clinically improved or unchanged, and 11 experienced worsened conditions. The mortality rate was 0.0%. A nidus size < 3cm was the only significant factor of the hemorrhagic presentation (OR, 9.71; 95% CI 2.22-42.50; p = 0.003), and a preoperative mRS ≥ 3 (OR, 10.65; 95% CI 1.80-63.03; p = 0.009), localization in an eloquent area (OR, 6.49; 95% CI 1.46-50.21; p = 0.025) and a higher SM grade (≥ 4) (OR, 12.69; 95% CI 1.51-106.56; p = 0.019) were the risk factors associated with poor clinical outcomes. In conclusion, microsurgical resection is a feasible and effective treatment for small sized non-eloquent, superficial cAVM, and cAVM with hematoma owing to less complication rate, auto-dissection by hematoma, and reducing ICP. Safer and easier surgery can be performed with innovative technique such as FLOW 800®. Microsurgery should also be preferential for the treatment of cerebral AVM with combined lesions.
Comprehensive Neurosurgical Management for Deep-seated Brain AVMs

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Objectives: Surgical managements for deep-seated brain arteriovenous malformations (AVM) are controversial after the introduction of stereotactic irradiation and embolization. We here present our experience with multimodality treatment and the outcome of deep-seated AVMs.

Methods: Twenty-eight deep-seated AVMs have been treated between 2002 and 2016 in our institute. The series consist of 17 males and 11 females; their ages ranged from 7 to 74 years old. Twenty-one cases (75%) presented with hemorrhage. Locations include cerebellar hemisphere in 7, dorsal cerebellar hemisphere in 6, thalamus in 6, cerebellar pontine angle in 4, and midbrain, periventricle, basal ganglia, corpus callosum and vermis in 1 case each.

Results: Sixteen patients were operated directly, 2 cases with severe hemorrhage treated only by ventricular drainage, and 10 deep highly eloquent cases were treated by radiosurgery. Two-staged operation were performed in 8 ruptured AVMs with hematomas. Preoperative embolization was performed in 7 cases. The direct surgical results in 16 cases was mRS-0 in 4, mRS-1 in 3, mRS-2-4 in 3, mRS-4 in 1, and mRS-5 in 1. Radiosurgery group (10 cases) could be followed from 30 to 108 months. Decrease of size in 7 and disappear in 3 cases. No hemorrhage except one case after radiosurgery were seen during the follow-up periods.

Conclusions: Deep-seated AVMs are complex neurovascular lesions that pose an increased risk for hemorrhagic presentation as well as increased morbidity and mortality. Multidisciplinary teams will probably become increasingly important for optimal management to these complex lesions.