Cerebral arteriovenous malformation surgery

- Delayed but Dangerous: Chronic Encapsulated Expanding Hematoma as a Reversible Cause of Steroid-Resistant Extensive Edema Following Stereotactic Radiosurgery for Cerebral Arteriovenous Malformation
- Clinical characteristics and management of cerebral developmental venous anomalies accompanied with cavernous malformation
- The use of Bevacizumab in the treatment of brain arteriovenous malformations: a systematic review
- Indirect surgical revascularization for management of vascular steal phenomenon in high-grade untreatable brain arteriovenous malformations
- Dural Arteriovenous Fistula with Bilateral Agenesia of Intracranial Venous Sinuses: A Case Report
- A Case Report of an Adverse Outcome: Development of a Dural Arteriovenous Fistula Following Foramen Magnum Decompression for Chiari Malformation
- Comprehensive assessment of the feasibility, safety, and efficacy of the pressure cooker technique in the treatment of brain arteriovenous malformations: Systematic review and meta-analysis
- The Dynamics of Seizures After Microsurgical Treatment of Brain AVMs in Patients with Symptomatic Epilepsy: A Single-Center Experience over 10 Years

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Judicious patient selection is essential to avoiding surgical complications and poor neurological outcomes with cerebral arteriovenous malformation surgery. The combination of nidus size, deep venous drainage, and eloquence of adjacent brain that comprises the Spetzler-Martin grading scale provides a preliminary assessment of surgical risks.

The Spetzler-Martin grading scale published in 1986 assigned one to three points for AVM size, one point for involvement of eloquent cortex, and one point for deep venous drainage for a total of five points. In their retrospective study, Spetzler and Martin retrospectively applied their scoring scale to 100 AVM patients. Higher Spetzler-Martin grade demonstrated a direct correlation between post-operative neurologic deficit as well as an inverse correlation between likelihood of surgical resection [1)].

Books

Seven AVMs: Tenets and Techniques for Resection.

Neurosurgery of Arteriovenous Malformations and Fistulas: A Multimodal Approach by Robert Schmid-Elsaesser (Author), Alexander Muacevic (Author), Hartmut Brückmann (Author), Berndt Wowra (Author).

Videos

see Cerebral arteriovenous malformation surgery videos.

Anesthetic management

Anesthetic management for cerebral arteriovenous malformation surgery.

Technique

At the early stage of cerebral arteriovenous malformation surgery, extensive dissection of the sulci, fissures, and subarachnoid cistern should be performed to expose feeders, nidus, and drainers. Problems with the surgery of large and/or deep-seated lesions are exacerbated when arterial bleeding from the nidus continues even after all major feeders are thought to have been occluded.

Temporary clip application on feeders and less coagulation of the nidus is necessary to control intranidal pressure and to avoid uncontrollable bleeding from the nidus and adjacent brain. Intraoperative navigation images superimposed on tractography images can provide us with valuable information to minimize neurological deficits. Deeper insight into AVM nature and into events that occur during AVM surgery will open new horizons for the safe and effective treatment of AVMs [2)].

The most important factors governing the operability of an AVM are location, size, age of the patient, and the neurosurgeon's and team's experience.

Hernesniemi et al. present in a review the surgical experience. This consists of the following steps: (1) accurate preoperative embolization; (2) optimal selection of the surgical approach; (3) accurate definition and preservation of the normal arterial vessels of passage; (4) temporary clipping of the feeding arteries; (5) a special method of coagulation called “dirty coagulation” of the deep small difficult vessels inside apparently normal brain around the AVM; (6) removal of all AVM; (7) meticulous hemostasis; (8) intra- and postoperative digital subtraction angiography (DSA); (9) clinical and radiological follow-up. These steps are not possible in AVMs lying entirely within central eloquent areas. Nine out of ten small- and medium-sized arteriovenous malformations (AVMs) are suitable for direct surgery, but surgical complications increase drastically with the size of the AVM. Nevertheless, the actual results of combined treatment with preoperative Onyx embolization followed by microsurgery have decreased these risks [3)].

Wang et al. evaluated the application of intraoperative ultrasound (IOU) combined with indocyanine green videoangiography for arteriovenous malformation and concluded that it can identify the boundary of AVM, detect deep vessels, and discriminate between feeding arteries and draining veins,

reducing operation difficulty, decreasing mortality and disability rate, and increasing the rate of complete excision [4].

Tubular Retractor System for cerebral arteriovenous malformation surgery

Tubular Retractor System for cerebral arteriovenous malformation surgery

Case series

2022

From June 2014 to May 2021, 1010 patients were recruited at 30 TOBAS centers. Surgery was selected for 229/512 patients (44%) considered for curative treatment; 77 (34%) were included in the surgery versus observation randomized trial and 152 (66%) were placed in the surgical registry. Surgical registry patients had 124/152 (82%) ruptured and 28/152 (18%) unruptured arteriovenous malformations (AVMs), with the majority categorized as low-grade Spetzler-Martin grade I-II AVM (118/152 [78%]). Thirteen patients were excluded, leaving 139 patients for analysis. Embolization was performed prior to surgery in 78/139 (56%) patients. Surgical angiographic cure was obtained in 123/139 all-grade (89%, 95% CI 82%-93%) and 105/110 low-grade (95%, 95% CI 90%-98%) AVM patients. At the mean follow-up of 18.1 months, 16 patients (12%, 95% CI 7%-18%) had reached the primary safety outcome of mRS score > 2, including 11/16 who had a baseline mRS score ≥ 3 due to previous AVM rupture. Serious adverse events occurred in 29 patients (21%, 95% CI 15%-28%). Permanent treatment-related complications leading to mRS score > 2 occurred in 6/139 patients (4%, 95% CI 2%-9%), 5 (83%) of whom had complications due to preoperative embolization.

The surgical treatment of brain AVMs in the TOBAS registry was curative in 88% of patients. The participation of more patients, surgeons, and centers in randomized trials is needed to definitively establish the role of surgery in the treatment of unruptured brain AVMs. Clinical trial registration no.: NCT02098252 (ClinicalTrials.gov) [5].

A retrospective review of patients who underwent resection of a bAVM over a 15-year period was performed. Patients who did not present with seizure were included, and the primary outcome was de novo epilepsy (i.e., a seizure disorder that only manifested after surgery). Demographic, clinical, and radiographic characteristics were compared between patients with and without postoperative epilepsy. Subgroup analysis was conducted on the ruptured bAVMs.

Results: From a cohort of 198 patients who underwent resection of a bAVM during the study period, 111 supratentorial ruptured and unruptured bAVMs that did not present with seizure were included. Twenty-one patients (19%) developed de novo epilepsy. One-year cumulative rates of developing de novo epilepsy were 9% for the overall cohort and 8.5% for the cohort with ruptured bAVMs. There were no significant differences between the epilepsy and no-epilepsy groups overall; however, the de novo epilepsy group was younger in the cohort with ruptured bAVMs (28.7 ± 11.7 vs 35.1 ± 19.9 years; p = 0.04). The mean time between resection and first seizure was 26.0 ± 40.4 months, with

the longest time being 14 years. Subgroup analysis of the ruptured and endovascular embolization cohorts did not reveal any significant differences. Of the patients who developed poorly controlled epilepsy (defined as Engel class III-IV), all had a history of hemorrhage and half had bAVMs located in the temporal lobe.

Conclusions: De novo epilepsy after bAVM resection occurs at an annual cumulative risk of 9%, with potentially long-term onset. Younger age may be a risk factor in patients who present with rupture. The development of poorly controlled epilepsy may be associated with temporal lobe location and a delay between hemorrhage and resection [6].

In Zhongnan Hospital of Wuhan University, 14 patients who underwent surgery with LSCI were collected. To analyze the hemodynamic features of AVM and the influence on the peripheral cortex of AVM embolization and resection, we assessed the transit time between feeding arteries and drainage veins by intraoperative digital subtraction angiography (DSA). Meanwhile, LSCI was performed at pre-embolization, post-embolization, and after complete resection of bAVM.

In this study, the transit time of bAVM before and after embolization was compared, the transit time before embolization was significantly shorter than that after embolization ($p < 0.05$). We also got good visualization of relative CBF, in addition, to flow imaging in the cortical vasculature round bAVM with LSCI. The flux of post-surgery was significantly higher than pre-embolization ($p < 0.01$).

Hemodynamic variable assessment plays an important role in the resection of AVM in the hybrid operative room and LSCI can be used to visualize and evaluate cortical cerebral blood flow to detect pathological hyperperfusion in real-time with a good spatial-temporal resolution in a sensitive and continuous, non-invasive mode [7].

2021

A retrospective single-center case series enrolled the patients who underwent surgical treatment of pial AVM at the Department of Neurosurgery, University Hospital Brno, between 2005 and 2019. The data are summarized as descriptive statistics presenting basic characteristics in all the patients and in sex or age subgroups.

Results: Fifty patients were enrolled. The majority of AVMs were of Spetzler-Martin grade II (n=27; 54%), localized supratentorialy (n=43; 86%), and half of the AVMs were ruptured. A total resection was performed in 48 patients (96%), and a good overall outcome was achieved in 44 patients (88%). Surgery-associated morbidity was 2%, and the mortality rate was 0% due to meticulous selection of patients for surgical treatment.

Conclusion: Microsurgery is an appropriate method of treatment for S-M grade I-III pial AVMs. Microsurgery may be used to treat the majority of small-nidus AVMs with low mortality and morbidity when precisely planned and performed by an expert vascular team. The meticulous selection of patients for surgical treatment is crucial [8].

2017

Data of patients with AVM were collected prospectively. Cases were identified in which an AVM was resected and an associated space-occupying ICH was evacuated at the same time, and divided into “group 1,” in which the surgery was performed acutely within 48 h of presentation (secondary to elevated intracranial pressure); and “group 2,” in which selected patients were operated upon in the presence of a liquefying ICH in the “subacute” stage. Clinical outcomes were assessed using the modified Rankin Scale, with a score of 0 to 2 considered a good outcome. Obliteration rates were assessed using postoperative angiography.

From 2001 to 2015, 131 patients underwent microsurgical resection of an AVM, of which 65 cases were included. In “group 1” (n = 21; Spetzler-Ponce class A = 13, class B = 5, and class C = 3), 11 of 21 (52%) had a good outcome and in 18 of 19 (95%) of those who had a postoperative angiogram the AVMs were completely obliterated. In “group 2” (n = 44; Spetzler-Ponce class A = 33, class B = 9, and class C = 2), 31 of 44 (93%) had a good outcome and 42 of 44 (95%) were obliterated with a single procedure. For supratentorial AVMs, the ICH cavity was utilized to provide an operative trajectory to a deep AVM in 11 cases, and in 26 cases the ICH cavity was deep to the AVM and hence facilitated the deep dissection of the nidus.

In selected patients the presence of a liquefying ICH cavity may facilitate the resection of AVMs when performed in the subacute stage resulting in a good neurological outcome and high obliteration rate [9)].

2014

A total of 264 patients were treated with microsurgical resection between 1994 and 2010 at the Jefferson Hospital for Neuroscience. Initial hemorrhage, clinical presentation, Spetzler-Martin AVM grading system (SM), treatment modalities, clinical outcomes, and obliteration rates were reviewed.

Univariate analysis and multivariate analysis were used to determine predictors of operative complications.

Of the 264 patients treated with microsurgery, 120 (45%) patients initially presented with hemorrhage. There were 27 SM Grade I lesions (10.2%), 101 Grade II lesions (38.3%), 96 Grade III lesions (36.4%), 31 Grade IV lesions (11.7%), and 9 Grade V lesions (3.4%). Among these patients, 102 (38.6%) had undergone prior endovascular embolization. In all patients, resection resulted in complete obliteration of the AVM. Complications occurred in 19 (7.2%) patients and resulted in permanent neurological deficits in 5 (1.9%). In multivariate analysis, predictors of complications were increasing AVM size (OR 3.2, 95% CI 1.5-6.6; p = 0.001), increasing number of embolizations (OR 1.6, 95% CI 1.1-2.2; p = 0.01), and unruptured cerebral arteriovenous malformation (OR 2.7, 95% CI 1-7.2; p = 0.05).

Microsurgical resection of AVMs is highly efficient and can be undertaken with low rates of morbidity at high-volume neurovascular centers. Unruptured and larger AVMs were associated with higher complication rates [10)].

Case reports

Occult AVM nidus in symptomatic left temporal arteriovenous malformations: operative management strategies in two sister cases [11].

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