## Brainstem arteriovenous malformation

The surgical management of brainstem arteriovenous malformations (AVMs) might benefit from the definition of anatomical subtypes and refinements of resection techniques. Many brainstem AVMs sit extrinsically on pia mater rather than intrinsically in the parenchyma, allowing treatment by occluding feeding artery circumferentially, interrupting draining veins after arteriovenous shunting is eliminated, and leaving the obliterated nidus behind.

The largest series of brainstem AVMs define 6 subtypes, assess this "occlusion in situ" technique, and analyze the microsurgical results.

## Classification

Brainstem AVMs were categorized as 1 of 6 types: anterior midbrain, posterior midbrain, anterior pontine, lateral pontine, anterior medullary, and lateral medullary AVMs. Data from a prospectively maintained AVM registry were reviewed to evaluate multidisciplinary treatment results.

## Case reports

During a 15-year period, the authors treated 29 patients with brainstem AVMs located in the midbrain (1 anterior and 6 posterior), pons (6 anterior and 7 lateral), and medulla (1 anterior and 8 lateral). The nidus was pial in 26 cases and parenchymal in 3 cases. Twenty-three patients (79%) presented with hemorrhage. Brainstem AVMs were either resected (18 patients, 62%) or occluded in situ (11 patients, 38%). All lateral pontine AVMs were resected, and the occlusion in situ rate was highest with anterior pontine AVMs (83%). Angiography confirmed complete obliteration in 26 patients (89.6%). The surgical mortality rate was 6.9%, and the rate of permanent neurological deterioration was 13.8%. At follow-up (mean 1.3 years), good outcomes (modified Rankin Scale [mRS] score  $\leq$  2) were observed in 18 patients (66.7%) and poor outcomes (mRS score of 3-5) were observed in 9 patients (33.3%). The mRS scores in 21 patients (77.8%) were unchanged or improved. The best outcomes were observed with lateral pontine (100%) and lateral medullary (75%) AVMs, and the rate of worsening/death was greatest with posterior midbrain and anterior pontine AVMs (50% each).

Brainstem AVMs can be differentiated by their location in the brainstem (midbrain, pons, or medulla) and the surface on which they are based (anterior, posterior, or lateral). Anatomical subtypes can help the neurosurgeon determine how to advise patients, with lateral subtypes being a favorable surgical indication along with extrinsic pial location and hemorrhagic presentation. Most AVMs are dissected with the intention to resect them, and occlusion in situ is reserved for those AVMs that do not separate cleanly from the brainstem, that penetrate into the parenchyma, or are more anterior in location, where it is difficult to visualize and preserve perforating arteries (anterior pontine and lateral medullary AVMs). Although surgical morbidity is considerable, surgery results in a better obliteration rate than nonoperative management and is indicated in highly selected patients with high rerupture risks <sup>1)</sup>.

## 1)

Han SJ, Englot DJ, Kim H, Lawton MT. Brainstem arteriovenous malformations: anatomical subtypes, assessment of "occlusion in situ" technique, and microsurgical results. J Neurosurg. 2014 Oct 24:1-11. [Epub ahead of print] PubMed PMID: 25343188.

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