Parafalcine arteriovenous malformation

Parafalcine arteriovenous malformations (AVMs) have a midline plane in common and extend down the medial cerebral hemisphere away from the convexity, often to ventricular depths. Nonetheless, they lie on a cortical surface.

Classification

Stein introduced a regional classification for 25 AVMs of the medial hemisphere and limbic system that included the medial temporal lobe (amygdala and uncus, Region A; and parahippocampus and fusiform gyrus, Region B), in addition to the trigone of the lateral ventricle (Region C); splenium (Region D); corpus callosum, and cingulate gyrus (Region E); and medial frontal lobe and septum (Region F) [1)].

Like Stein's publication, the report of Kim et al. was intended to provide a comprehensive review of a large, single-surgeon operative series. The regional classification differed from Stein's by excluding temporal lobe AVMs and including medial hemisphere AVMs in more superficial locations [2)].

Location

They differ in their location (anterior, middle, or posterior) and depth (superficial or deep).

Posteriorly located AVMs

Deep and posteriorly located AVMs often drain to the Galenic system, with the tip of the nidus in the lateral ventricle or deep subarachnoid cisterns, where intraoperative bleeding can be particularly dangerous [3)] [4)].

Corpus callosum arteriovenous malformation

Medial occipital lobe arteriovenous malformation

Tentorial incisura arteriovenous malformation

Treatment

The anatomy makes their surgical resection challenging. Eloquent brain— including motor and sensory cortex, visual cortex, the limbic system, and the corpus callosum—can be intimate with the AVM [5)].

Many parafalcine AVMs are managed conservatively or with stereotactic radiosurgery because of these anatomical and surgical difficulties.

Surgical management

Surgical management varies with AVM location and depth in terms of patient position, head position, craniotomy, and surgical approach.

Position

Gravity retraction helps access deeply located AVMs. Positioning the patient and the head to align the midline horizontally allows the ipsilateral hemisphere to sag downward.

The dura mater is opened with a flap based on the SSS, with tacking sutures pulling the flap to the opposite side for an unobstructed view along the falx. Draining veins from the AVM to the SSS often adhere to the dura or course within the dura and can be injured during the opening. Freeing adhesions between the falx and the medial hemisphere widens the opening of interhemispheric fissure, and freeing adhesions between the falx and the AVM's medial surface exposes this superficial plane. Subdural dissection along the falx leads to the free edge of the falx, where the corpus callosum cistern can be entered, CSF can be released, and dissection can transition to subarachnoid splitting of the deep interhemispheric fissure. Gravity-dependent approaches need CSF drainage early to relax the brain and initiate the sagging process. The corpus callosum cistern can be reached easily, and therefore Kim et al. have not found it necessary to use lumbar drains, even with posterior approaches to the superficial-posterior or deep-posterior zones [6)].

Interhemispheric approach

Convexity and other superficial AVMs are approached perpendicularly, following feeding arteries to their intersection with the nidus and encircling the nidus with dissection planes in full view. Conceptualizing an AVM as a cube, the nidus has a superficial plane, 4 sides, and a deep plane. The superficial plane faces the neurosurgeon; the 4 sides are confronted perpendicularly; and the deep plane is obscured by the nidus itself. In contrast, parafalcine and midline AVMs are approached tangentially. The midline plane and many of the AVM's sides are confronted tangentially, and the deep plane is obscured by the nidus. Perpendicular dissection with full visualization of dissection planes is possible with some parafalcine AVMs in superficial zones that have superior and lateral sides on the convexity, but tangential dissection of all 4 sides is required with parafalcine AVMs in deep zones. Tangential dissection requires working alongside the nidus, retracting or resecting some adjacent brain, and/or mobilizing the nidus into the operative corridor to compensate for obscured visualization.

The interhemispheric fissure gives access to arterial feeders from the ACA and PCA. Callosomarginal, pericallosal, and calcarine feeding arteries terminating in the AVM are divided. Arteries en passage are skeletonized, preserving trunks that continue beyond the AVM to supply normal brain. Large bridging veins to the SSS become obstacles throughout the dissection because they must be preserved until the AVM is completely circum-dissected. With a wide splitting of the interhemispheric fissure, the occlusion of large feeders from the ACA and PCA is often easier than the occlusion of small feeders from the MCA, particularly when these originate from lenticulostriate arteries that travel through deep white matter. Superficial MCA feeders on the cortical surface are easily coagulated; these other deep feeders are usually along the deep plane of AVMs in the superficial-middle and deep-anterior zones and resist occlusion with electrocautery [7].

Anterior cerebral artery and posterior cerebral artery (PCAs) that feed these AVMs along their deep borders may be inaccessible until late in the dissection. These feeding arteries reach opposite sides of the nidus and give it bidirectional supply [8] [9] [10].

Arteries “en passage” that supply the brain distal to the AVM must be preserved. The superior sagittal sinus (SSS), dilated draining veins, and normal bridging veins can be bleeding hazards or major obstacles during deep dissection [11].

Case series

2011

Patients with AVMs located on the medial surface of the cerebral hemisphere were identified retrospectively from a consecutive, single-neurosurgeon series that is registered prospectively as part of the UCSF Brain Arteriovenous Malformation Study Project. During a 12-year period, 443 patients with AVMs were treated surgically. Of these 443 patients, 132 (30%) had parafalcine AVMs, which were distributed in zones as follows: superficial-anterior, 25 (18.9%); superficial-middle, 26 (19.7%); superficial-posterior, 39 (29.5%); deep-anterior, 25 (18.9%); deep-posterior, 17 (12.9%). Five different surgical strategies were used depending on AVM zone.

Complete AVM resection was achieved in 123 (93.2%) of 132 patients. Overall, neurological condition improved in 74 patients (56.1%) and remained unchanged in 41 patients (31.1%). Neurological condition deteriorated in 12 patients (9.1%), and 5 patients (3.8%) died. Patients with AVMs in the superficial-middle zone had the highest rate of neurological deterioration (26.9%).

Parafalcine AVMs lie on a midline surface that, when exposed with a bilateral craniotomy across the superior sagittal sinus and a wide opening of the interhemispheric fissure, makes them superficial. However, unlike convexity AVMs, which are approached perpendicularly, parafalcine AVMs are approached tangentially. Gravity retraction is useful with deeply located AVMs (those in the deep-anterior and deep-posterior zones), because it widens the interhemispheric fissure and accesses deep arterial feeding vessels from the anterior and posterior cerebral arteries. Surgical risks were increased in the superficial-middle zone, which is likely explained by the proximity of sensorimotor cortex. The authors' regional classification of parafalcine AVMs may serve as a guide to surgical planning [12].

Video

<html><iframe width=“560” height=“315” src=“https://www.youtube.com/embed/oYNUZxEl3zc” frameborder=“0” allowfullscreen></iframe></html>

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