Surgical Treatment of Spinal Cord Vascular Malformations

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The surgical treatment for spinal cord arteriovenous malformations (AVMs) depends on the location of the lesion with its abnormal connections between the arterial and venous circulation. The appropriate surgical approach depends on understanding the classification of spinal AVMs.

The traditional classification involves four types of lesions³ that have now been reclassified into arteriovenous fistulae (AVFs), AVMs,¹ and lesions involving the conus medullaris⁷.

Arteriovenous Fistulae

AVFs are subdivided into intradural and extradural lesions^{4,7}. The intradural lesions are further divided into dorsal and ventral lesions⁷.

The diagnostic modalities best suited for the diagnosis of extradural AVFs are MR imaging and angiography. Due to a direct communication between extradural artery and venous system, over time a high-flow fistula develops and can lead to intradural venous hypertension by increasing the resistance to outflow.

This process results in engorgement of the venous system and compression of the spinal cord. Subsequently, spinal cord compression and vascular steal can cause progressive myelopathy.

Intradural dorsal AVFs that correspond to the classic type I lesion are the most common

type of spinal AVFs. MR imaging and angiography are best suited for their diagnosis. Selective angiography demonstrates a slow flow pattern produced by the dorsal radiculomedullary artery. The artery enters the dura at the dural root sleeve and forms a fistula, arterializing the coronal venous plexus.

Many extradural and dural vessels may feed into the intradural fistula. There are two subtypes.

Types A have a single feeding artery while types B have multiple feeding arteries. These lesions are most common in the thoracic region. Their primary pathophysiology consists of venous hypertension with resultant progressive myelopathy.

Intradural ventral arteriovenous fistulae correspond to the classic types IVA, B, and C. MR imaging and angiography are recommended for their diagnosis. These lesions are devoid of a capillary system and are located in the midline in the subarachnoid space. They arise from the anterior spinal artery and feed directly via a fistulous pathway into an enlarged venous network. Venous hypertension and vascular steal are common findings. The high pressure can cause haemorrhage or lead to the development of aneurysms causing symptoms related to compression.

Intradural ventral type A AVFs are small shunts associated with slow blood flow and

moderate venous hypertension. Types B and C have progressively larger shunts. Progressive myelopathy is a common presentation.

Arteriovenous Malformations

Extradural-intradural AVMs correspond to classic juvenile type AVMs.

Multiple feeders and high-flow are demonstrated on MR imaging and angiography. The pathophysiology consists of compression, vascular steal, and haemorrhage. Patients often become symptomatic with pain and progressive myelopathy.

Intramedullary AVMs correspond to classic glomus type AVMs. MR imaging and angiography can demonstrate a compact or diffuse nidus supplied by multiple branches of the anterior and posterior spinal arteries. Low resistance, high blood flow, and high pressure are characteristic of these lesions. Associated aneurysms are common. The pathophysiology usually consists of haemorrhage with resultant acute myelopathy. Progressive myelopathy can also be related to vascular steal.

Conus Medullaris Arteriovenous Malformations

These lesions represent a distinct subgroup of spinal vascular malformations because they contain multiple arterial feeders, intradural fistulae, and multiple arteriovenous pial-based niduses with complex venous drainage. MR imaging and angiography are recommended for defining their precise angioarchitecture. The arteriovenous shunts originate from both the anterior and posterior spinal arteries. The pial-based niduses are usually extramedullary although they also may have an intramedullary component. These lesions are usually located in the conus medullaris and cauda equina. However, they may extend along the entire filum terminale. Venous hypertension, compression, and haemorrhage are common pathophysiological findings and associated with the resultant radiculopathy and progressive myelopathy.

Surgical Approach

The goal of surgical intervention is total extirpation of the lesion. Each procedure is tailored to the type of lesion and the location in-

involved. Either a laminectomy, laminoplasty, vertebrectomy, or costotransversectomy may be warranted. Laminectomies are extended laterally to the level of the pedicles on each side. Utmost care is taken to leave all vessels intact during the dural opening.

Extradural Arteriovenous Fistulae

For extradural AVFs an endovascular procedure is the definitive treatment. Surgery is an adjunct or alternative intervention because these lesions can be treated effectively and precisely with the former method.

Dorsal and Ventral Intradural Arteriovenous Fistulae

For dorsal and ventral intradural AVFs, preoperative superselective embolisation can be combined with open surgery for definitive treatment. Endovascular treatment, however, may pose a high risk due to the small size of the fistula. The primary goal of surgery should include complete obliteration of the fistula. Without thorough obliteration of all arterial feeders, the AVM is most likely to recur.

A longer incision and dural opening may be required for these types of lesions. Retraction of the spinal cord and dissection of the tortuous vessels on the pial surface should be avoided because these maneuvers increase the risk of morbidity.

Extradural-intradural Arteriovenous Malformations

Extradural-intradural AVMs usually require a multidisciplinary approach. The goal is to embolise all of the multiple arterial feeders^{7,8}. This process can be followed by staged surgical resection⁷.

Intramedullary Arteriovenous Malformations

Intramedullary AVMs also requires a multidisciplinary approach. Superselective preoperative embolisation is followed by surgical resection². Due to the extensive nature of these lesions, appropriate exposure is crucial for their successful treatment. Embolisation may be staged followed by partial resection if complete resection poses a significant risk of neurologic morbidity.

Conus Medullaris Arteriovenous Malformations

A multidisciplinary approach is also warranted for the successful treatment of conus AVMs. Preoperative superselective embolisation is recommended followed by surgical resection. Depending on the location of the lesion, either a laminectomy, laminoplasty, vertebrectomy, or costotransversectomy may be warranted. Through microdissection the arteriovenous nidus and the arterial feeders are identified. Small feeders originating from the larger arterial feeders are isolated, coagulated, and transected. The nidus is cauterized and resected as well.

Conclusions

The new classification of spinal vascular lesions represents a comprehensive assessment of all forms of spinal vascular malformations. Unlike the traditional classification that involves Types I-IV, the new version includes conus medullaris AVMs, associated aneurysms, and vascular neoplasms. Treatment options for all spinal vascular lesions are contingent on the location and pathophysiology of the lesion. Understanding the angioarchitecture is crucial for a successful approach.

The aim of management should be complete obliteration of the lesion with minimal manipulation of the spinal cord.

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