Spine vascular lesions from embryology to imaging findings review article with serial cases

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ABSTRACT

Spine vascular lesions like brain vascular lesions include spinal cord stroke, vascular malformation such as venous malformation or venous angioma, cavernous malformation, arteriovenous malformation or arteriovenous fistula. Embryogenesis of spinal vascular is the basic principle to understand the vascular malformation of the spine. This study aims to report serial cases with review of spinal vascular lesions. MR angiography techniques with contrast injection may reflect the direction of flow epidural veins to describe the site of arterial feeders. Serpiginous veins are commonly visible through the dorsal cord surface in MR myelography. The gold standard for diagnosing vascular malformation is Digital Subtraction Angiography (DSA). MRA helps to guide the location for DSA. Several cases are reported using MRA modalities and show the special location site of the spinal disorder.

Keywords: Spinal cord infarction; spinal haemorrhage; vascular malformation; MRI; MRA; DSA.


INTRODUCTION

Incidences of spinal cord strokes are rare compared to cerebral stroke, divided into two yields, ischemic and hemorrhagic, and it is reported that one percent of all strokes and around five to eight percent of acute myelopathies cases. 1 The majority of causes of ischemia or infarction, arterial infarction caused by aortic disease, embolic disease, dissection, infection and inflammation, toxic, global ischemia, venous infarction in patients with spinal arteriovenous malformation and spinal cavernous malformation, thrombosis in spinal veins or increased pressure in venous system can cause infarction. The most common etiology of venous infarction are mechanical compression, infection, and inflammation, which obliterate the veins. 1,5

Spinal vascular disorders are similar to brain vascular disorders, such as telangiectasis, venous malformation or venous angioma, cavernous malformation, arteriovenous malformation or arteriovenous fistula. 1,6,7 Hematomyelia is often caused by trauma. Other causes include Arteriovenous Malformation (AVM), other vascular malformations, anticoagulation, and hemophilia. Spinal epidural hemorrhages are reported more often and around four times more than spinal subdural hematomas. 1,7

The best modality to detect cytotoxic edema in acute infarction is Diffusion-Weighted Imaging (DWI); it visualizes even small areas of ischemia, however, limited due to technical reasons. The new generation of Magnetic Resonance Imaging (MRI) has improved coil and gradient designs for spinal cord imaging and relevant to implement this imaging method for spinal cord ischemia. 8 Magnetic Resonance (MR) angiography techniques with contrast injection may reflect the direction of flow epidural veins to describe the site of arterial feeders. Serpiginous veins are commonly visible through the dorsal cord surface in MR myelography. The gold standard for diagnosing vascular malformation is Digital Subtraction Angiography (DSA). Magnetic resonance angiography (MRA) helps to guide the location for DSA. 9,10

SERIAL CASE

Case 1: 14-year-old post trauma with acute wedge compression fracture at Th12 level, spine MR performed 24 hours later showed an increased signal intensity on T2WI, axial Th12 level showing bilateral thoracal cord hyperintensities (“snake-eye” conformation), DWI reflecting restricted diffusion, consistent with cervical cord infarction. 10

Case 2: 52 years old, male with COVID-19 infection during hospitalization suddenly got paraplegia. MRI has been performed, sagittal T1, T2 Fat Sat and T2*GRE show late subacute epidural hemorrhage in posterior epidural space from Th10 through Th12, compressing adjacent
Imaging in Spinal cord infarction, spinal hemorrhage, spinal vascular malformation

Spinal cord ischemia or infarction, arterial infarction, most commonly caused by aortic disease, embolic disease, dissection, infection and inflammation, toxic, global ischemia in severe hypotension, shock, cardiac arrest and iatrogenic in endovascular procedures and arteriography involving the aorta can cause spinal cord infarction, venous infarction also could happen in a patient with spinal arteriovenous malformation and spinal cavernous malformation, thrombosis in spinal veins or increased pressure in venous system can cause an infarction, venous infarction most common caused by mechanical compression, infection, and inflammation, which obliterate the veins. Intramedullary hemorrhage is often caused by trauma; other causes include AVM, other vascular malformation, anticoagulation, and hemophilia. Spinal epidural hemorrhages are reported around four times compared to spinal subdural hematomas.

Diffusion-weighted imaging (DWI) often shows acute spinal cord infarction. Early MRI scans may be negative, and rescans are often necessary for appropriate clinical settings. Most common ischemia causes edema with increased signal on T2-weighted scans, and prior infarcts also have abnormal increased T2 signal. The key finding that suggests the presence of a dura fistula is serpiginous dilated veins on the surface of the spinal cord. These are often visible on T2-weighted and gadolinium-enhanced images and contrast-enhanced MR angiography.

First, differentiating or excluding from longitudinally extensive transverse myelitis (LETM) is important by recognizing T2 signal abnormality or enhancement. Spinal imaging is good when using a high field above 1.5 T to achieve better resolution and signal-to-noise ratio (SNR). MR protocol suggests at least two-dimensional (2D) Fast Spin Echo (FSE) T1- and the sagittal plane T2-weighted sequences with thickness up to 3 mm, and axial plane T2-weighted.

This serial case reflects the MRA describing the location of the spinal cord and causing cord edema.6

Case 3: 24 yo with sudden paraplegia, Thoracolumbal MRI has been performed in sagittal and axial T1, T2, MR myelography revealed dotted hyperintense signal intramedullar in T1 and T2 at the level Th9-10 and Th11-12 consistent with hemorrhage, perimedullary abnormal flow void better seen in axial and MR myelography, consistent with intramedullary or pial AVM. DSA shows intramedullary AVM with nidus and feeding artery from Anterior spinal artery.

Case 4: 14 years old Male with paraplegia; Thoracolumbal MRI has been performed, sagittal T2 shows dural AVF with a tortuous draining vein from the level Th9 through L1 and spinal cord congestion, contrast-enhanced MRA revealed spinal dural AVF with feeding artery from Sacral artery.

Case 5: Boy, 4 years old, Cervico-thoracal MRI has been performed, sagittal T1, T2 revealed hemorrhage at C3-4 level with hemosiderin post hemorrhage and cord edema, another lesion at Th12-L1 level with a sinusoid lesion, multiple microhemorrhage with different age and hemosiderin rim, adjacent cord edema, consistent with an intramedullary cavernous angiomatosis with the episode of bleeding at the C3-4 level.
REVIEW

Embryology of Spinal Vascular

First weeks of pre-natal life, after the segmentation of the paraxial mesoderm formed 31 somites, which each somite supplies one pair of arteries by the dorsal aorta, termed segmental arteries branches of each segmental arteries supply the vertebral bodies, paraspinal muscles, dura, nerve roots and spinal cord (metamer).

The fusion and desegmentation happened in the sixth week to the fourth month of intrauterine life. Fusion of the longitudinal artery has become into the anterior spinal artery, and the segmental arteries have vascularization; the fusion of longitudinal arteries will be the future of radiculo-medular arteries.

Anatomy Imaging for spinal vascular

The anterior spinal artery supplies most of the spinal cord except the dorsal column. It arises from the intercostal arteries, which arise from the aorta of the thoracic spinal cord and the vertebral arteries of the superior cervical spinal cord. Multiple underlying etiologies can lead to spinal cord infarction, with the modern series of aortic dissection and repair or thoracic aortic aneurysm being the most reported. Particulate occlusion of the intercostal artery causes adjacent infarction, and hypoperfusion affects the T4-T6 region, recognized as the ‘watershed’ region. Preventive strategies in aortic surgery have significantly reduced the risk of spinal cord infarction, and lumbar drainage with cerebrospinal fluid drainage has become more specifically. Using MR angiography techniques with contrast can reflect flow within the epidural veins to recognize the location of the arterial feeders. Serpiginous veins are commonly visible through the dorsal cord surface in MR myelography. The gold standard for diagnosing vascular malformation is Digital Subtraction Angiography (DSA). MRA helps to guide the location for DSA.

Figure 6. Arterial blood supply in the spinal cord.

Figure 7. a cross-section of the spinal cord displaying the vascular supply patterns. A single midline artery called the anterior spinal artery (ASA) is found in the anterior fissure. The anterior horns and white matter are supplied by the left and right sulcal arteries that branch out from this artery. An anastomotic rete supplies the posterior gray horns and the posterior columns of the two posterior spinal arteries, one on each side.

Figure 8. Patterns of spinal cord infarction. (A) Anterior bilateral infarction. (B) Anterior predominantly unilateral infarction. (C) Posterior bilateral infarction. (D) Posterior predominantly unilateral infarction. (E) Central spinal cord infarction.

Figure 9. The most common location of the artery of Adamkiewicz: T9-T12: 75%, T5-T8: 15%, L1-L2: 10%. With kind permission from Elsevier: Wells-Roth D, Zonnenshayn M. Vascular anatomy of the spine. Operative Techniques in Neurosurgery Sept 2003;6(3):116-121.
Table 1. Spinal vascular malformation initial classification, 1992.

<table>
<thead>
<tr>
<th>Type</th>
<th>Subtype</th>
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<tbody>
<tr>
<td>Type I</td>
<td>Spinal Dural AVF</td>
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<tr>
<td>Type II</td>
<td>Intramedullary, glomus-type SCAVM</td>
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<tr>
<td>Type III</td>
<td>Juvenile type SCAVM: Metameric AVM (Cobb’s syndrome)</td>
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<tr>
<td>Type IV</td>
<td>Intradural peri medullary AVF</td>
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<tr>
<td>Excluded</td>
<td>- Parspinous and epidural fistula</td>
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<td></td>
<td>- Cavernous malformation of the spinal cord</td>
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<td>- Isolated spinal cord aneurysm</td>
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Table 2. Spinal vascular malformation revised classification, 2002.

<table>
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<tr>
<th>Type</th>
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<tr>
<td>Neoplastic Vascular Lesions</td>
<td>- Hemangioblastoma</td>
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<td></td>
<td>- Cavernous malformation</td>
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<td>Spinal aneurysm</td>
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<td>Arteriovenous fistulas</td>
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<td>Dorsal **</td>
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<td>Intramedullary</td>
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<td></td>
<td>Compact</td>
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<td></td>
<td>Diffuse</td>
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<td>Conus medullaris</td>
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* Includes the following subtypes: A. small shunt, B. medium shunt and C. large shunt
** Includes the following subtypes: A. single feeder, B. multi feeders

Spinal cord infarction

Pattern A: Anterior bilateral infarction shows the bilateral motor and spinothalamic type sensory deficits, posterior column sensory functions (vibration and position sense) are spared.

Pattern B: a Brown-Sequard syndrome with characteristic anterior unilateral infarction, the clinical manifestation includes motor deficits as hemiparesis below the lesion with sensory loss contralateral spinothalamic tract.

Pattern C: Bilateral posterior infarct, the manifestation of sensory loss below the lesion with variably severe bilateral pyramidal tract signs.

Pattern D: Unilateral, mostly posterior; the patient complains of ipsilateral hemiparesis and posterior column sensory loss.

Pattern E: Central infarct, with clinically bilateral pain, loss of temperature sensation with posterior column and motor functions spared.

Transverse: clinically below the lesion level, having loss of motor, sensory, and sphincter functions. After aortic surgery, it more commonly involves anterior patterns than posterior.

Causes of spinal cord ischemia/infarction:

- Arterial:
  - Embolic disease: Infective endocarditis, atrial myxoma, non-bacterial thrombotic endocarditis, fibrocartilaginous.
  - Dissections: Vertebral artery dissections will cause cervical cord infarction, and aortic dissections block orifices of spinal radicular arteries.

- Infections and inflammations:
  - Tuberculosis, syphilis, fungal, Lyme disease all of these will cause spinal arteritis.
  - Toxic: Heroin injection, and cocaine inhalation, will cause prolonged vasoconstriction.
  - Global ischemia: Severe hypotension, shock, cardiac arrest, T4-T8 is a vulnerable segment (Longitudinal watershed zone).
  - Venous: Spinal AVF or AVF, cavernous spinal malformations, venous thrombosis induced infarct of the spinal cord.

CONCLUSION

Understanding the spinal vascular anatomy important to make a definitive decision. A high index of suspicion and proper evaluation of abnormality spinal lesion in MRA is essential for an early diagnosis and treatment of spinal lesion to decrease the morbidity and mortality associated with this disease.

AUTHOR CONTRIBUTION

All authors have contributed to this research process, including conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, collection and assembly of data.

CONFLICT OF INTEREST

There is no conflict of interest in this manuscript.

ETHICAL CONSIDERATION

The patient received information and consent regarding data publication before any data collection.

REFERENCES