Endovascular Therapy of Spinal Vascular Malformations

Italo Linfante MD, FAHA
Director
Endovascular Neurosurgery
Interventional Neuroradiology
Clinical Professor
Disclosures

• Consultant: Codman Neurovascular
• Consultant: Concentric Medical
• Consultant: Microvention
• Consultant: Stryker
Classifications and Description

- Space (paravertebral, epidural, dural, pial, ...)
- Etiology (traumatic, congenital, degenerative…)
- Angioarchitecture (AVM, AVF…..)
- Hemodynamics (high-flow, low-flow)
An Spine and Paraspinal Spaces

- Vertebral Body
- Epidural Space
- Dura
- Intra Dural Space
- Cord, Subpial Space

Spine and Paraspinal Spaces
1. Around 3rd wk development of segmental blood supply

2. Appearance of somites in a rostral-caudal direction

3. 31 somites persist, corresponding to 31 pairs of spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal)

4. Segmental arteries are named according to the nerve they accompany
Arterial Supply to Spine

- Macro-circulation (Paraspinal Structures and Spinal Cord Surface)
- Micro-circulation (Spinal Cord)
Anatomy

- **Cervical level**
  - Vertebral, ascending cervical branch, deep cervical branch, ascending pharyngeal, occipital artery

- **Thoracic level**
  - Costocervical trunk, internal thoracic artery, intercostal branches

- **Lumbo-Sacro-Coccygeal level**
  - Lumbar arteries, median sacral artery, lateral sacral artery, iliolumbar branches
Segmental Arteries and Major Anastomoses

- Ventrolateral (e.g., ascending cervical artery)
- Pre-transverse (anterior to the transverse process, vertebral artery or lateral sacral artery)
- Dorsal-longitudinalal (e.g., deep cervical artery)
Vascular Connections: Extra- to Intraspinal space

• Radiculo-pial arteries:
  – Supply the nerve roots, dorsal or ventral
  – have anastomoses with pial branches of PSA and ASA

• Radiculo-medullary arteries:
  – ventral surface of the nerve root, dominant supply to ASA
Macro-circulation

Micro-circulation
Normal Vascular Anatomy
Micro-circulation: Spinal Cord
Normal Vascular Anatomy
Spinal Cord

Venous System
Role of various Imaging Modalities for Spinal Vascular Lesions and Treatment

<table>
<thead>
<tr>
<th></th>
<th>3D Angio/DSA</th>
<th>MRI*</th>
<th>CTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial resolution</td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Temporal resolution</td>
<td>+++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Diagnostic + Intervention</td>
<td>+++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Follow-up</td>
<td>+++</td>
<td>+(+</td>
<td>(+)</td>
</tr>
<tr>
<td>Expense</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Invasive</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*3D and 4D contrast-enhanced MR angiography*

Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Extradural AVF with parenchymal drainage

- Extradural AVMs and AVFs are rare
- Sporadic case reports and small series have been reported
- Clinically, can present with acute and progressive neurological deficit similar to those caused by their dural-based intradural shunts
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Congenital Paraspinal AVF
Somatic Blood Supply – Vertebral Body
Combined Transarterial and Transvenous Embolization
Combined Transarterial and Transvenous Embolization
Embolization nBCA
Congenital Paraspinal AVM
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Normal Vascular Anatomy
Vertebral & Paraspinal System

Hemangiomatosis
Epidural cavernous angiomas

• Symptoms of spinal epidural cavernous hemangioma are variable
• Venous drainage directly correlates the pathologic mechanisms of presentation
• They may be manifested as back pain, radiculopathy mimicking progressive paraparesis rarely as acute paraplegia.
• Trauma, exercise, pregnancy and straining may aggravate the patient’s symptoms.
Thoracic Vertebral Hemangioma
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Epidural AV Shunts
Epidural AV Shunts
ONYX Cast
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)

Extra/Intraspinal
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Spinal Dural Malformation (Type IA & IB)

Berenstein, Lasjaunias

Spetzler/Schornak
Spinal Dural Malformation (Type IA & IB)

- Most common
- M > F
- > 41 yrs (86 %) (mean 55)
- progressive paraparesis legs
- sensory changes legs
- urinary incontinence/retention, bowel dysfunction.
- back and leg pain
- worsening by physical activity & upright posture
Spinal Dural Malformation (Type IA & IB)

Often misdiagnosed as transverse myelitis
Treatment

• Endovascular

• Laminectomy(ies) & surgical disconnection of the draining vein
Patient

- 74 yo man who developed progressive bilateral leg weakness, gait disturbance, bowel and bladder dysfunction –
- MRI suggestive of vascular malformation with cord edema
- Angiography revealed a type 1A SDAVF
74 y o m: leg weakness, gait disturbance, bowel and bladder dysfunction – Type 1A SDAVF
Patient

- 79 year old woman with back pain
- Progressive leg weakness to wheelchair
- Evaluated 4 months after onset of weakness
- Angiography revealed a type I b
Spinal Dural Malformation (Type IA & IB)

Berenstein, Lasjaunias

Spetzler/Schornak
Spinal dural AVFs

• Endovascular embolization is effective if the embolic agent reaches the shunt and the proximal section of the venous drainage

• Surgery is a valuable option
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Subpial Arteriovenous Fistula Malformation (Type IV)

- fistula from ASA to the coronal venous plexus.
- Radiculo-pial supply possible
- vascular steal, venous hypertension, mass effect, SAH (up to 40%)
- Clinical signs and symptoms < 40 yrs
- Progressive paraparesis or paraplegia
- Myelopathy or radiculopathy (mass effect from dilated venous structures)
Subpial Arteriovenous Fistula /Malformation (Type IV A-C)
Patient

- 17 year old with persistent back pain (thought to be a sport accident)
- Suddenly developed “the worst headache of his life” followed by transient bilateral leg weakness
- CT showed a SAH
- “negative cerebral angiogram” outside institution
- MRI showed flow voids
- Transferred to BCVI
MRI
Right L4

AV shunt
Spinal Vascular Lesions

- Paraspinal (1)
- Vertebral Body (2)
- Epidural (3)
- Dural (4)
- Pial (5)
- Cord (6)
Arteriovenous Malformation (Type II)
Spinal AVM (Type II)

- second most common spinal vascular malformation
- Age< 40 yrs.
- acute myelopathy from IMH/SAH
- vascular steal, venous hypertension or venous compression, pain
- intermittent or progressive myelopathy with deterioration of limb function or bowel and bladder function
Arteriovenous Malformation (Type II)

- Repetitive bleeding with progressive deterioration
- Death in 4-10% secondary to SAH
- Hematomelia
- Wheel chair bound within 3 year from diagnosis 60 patients, 8 year f/u:
  - 36% of patients < 41 years of age
  - 48% of patients 41-61
Arteriovenous Malformation (Type II)

19 yr-old m, SAH, no deficit
Arteriovenous Malformation (Type II)
Arteriovenous Malformation (Type II)

ASA

Sulco-comm. Art.
Type II Spinal AVM
AVM (Type II) nBCA

Pre-Embo

Post-Embo (x6)
Extra-dural/intra-dural AVM (Type III)

- metameric or juvenile AVM’s.
- if entire metamere, i.e. skin, muscle, bone, dura and cord is involved, known as Cobb’s syndrome

Cobb S. Haemangioma of the Spinal Cord:
Spinal arteriovenous malformation associated with spinal metameric syndrome: a treatable cause of long-term paraplegia?

Linfante I, Tari-Capone T, Dabus G, Gonzales-Arias S, Samaniego

JNS 2012;16:408-13
14 year old who developed progressive bilateral leg weakness 4 years prior resulting in spastic paraplegia

- Wheel chair bound for the past 4 years
- Developing bilateral proximal arm weakness
- On exam: nevus in the torso, spastic paraplegia with sustained bilateral clonus
- Sensory anesthesia at T8
- Spastic bladder, bowel incontinence
Microcather angiography T8
Left T6 left intentionally unembolized
Patient

- Day after the procedure she started to feel her legs
- Two days later had some minimal proximal movement
- One month later was able to make steps at the parallel bar with support
Conclusions

- Spinal AV shunts can be deadly and highly disabling
- Deep knowledge and understanding of anatomy is essential
- In particular, connections between the extra and intradural vascular sections
- Endovascular treatment of spinal shunts is challenging but possible
Thank you
Spinal Vascular Lesions

Miscellaneous