Overview of Imaging of Myelopathy

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- Most common etiology of myelopathy is related to degenerative disease of the spine from osteophyte or extruded disc.

- The next common etiologies are spinal cord compression due to extradural
masses caused by metastatic disease to bone, trauma, primary neoplastic, infectious, inflammatory, neurodegenerative, vascular, nutritional and idiopathic disorders that lead to myelopathy.

- (Seidenwurm, et al., 2012)

Myelography

- Still has a role when MRI is insufficient, or there is poor correlation of physical findings with the MRI studies, or the use of MRI is precluded.
- e.g. patient's habitus, surgical hardware or medical devices

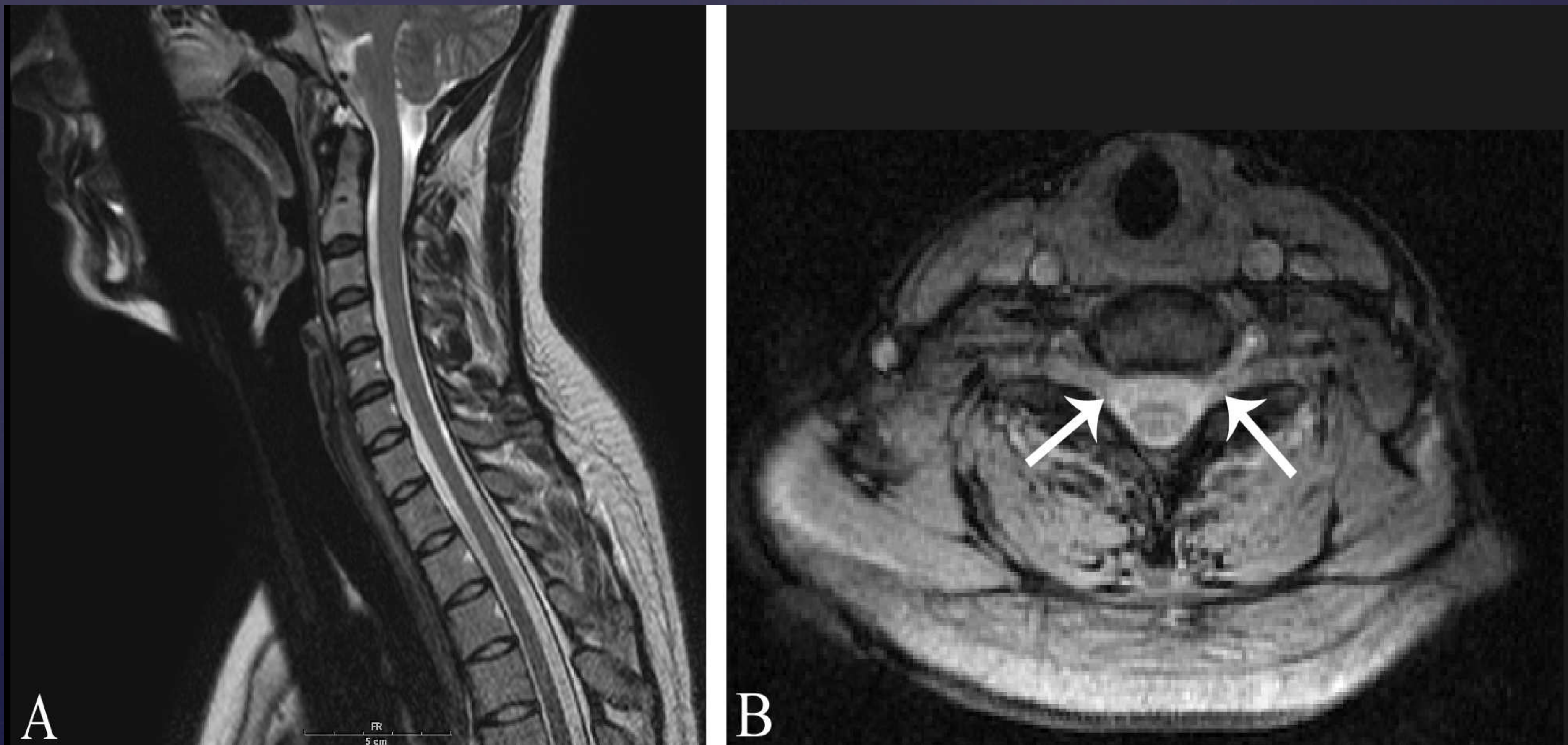


- T1, T2 weighted, T2* weighted images providing variable intrinsic tissue detail.
- Short tau inversion recovery (STIR) methods may better assess osseous, cord or ligamentous lesions.
- Fat Sat- suppression of the MR signal from lipid containing regions, where fat is dark on the images.
- Post contrast T1 are often acquired with a Fat Sat technique

Artifact

- T2* axial and sagittal images are less susceptible to CSF flow artifacts than T2 weighted fast spin echo images.
- Hardware artifact can be reduced by imaging the with lower magnetic field strength unit and by choosing acquisition parameters which limit artifacts due to magnetic field inhomogeneity. Multiple venders.
- Placement of saturation pulses to suppress of artifacts from blood flow or breathing.
- Gibbs or truncation artifact-pseudosyrnix-matrix size, filters, fat supression

Normal Cervical Spine/Saturation pulse



- T2* acquisitions have increased sensitivity to tissue inhomogeneity and provide better resolution of hemorrhagic products, calcium, metallic artifact, along and less sensitive to CSF flow artifact than spin echo T2 views.

- T2 spin echo view are less susceptible and provide better resolution with metallic fusion studies.

Spondylotic Myelopathy

- Spondylosis is a result of new bone formation in areas where the annular ligament is stressed

- Central canal stenosis
- Diffuse idiopathic skeletal hyperostosis (DISH) also known as Forestier's disease
- Ossification of the PLL
- Foraminal Stenosis
- Disc disease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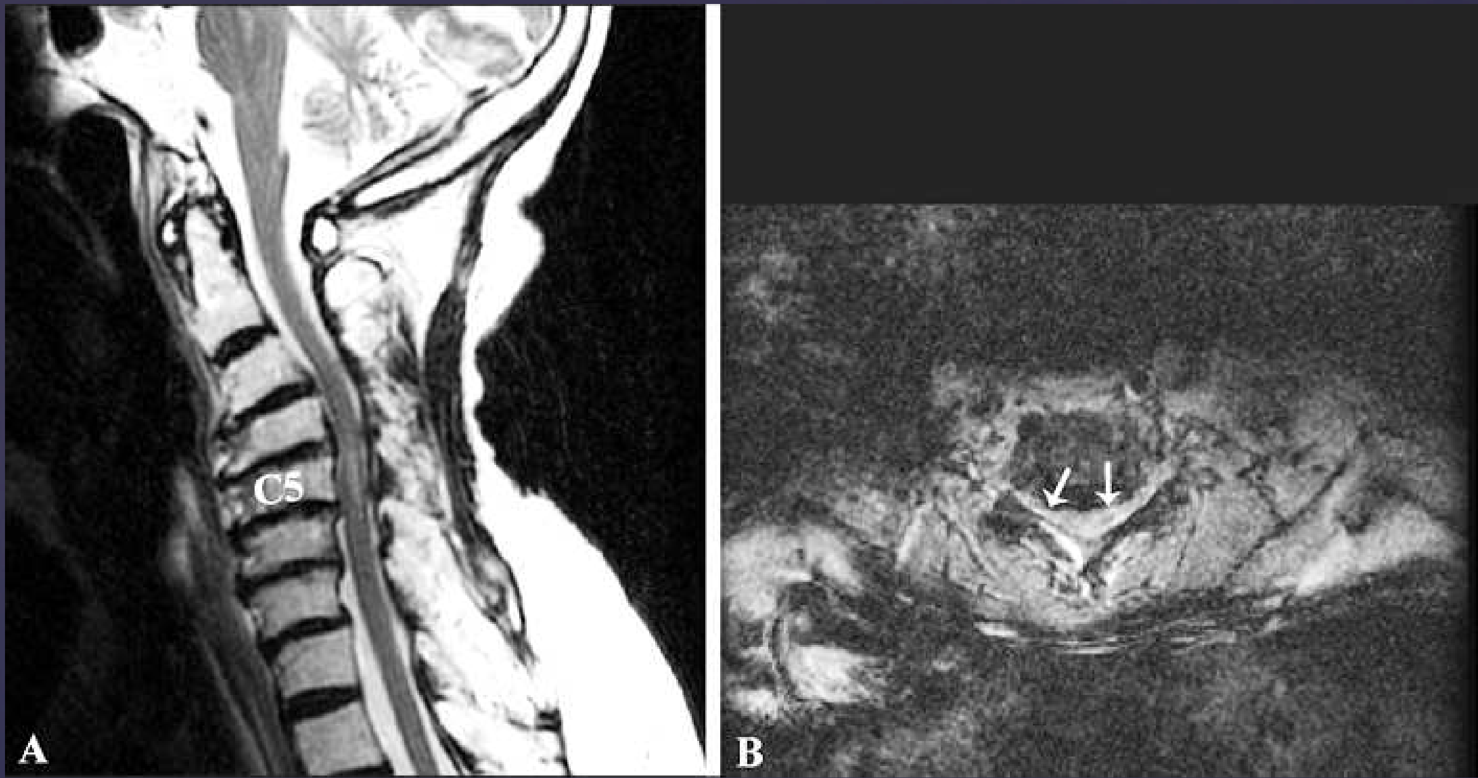
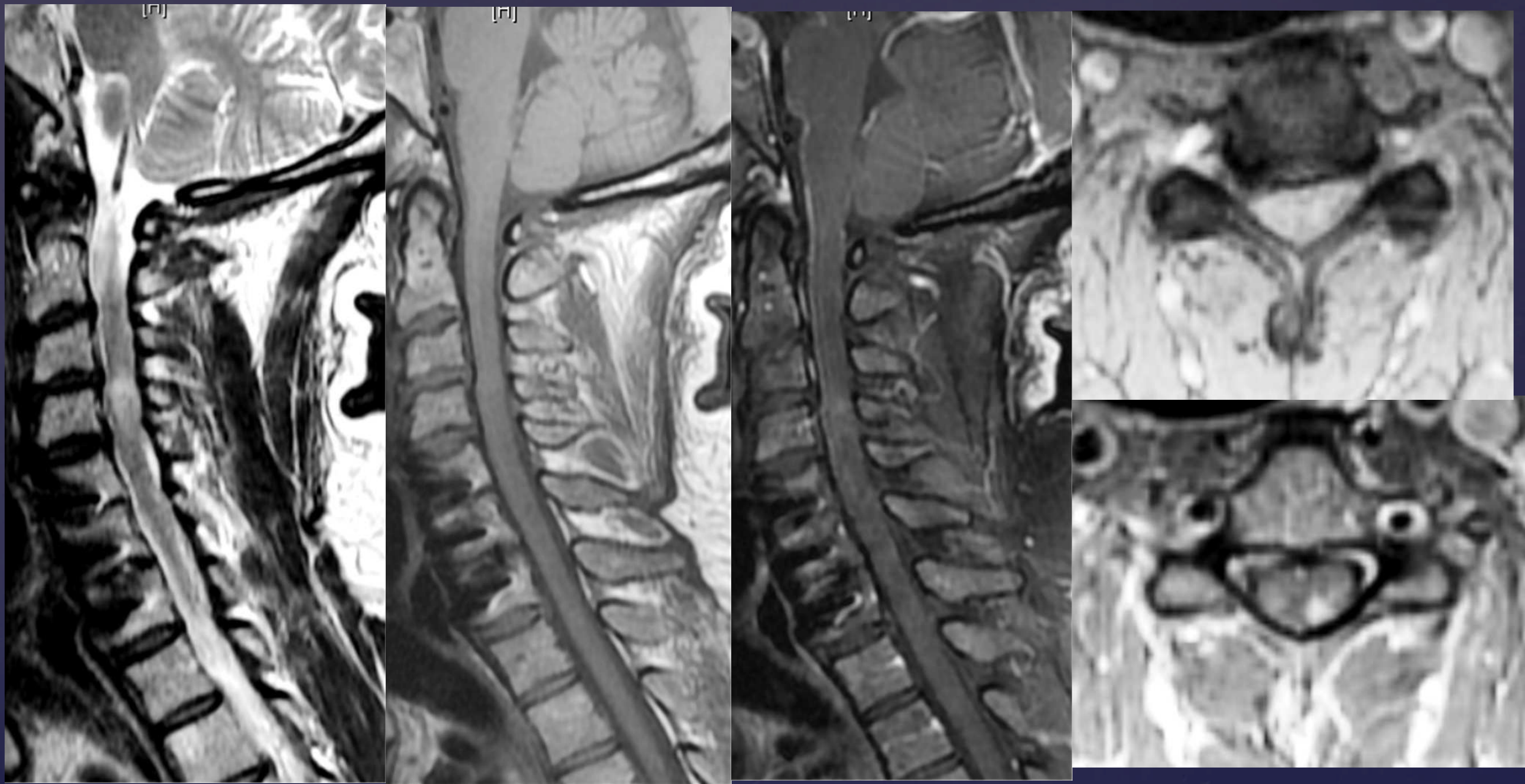
Spondylotic Myelopathy



The cord in average anteroposterior and transverse diameter 8.7 mm x 14 mm at C4 to 7.4 mm x 11.4 mm at C7. AJNR 11:369-372, 1990

“Absolute stenosis” has been defined as a sagittal canal diameter <10 mm and a “relative stenosis” as a canal diameter <13 mm, and a normal sagittal diameter in the mid-cervical spine of 17–18 mm.
HSS J. 2011 Jul; 7(2): 170–178

Edema associated with Foraminal Stenosis



Venous hypertensive myelopathy as a potential mimic of transverse myelitis

Spinal Cord (2004) **42,** 261–264.

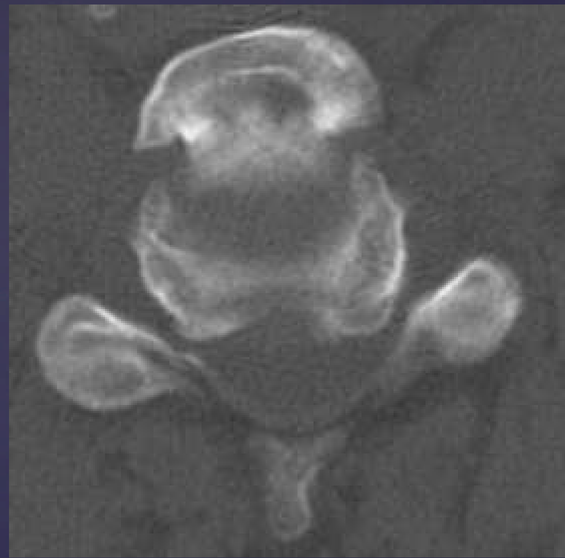
Diminished venous return, likely of medullary veins draining through the intervertebral foramina results in decreased venous return from the spinal cord and caused the development of venous hypertensive myelopathy.

Venous plexus are compressed just prior to the intervertebral foramen. The veins draining the spinal cord to this point are valve less and therefore, effectively transmit backflow of venous drainage into the spinal cord. Veins at or distal to the junction of the medullary veins and the vertebral plexus have valves and, therefore, compression at or distal to the intervertebral foramina would result in limited backflow of venous blood into the spinal cord.

?Venous hypertensive myelopathy vs arterial

A congenitally small spinal canal predisposes to the development of myelopathy. In a series of 63 patients, 40 (63%) had developmentally narrow canals.

The arterioles that branch from the anterior spinal artery may be mechanical compressed leading to ischemia of cord

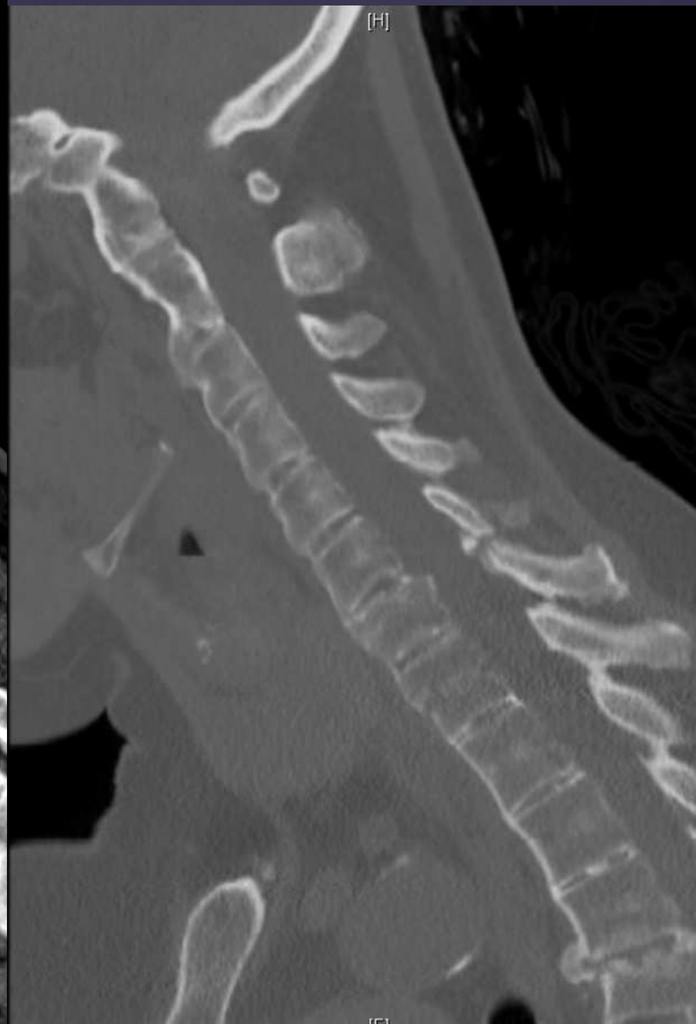


Diffuse Idiopathic Skeletal Hyperostosis

Diffuse idiopathic skeletal hyperostosis (DISH), also known as Forestier's disease is a non-inflammatory spondyloarthropathy of the spine.

Ossification of the ligaments and entheses. The most commonly affects the thoracic and thoraco-lumbar spine, but involvement is variable and can include the entire spine.

Ankylosing Spondylitis



Ankylosing Spondylitis

Ankylosing spondylitis is a systemic rheumatic disease, and a seronegative spondyloarthropathy

Ossification of the fibrous ring of the annulus (Bamboo spine)

TNF-Alpha and HLA B27

Uveitis

Psoriasis

Colitis

Interstitial lung disease

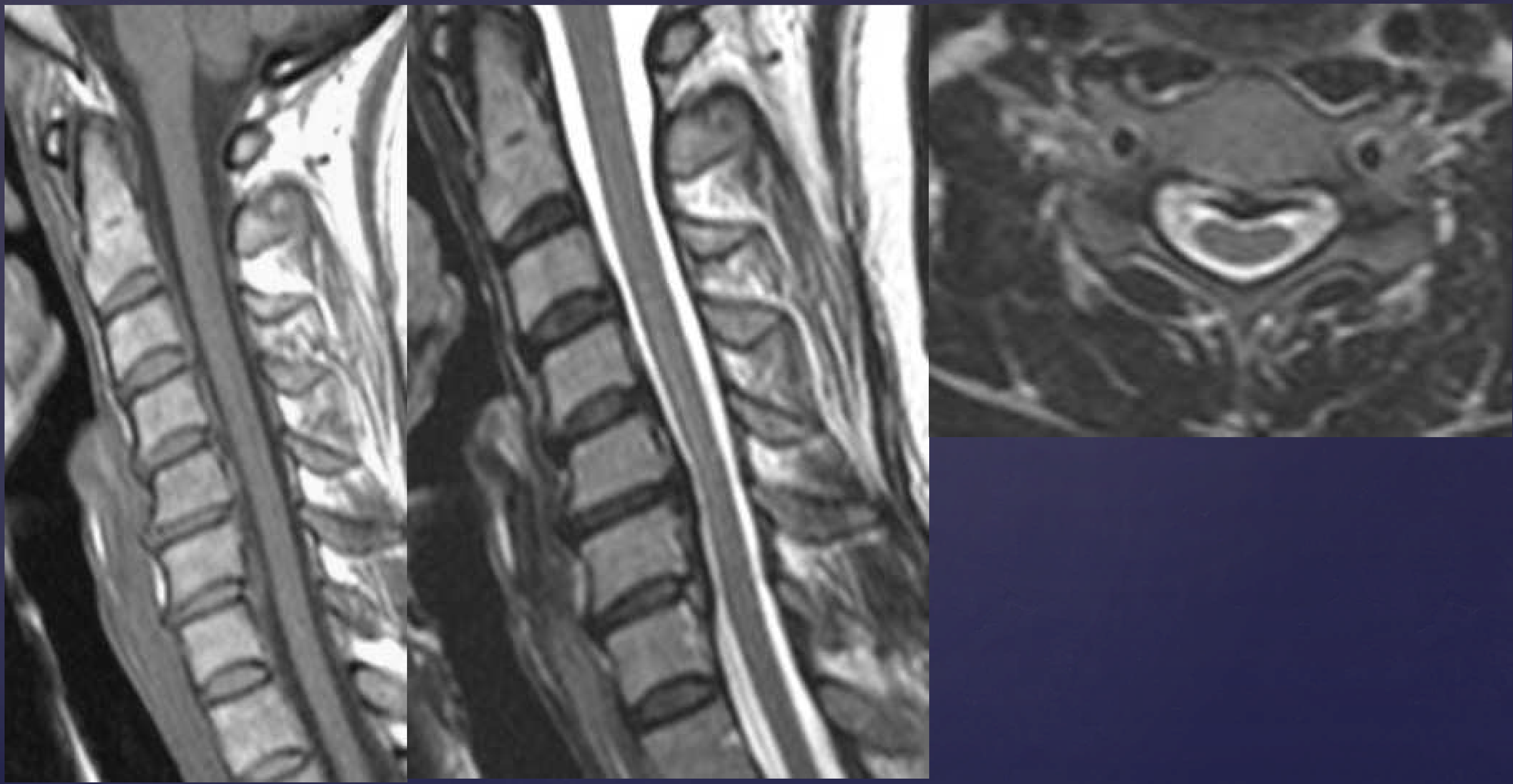
Aortic valve disease

Aortitis

Amyloidosis

Radiopaedia.org

Ossification of the Posterior Longitudinal Ligament



Up to 25% of patients presenting with cervical myelopathy have features of OPLL.

Neurosurg Focus 13:2ECP1, 2002

Trauma

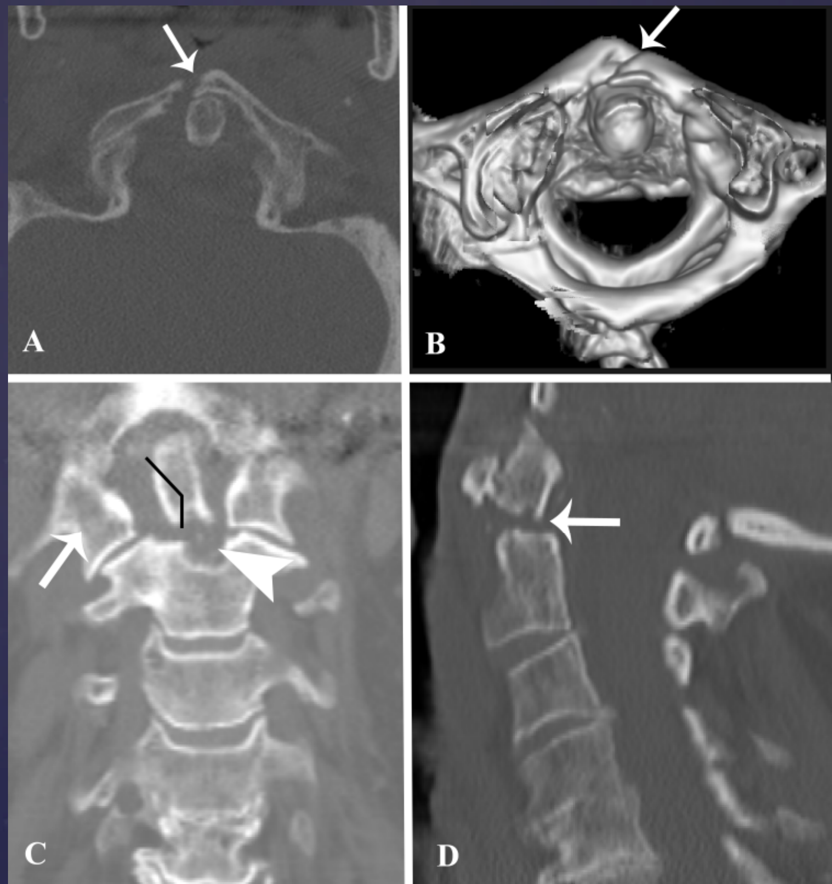
MRI and CT are complimentary

- MRI for visualization of the architecture of the injured spinal cord parenchyma and the surrounding structures.
- CT is better in the evaluation of osseous trauma.
- STIR sagittal views should be included in all spine trauma due to fat signal suppression with increase sensitivity for edema in the cord, ligamentous or other soft tissues along with improved sensitivity for acute subtle osseous fractures.

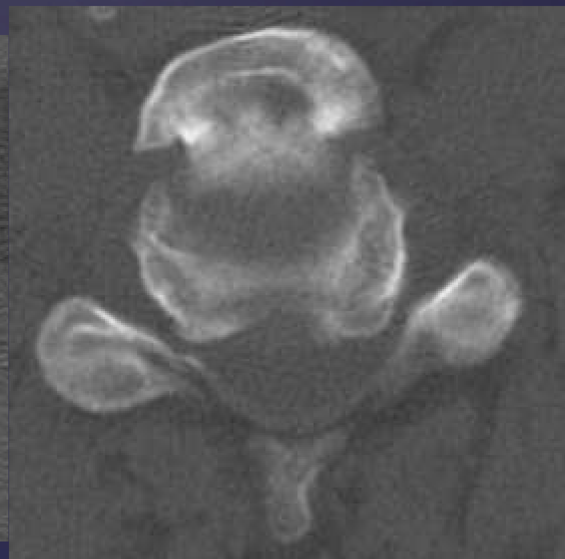
Spine Trauma-Overview

Annual Incidence between 11,000 and 13,000 in US

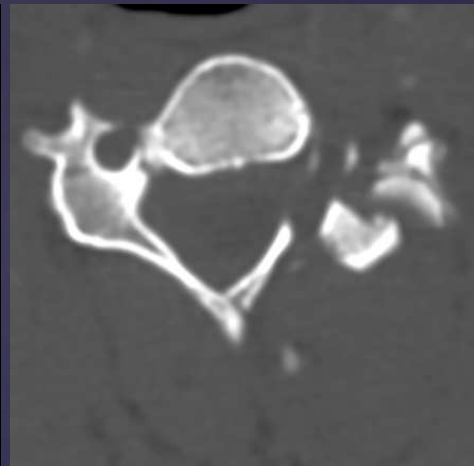
1. 5 to 6% of significant motor vehicle accidents result in spinal fractures. The majority at the L1, L2 or T12 level.
2. 1/2 occur at C6, C7
3. 1/3 of cervical injuries occur at C2











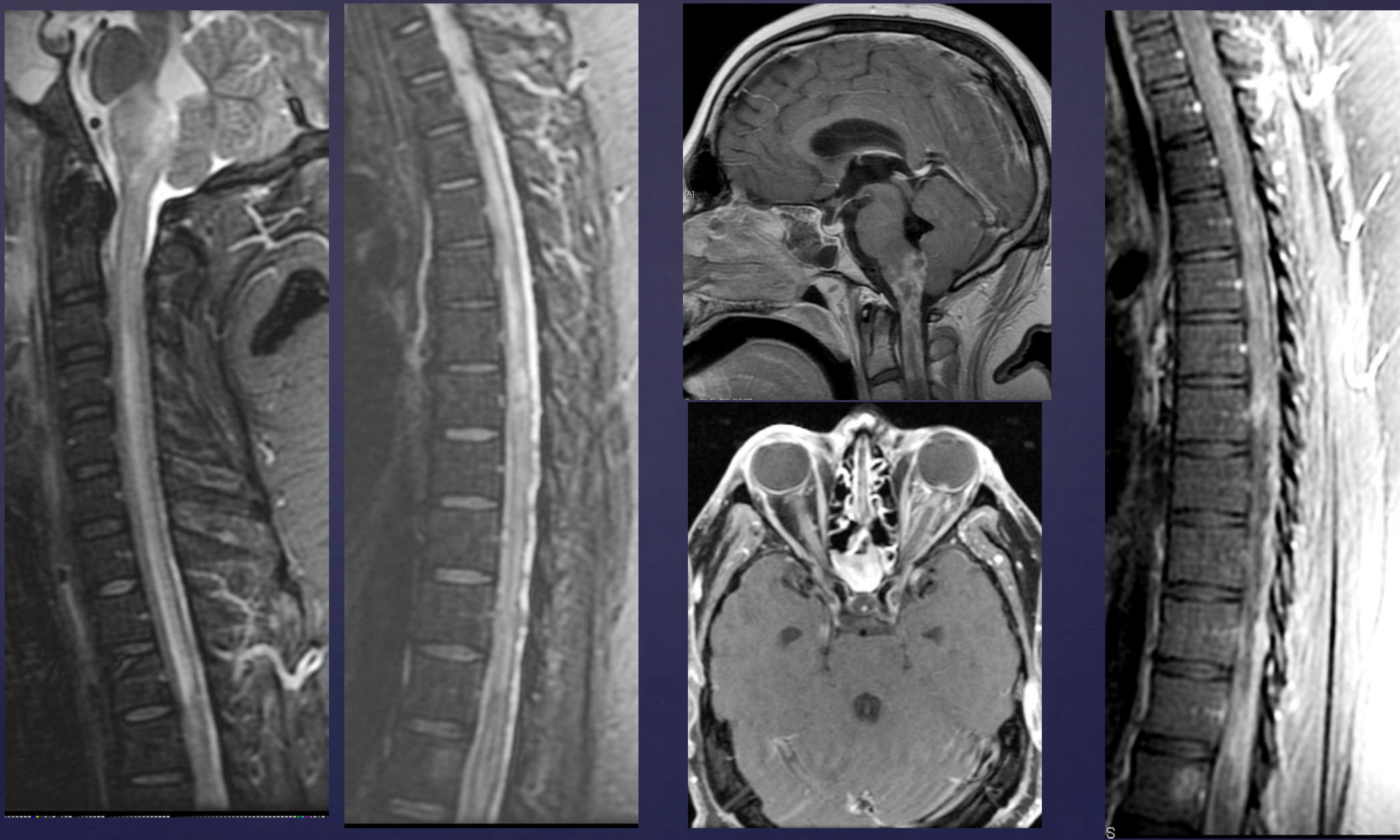
MVA

MVA

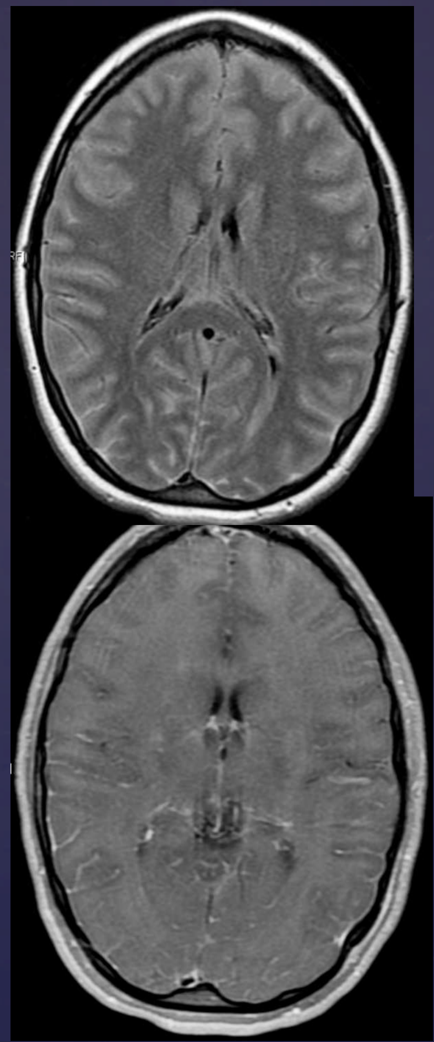
Inflammatory/Autoimmune/Demyelinating Diseases of the Spinal Cord

- Acute transverse myelitis is a broad clinical syndrome associated with cord inflammation due to numerous etiologies e.g. infections, vaccinations, paraneoplastic syndromes, systemic lupus erythematosus, neuromyelitis optica

Neuromyelolitis optica



Neuromyelitis optica



Multiple Sclerosis

- Multiple sclerosis lesions generally do not involve the entire cross-sectional area of the cord, are located peripherally and are not confined to the boundaries between gray and white matter and extend two levels or less.

- Gradient echo, STIR and proton sequences depict more cervical cord plaques than fast spin echo sequences

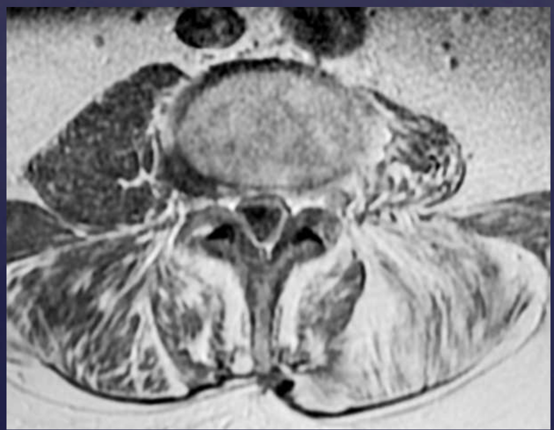
- DTI and anisotropy can improve the sensitivity and detect abnormalities that may otherwise have a normal appearance on T1 and T2 imaging. (Tanenbaum, 2013).

Multiple Sclerosis

Neurosarcoidosis

- Neurosarcoidosis is characterized by arachnoid infiltration by lymphocytes and granulomatous nodules most common is the cervical spinal cord followed by the thoracic and lumbar regions.

- MRI findings may include focal expansion of the cord with diffuse T2 hyperintensity or a mass-like intramedullary enhancement, smooth or nodular leptomeningeal enhancement with patchy peripheral cord enhancement with infiltration of perivascular spaces.
- (Kasliwal, et al., 2013) (Mendonca, 2002).



Neurosarcoid

Acute disseminated encephalomyelitis

- Acute disseminated encephalomyelitis (ADEM) is an uncommon acute immune mediated demyelinating disorder of the brain and spine occurring 1-3 weeks after a nonspecific viral illness or vaccination. ADEM more frequently occurs in children and young adults.

- On MR there are ill defined hyperintense lesions on T2 images and hypointense on T1 images. The lesions are usually larger and extend over a longer segment of spinal cord with cord expansion. The thoracic cord is most commonly affected.

Rheumatoid Arthritis

- Rheumatoid arthritis of the cervical spine is characterized by an autoimmune reaction to the synovial joint cells leading formation of pannus and odontoid erosion.
- Contrast enhancement has prognostic value and correlates with disease activity and bone destruction. British Journal of Rheumatology 1996;35(suppl 3)26-30

Infectious Diseases of the Spine

- The most common route is via hematogenous spread, there can be extension from the brain and meningeal infections as well as vertebral osteomyelitis.

- Bacterial infections of the spinal cord of different etiologies have similar appearances

- Spinal tuberculosis can present as a vertebral mass, extension of tuberculous spondylitis into adjacent ligaments and soft tissue, creating a paravertebral mass and intramedullary spinal tuberculomas in 2% of tuberculosis in the CNS “target sign”

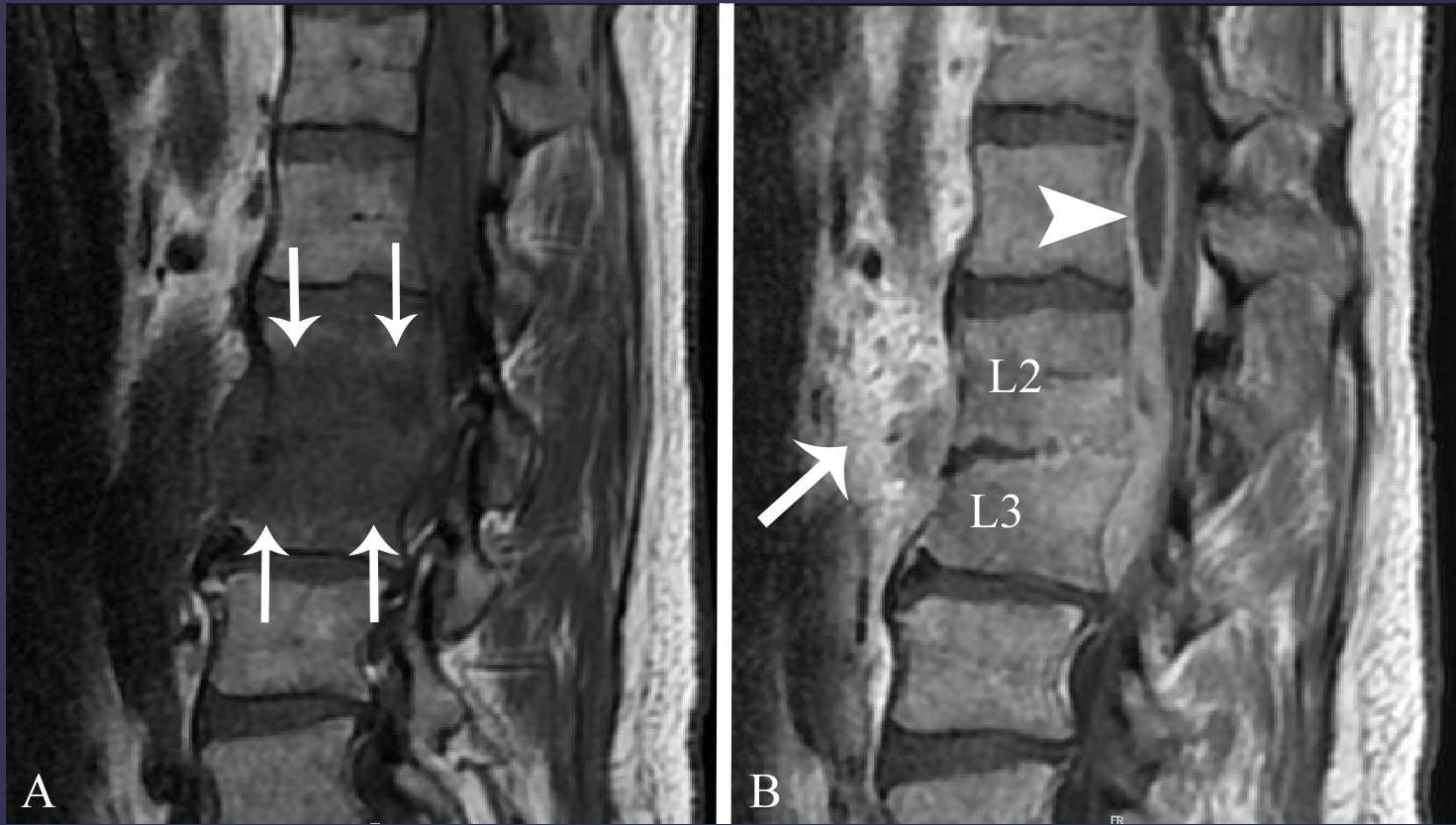
- Syphilitic myelitis- nonspecific hyperintensity on T2 weighted images of the cord. The post-contrast images may also have enhancement of the pia and the spinal cord nerve roots. T2 images may represent reversible edema, ischemia, or cord infarction.

- Fungal infections involving the spinal cord are due to pathogenic fungi or an opportunistic infection in an immunocompromised individual. Spine involvement can present as osteomyelitis, discitis, meningitis, abscess and granuloma formation, and, thrombosis with cord infarction. Candida and aspergillosis are the most common opportunistic infections. (Lucas, et al., 2008) (Williams, et al., 1999)

- Parasitic infections-the most common is neurocysticercosis which may either be a primary isolated spinal infestation or a secondary extension from intracranial cysticercosis. The scolexes may be located intra or extra medullary.

Infectious Discitis

Infectious Discitis/Epidural Abscess

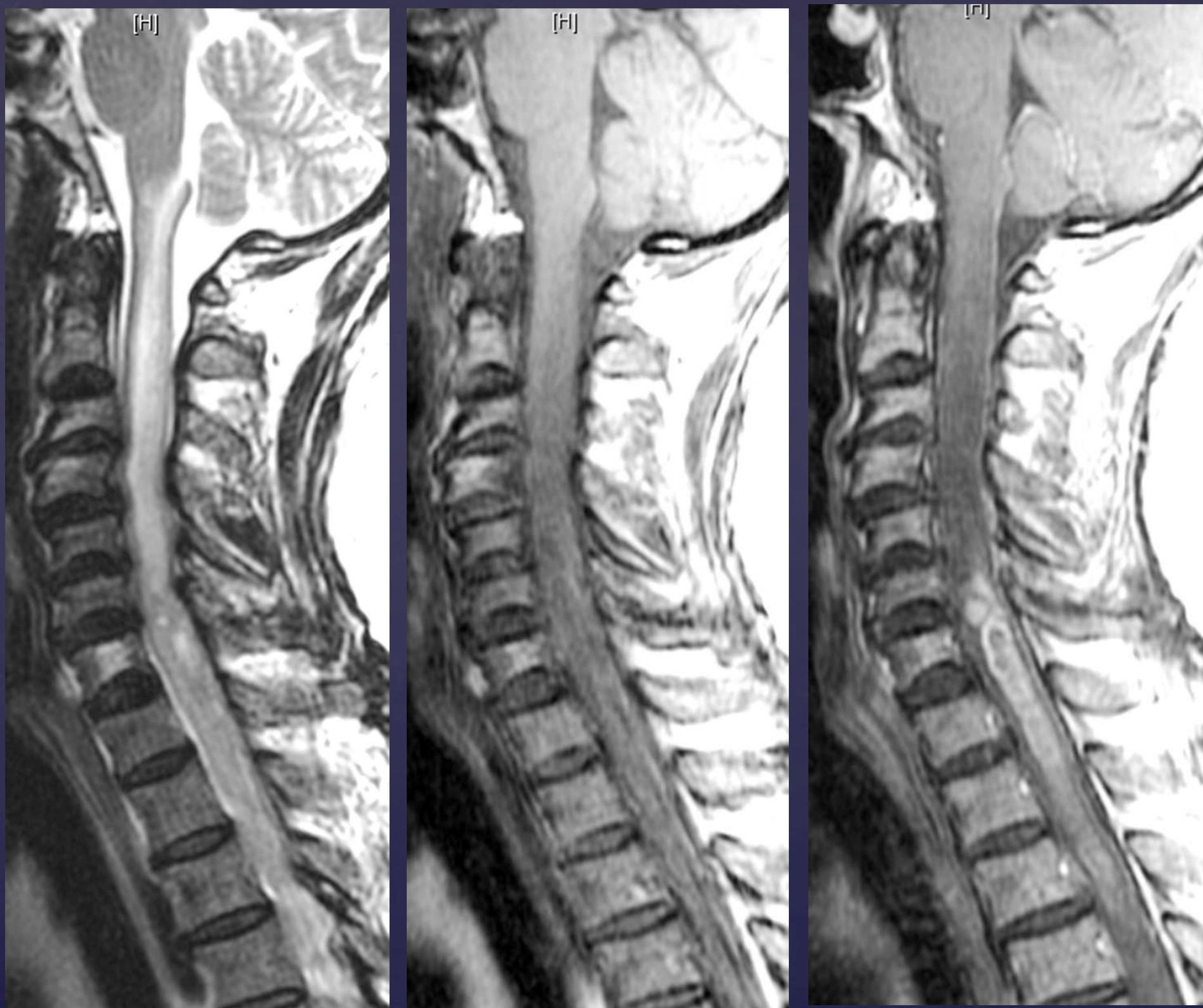


A. Sagittal T1-weighted view of the lumbar spine demonstrating hypointensity of the L2 and L3 vertebral bodies due to replacement of the normal fatty marrow (typically bright on T1) with inflammatory cells and edema.

B. Sagittal T1 post-contrast view. Note the mild loss of vertebral body height anteriorly at L3 as a result of pathologic fracture from infection. Anterior to thecal sac is an epidural fluid collection, with a non-enhancing abscess adjacent to L1 vertebral body (arrowhead). Significant inflammation from infectious spread also seen anterior to vertebral bodies (arrow).

Epidural Abscess

Nocardia Abscess



Viruses

- Most commonly affect the spinal cord:
- The herpes viruses : 1. varicella zoster, herpes simplex 1&2 , Epstein Barr, cytomegalovirus (CMV),
- 2. Enterovirus
- 3. retroviruses (HIV and HTLV-1)

- With a few exception all viral myelopathies show abnormal T2 weighted signal within the cord.
- The herpes simplex virus 2 and the varicella-zoster virus may produce a necrotizing myelopathy
- (Mendonca, 2002).

- Cytomegalovirus infection, may also produce a polyradiculomyelitis with radicular pain, rapidly ascending progressive paraparesis and urinary retention:
- On pre contrast images thickening of the cauda equina and an ill-defined conus and hyperintensity of the cord on T2.
- On post contrast images, diffuse enhancement of the cauda equina and the surface of the meninges. The nerve roots are clumped and adherent to the walls of the thecal sac.
- (Gorsane, et al., 2013) (Tselis, 2014).

Less common viral myelitis

- Polio
- Enterovirus D-68
- Enteroviris A71
- West Nile Virus-Flavivirus
- Arboviruses

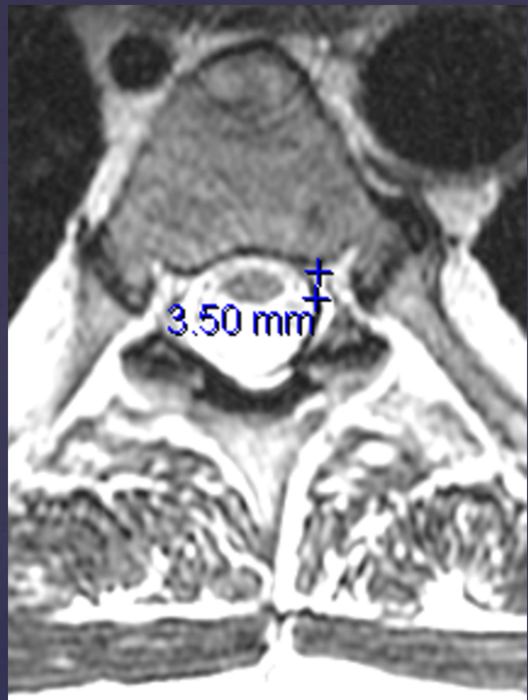
- Most have increased T2 signal of spinal grey matter, edema and CSF pleocytosis

- The HTLV-1 (tropic spastic paraparesis) show demyelination and axonal damage in the lateral and anterior columns with diffuse swelling of the spinal cord with increased T2 signal and in chronic state- cord atrophy (Gessain & Mahieux, 2012). (Alcindor, et al., 1992).

HIV Myelopathy

- The majority of patients (86%) with a clinical diagnosis of AIDS-associated myelopathy had abnormal MR findings in the spinal cord:
- most commonly, spinal cord atrophy (seen in 72% of patients),
- intrinsic cord signal abnormality (increase T2 signal) (29%).
- Fourteen percent of patients had both cord atrophy and intrinsic cord signal abnormality.
- AJNR 20:1412–1416, September 1999

HIV Myelitis



Spinal Cord (2004) **42,** 35–40.

Vascular disorders of the spine

- MR angiography or CT angiography are adjunctive modality of vascular pathology to digital subtraction angiography

- DWI are useful for ischemic infarction.

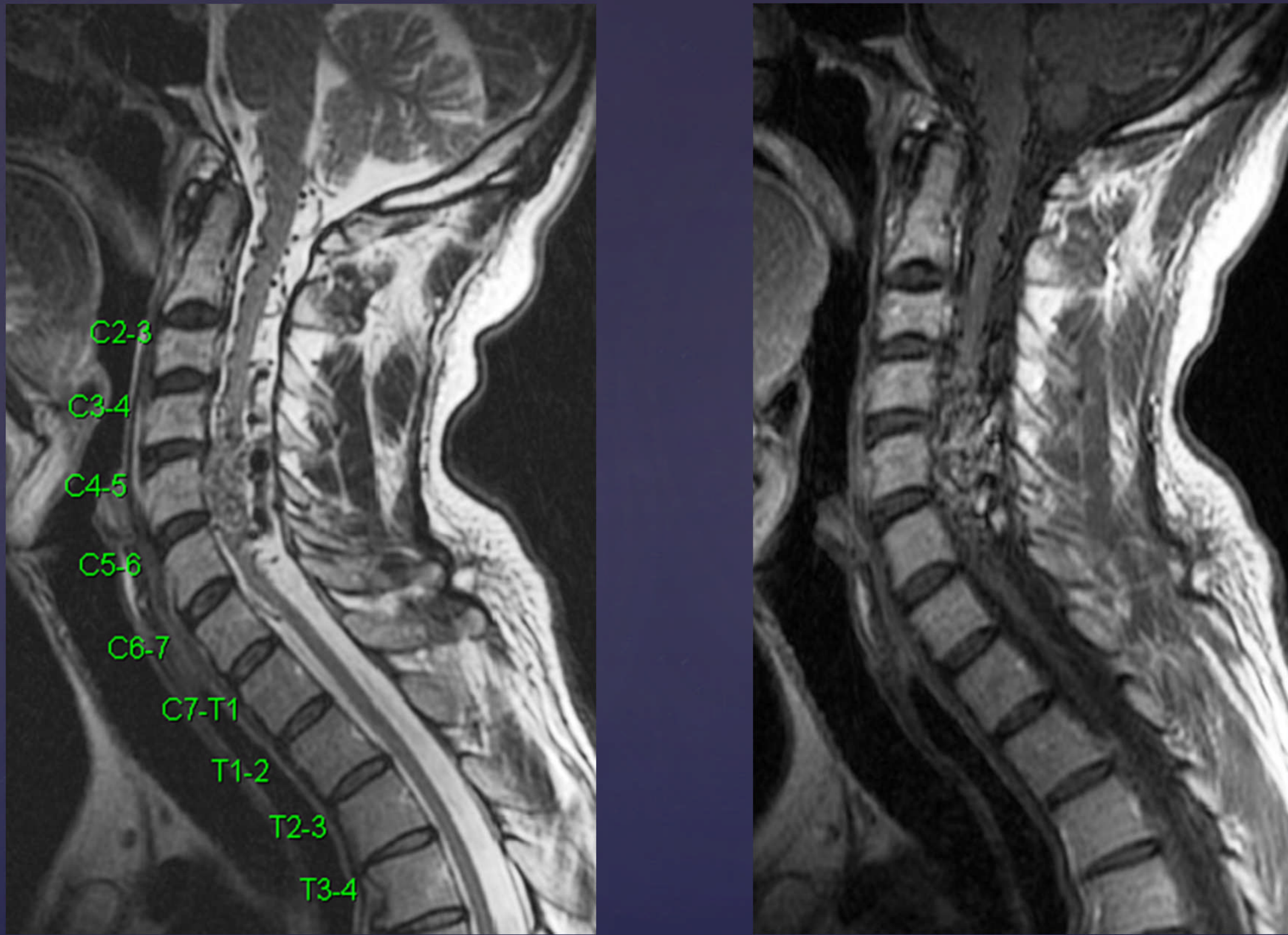
- Susceptibility weighted images (SWI) in delineating the detail of vascular malformation or hemorrhage and extrinsic spinal veins (2010).

- Dural arteriovenous fistulas are acquired lesions that arise via an abnormal communication between an artery and a cord vein.
- They are typically located in the lumbar and thoracic regions. MRI, MRA and catheter angiography will show the exact location of the fistula.
- Pre contrast T1 images will reveal multiple irregular flow voids along the surface of the cord.
- The post contrast T1 images will show enhancement of the veins along the cord surface. Sagittal and axial T2 images will demonstrate the cord edema and the flow voids from enlarged pial veins. (Cenzato, et al., 2004).

- Cord AVMs are congenital defects in vascular formation and have a nidus of vessels on or within the spinal cord supplied by feeders from the anterior and/or posterior spinal arteries into draining veins. Hemorrhage is common.

- T2 weighted images reveal multiple dilated extramedullary and intramedullary blood vessels forming a nidus and will demonstrate diffuse hyperintensity due to cord edema. There may be post-contrast intramedullary enhancement.

- Angiographic evaluation is required to plan treatment.



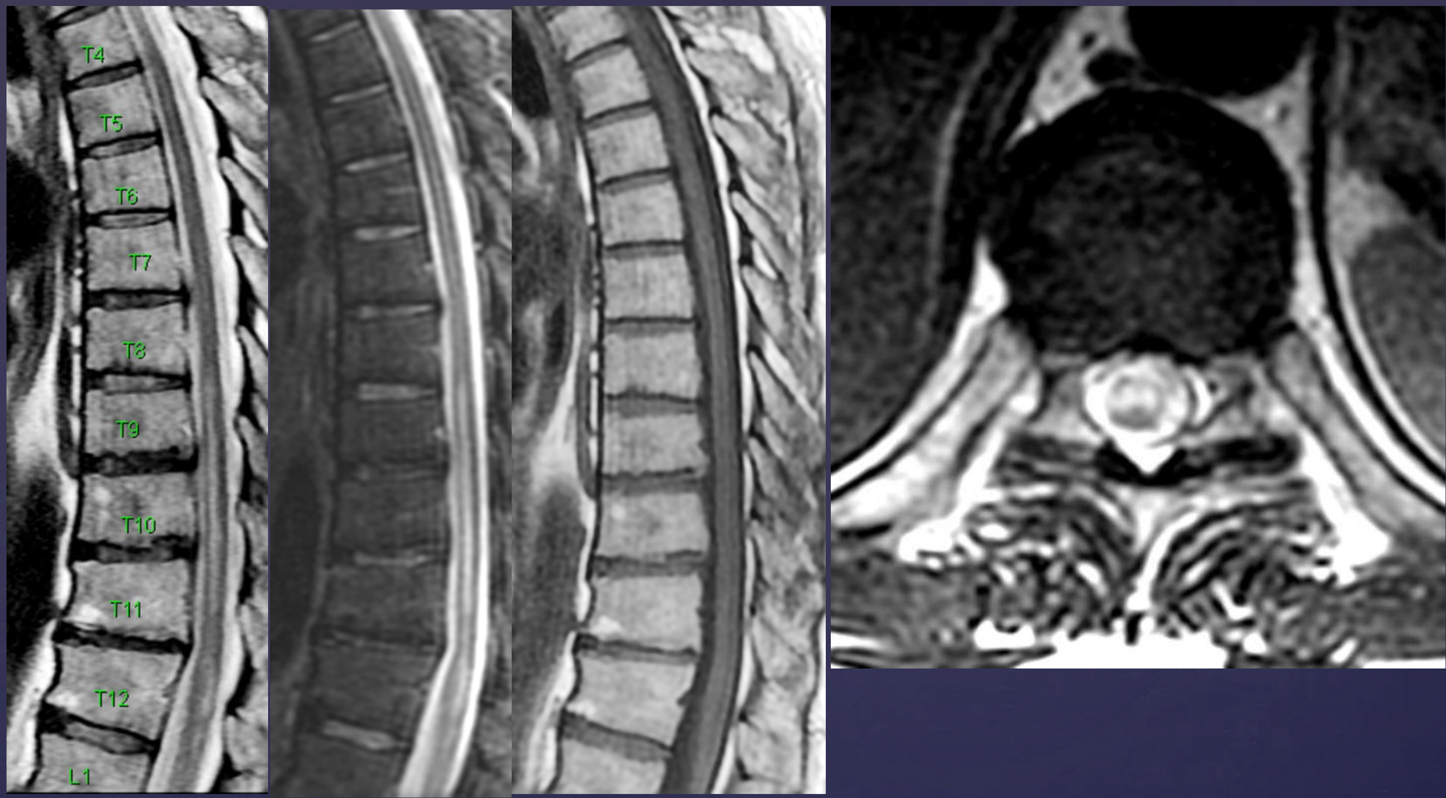
AVM

- Cord cavernous malformations are composed of dilated vascular sinusoids with hemosiderin.. Progressive myelopathy or hematomyelia may result. T1 and T2 images will have a heterogeneous signals.

- Cord infarctions are commonly due to atherosclerosis, hypertension, diabetes , etc. more common with the anterior spinal artery.

- Venous infarcts are rare and often associated with hypercoagulability, DAVFs, or fibrocartilaginous emboli.

Spinal Cord Infarct



T2 hyperintensity seen from T8 to T12 levels due to cord ischemia in the anterior spinal artery distribution.

- Spinal epidural hematomas are more common than the subdural, although they may occur concurrently. Predisposing factors include coagulopathy, trauma, vascular malformations, post-procedural complication, and are often spontaneous.

- MRI the sagittal images of epidural hematomas compression of the thecal sac and appear as a biconvex shape on axial views. The subdural hematoma will show diffuse filling of the subdural space on sagittal images with evidence of cord compression.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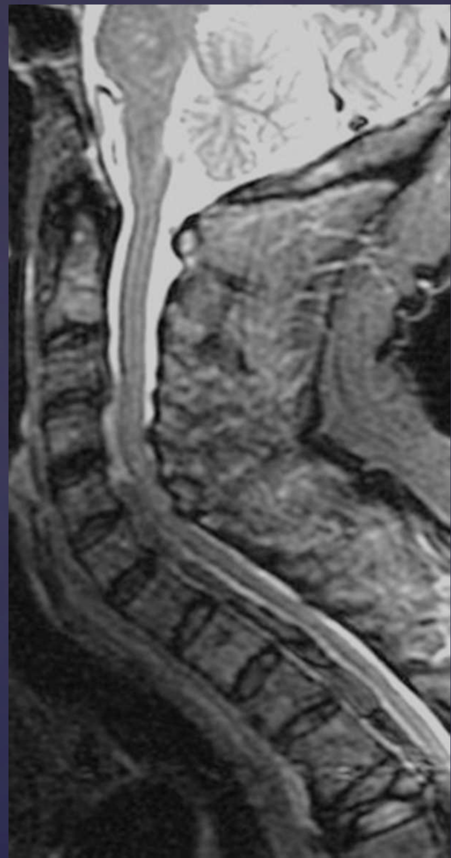
EPIDURAL HEMORRHAGE
Day 1





EPIDURAL HEMORRHAGE DAY 4

Dating Hemorrhages

Extracranial blood products age differently than intracranial blood products, often have a heterogeneous appearance, confounding attempts at reliably dating of an extracranial hemorrhage

Spinal Neoplasms

- CT of the spine -presence of lytic or sclerotic lesions.
- MRI will reveal vertebral or extradural metastasis. Generally low intensity on the T1 images.
- On T2 weighted images, can have variable appearance of hypo, iso, or hyperintensity.
- DWI can be a useful adjunct on this setting, allowing for greater sensitivity.
- When evaluating for metastasis, post contrast images with fat suppression are useful.

Prostrate Carcinoma

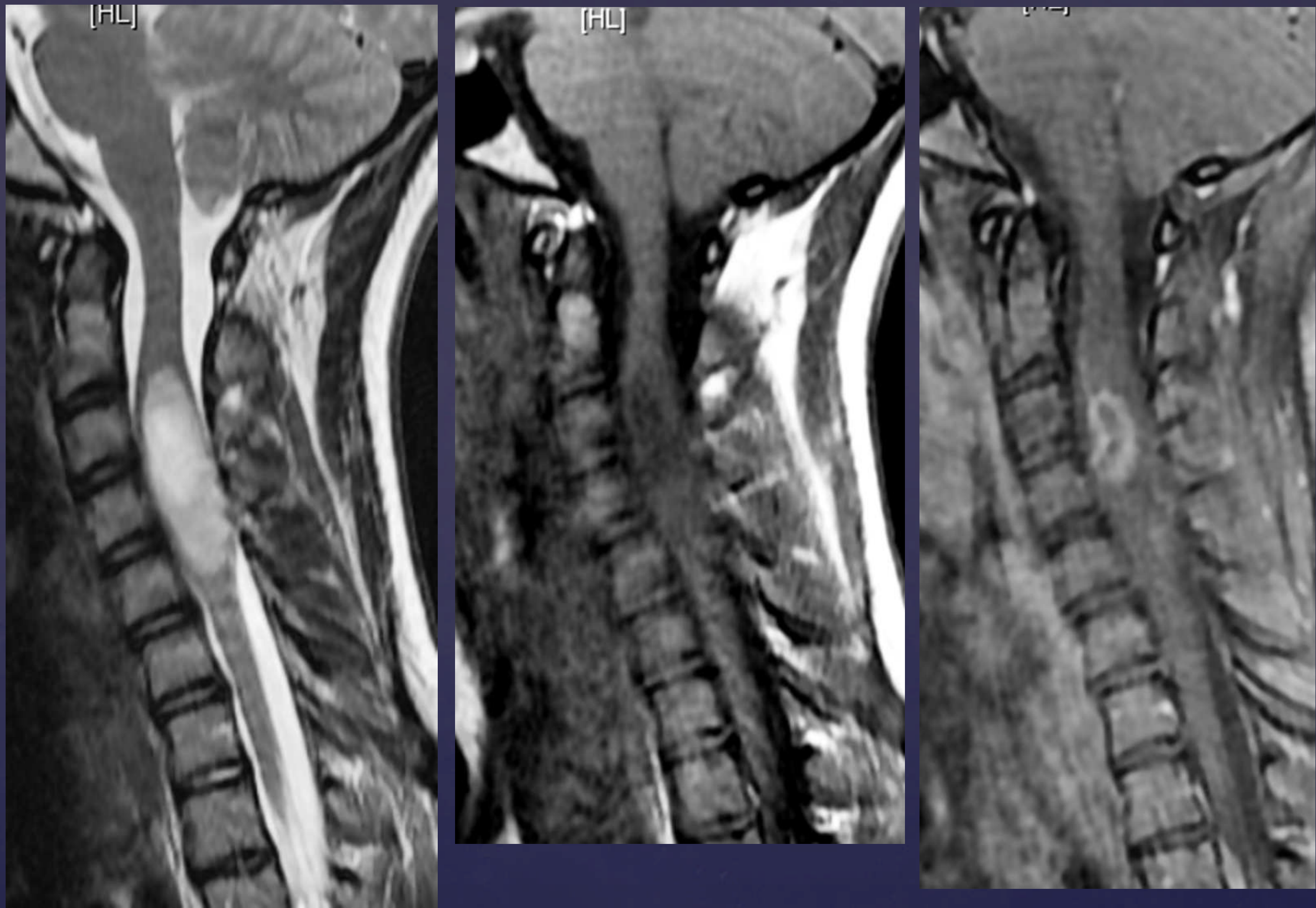
Pancreatic Ca

Lymphoma

Primary Cord Tumors

- Ependymomas are the most common primary intramedullary tumors, typically occurring in the lower spinal cord. 64% of spinal cord ependymomas have evidence of prior hemorrhage. They typically have well-defined margins.
- Spinal cord astrocytoma are the second most common primary intramedullary lesion:
- On T1 the lesions are low intensity and demonstrate marked cord enlargement. On post contrast images, may enhance and there are irregular borders.
- On T2, the lesions and edema show a high signal, often astrocytomas involve the entire or a large portion of the length of the spinal cord (Seo, et al., 2010)

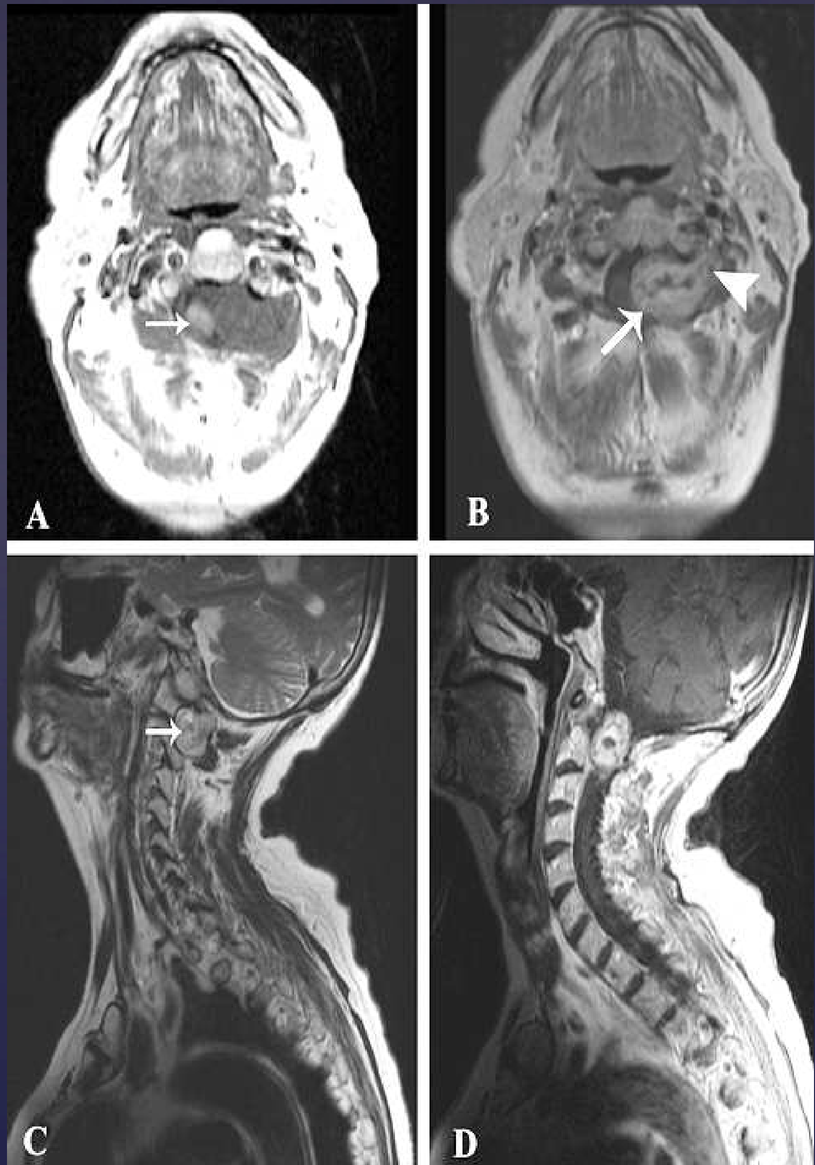
Cord Glioma



- Meningiomas are located posterolateral to the spinal cord. On T2, slightly hyperintense, and can be well seen in contrast to the intrinsically high signal from the CSF (Mechtler & Nandigam, 2013).

- Intradural extramedullary tumors, e.g. nerve-sheath tumors:
- On CT have decreased attenuation and present as a paraspinal and intraspinal mass.
- On MRI there is iso or hypointense signal intensity on non-contrast T1.
- On T2 there is marked increased signal intensity and frequently a central area of decreased signal intensity more characteristic of schwannomas.

Nerve Sheath Tumor

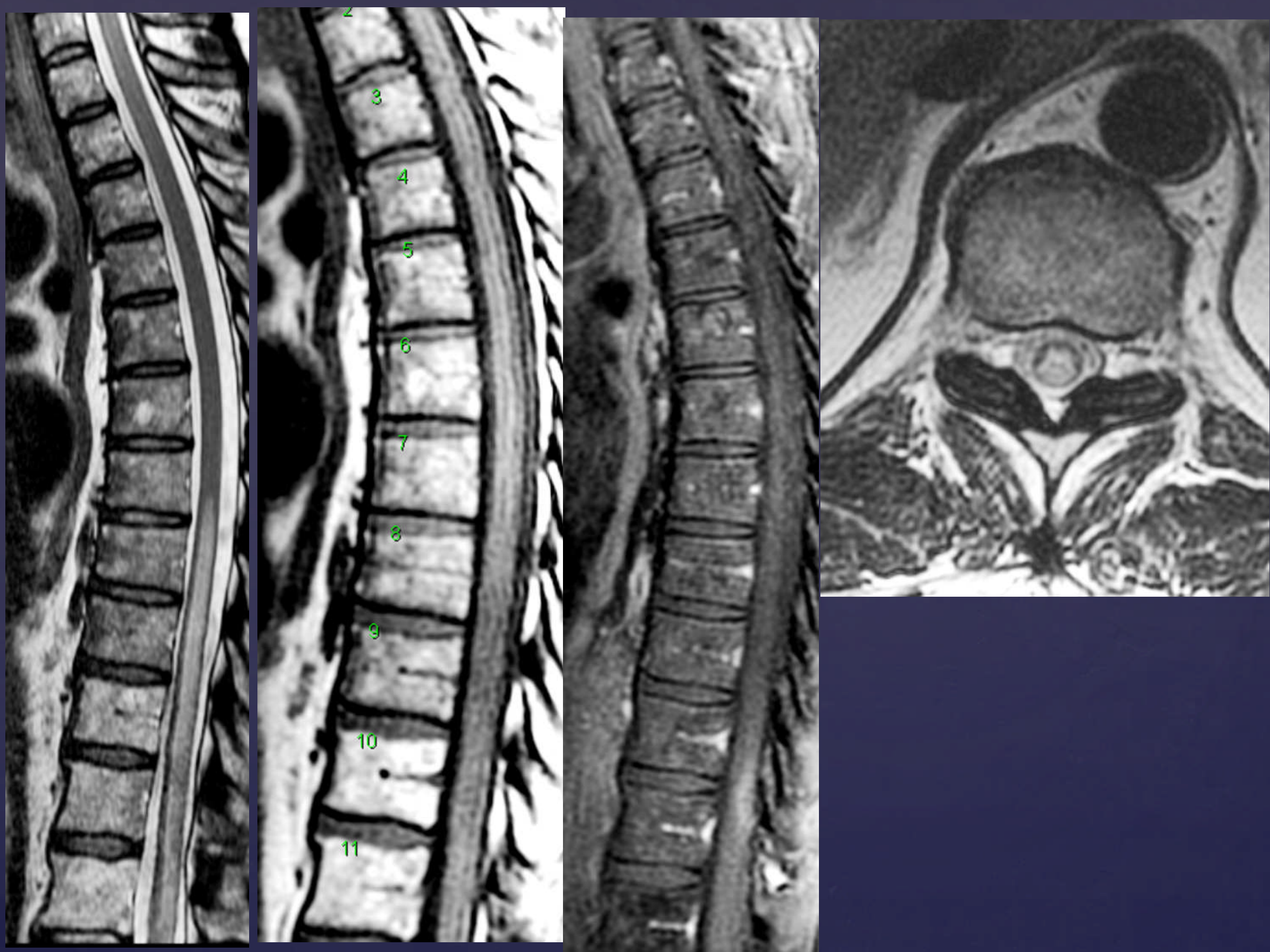


NEUROFIBROMATOSIS

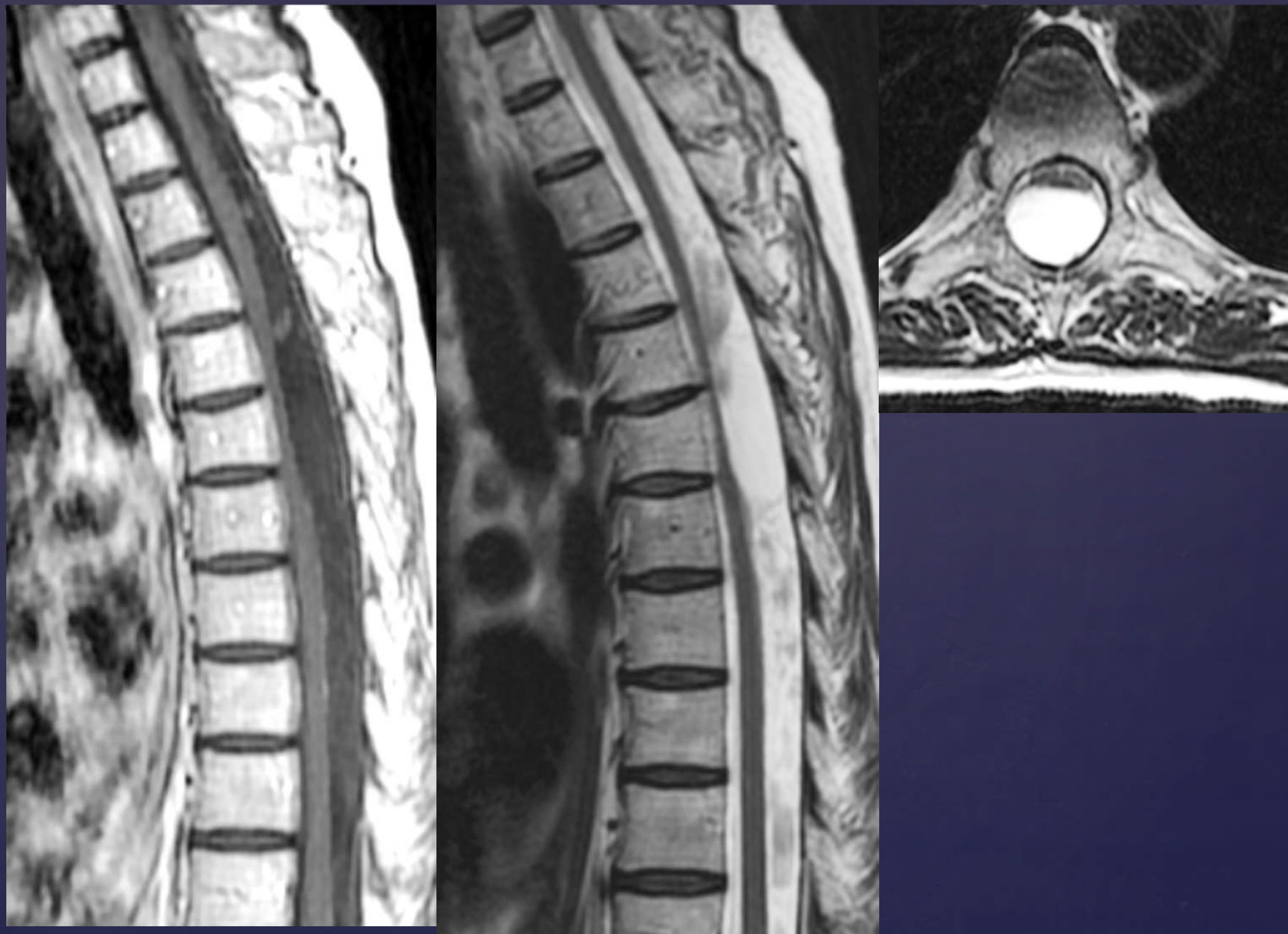


Thoracic Meningioma

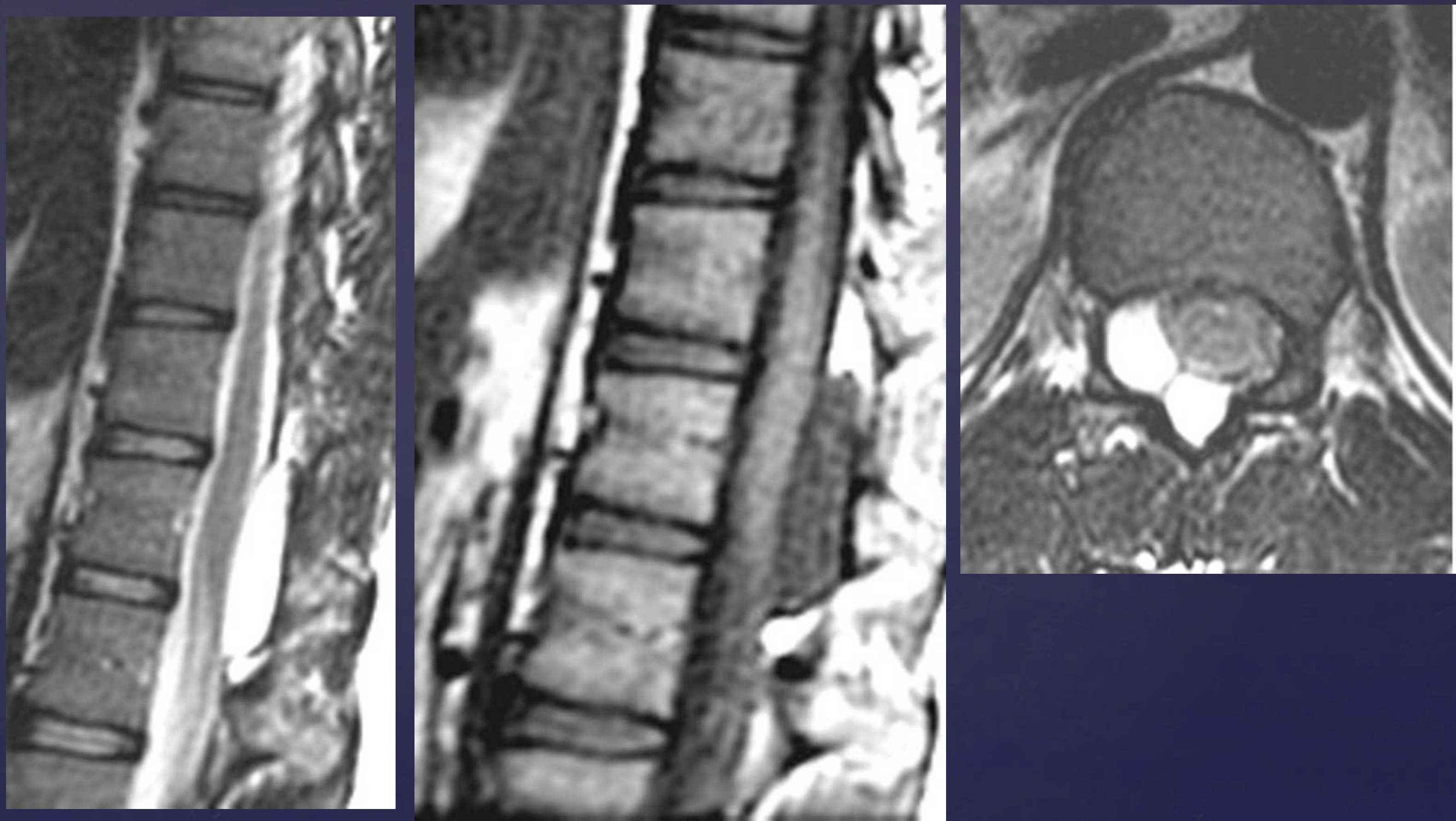
Radiation myelitis

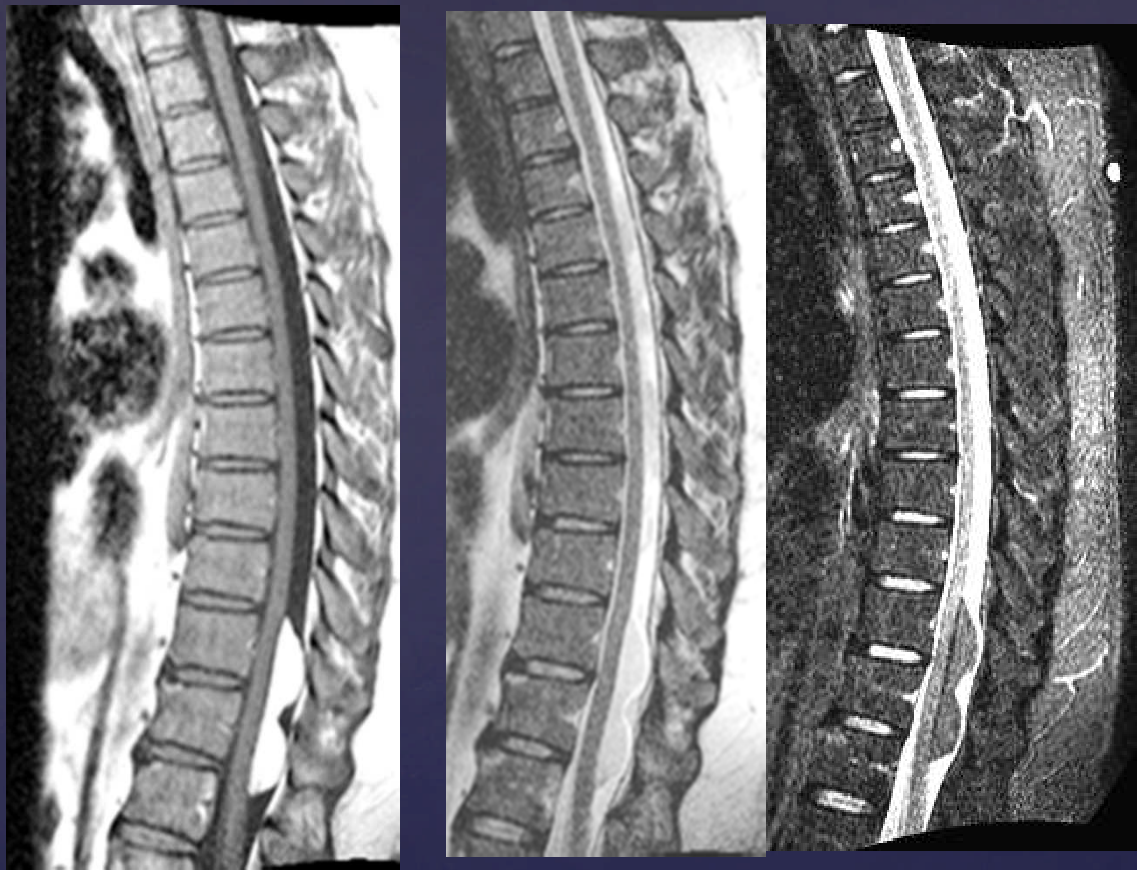


Developmental and Congenital

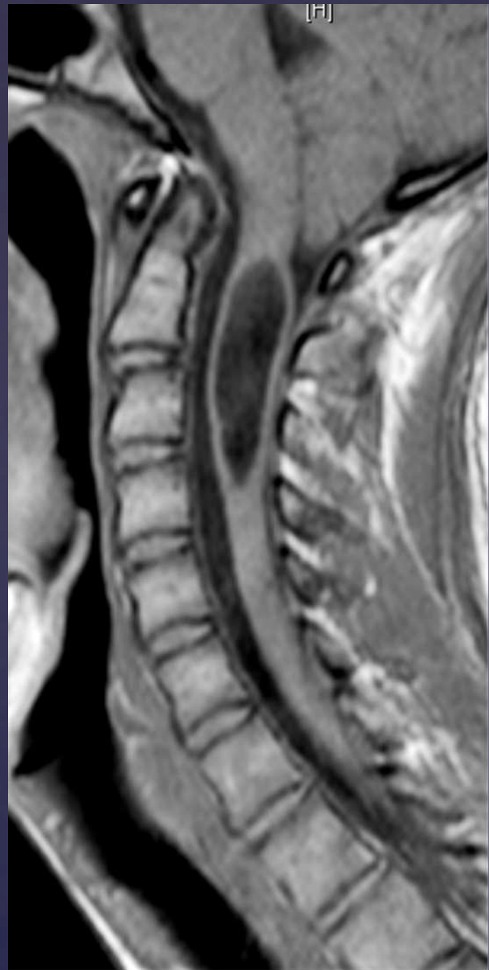


Epidural Cysts





Chiari Type 1



Diastodiatomyelia


Tethered Spinal Cord

- Sagittal T2-weighted image of the lumbar spine showing a tethered spinal cord, ending at the S2/3 disc interspace.

conus (below L2) and often thickened or fatty filum terminale (> 2 mm).

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