Introduction to Neuroimaging

SPINE

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Updated 6/13/06
Anatomy
Radiographic Anatomy
Cervical Spine – Oblique View

ML Richardson, Univ. Of Washington
Cervical Spine – Open-Mouth (Dens) View
MRI Anatomy

Source: CW Kerber and JR Hesselink, Spine Anatomy, UCSD Neuroradiology
Spine Pathology

- Trauma
- Degenerative disease
- Tumors and other masses
- Inflammation and infection
- Vascular disorders
- Congenital anomalies
Trauma
Evaluating Trauma

- Fracture – plain film / CT
- Dislocation – plain film / CT
- Ligamentous injury – MRI
- Cord injury – MRI
- Nerve root avulsion – MRI
Plain film findings may be very subtle or absent!

Anterolisthesis of C6 on C7

(Why??)
Fractures of C6 left pedicle and lamina
CT – 2D Reconstructions

Acquire images axially...

...reconstruct sagittal / coronal
Vertebral body burst fx with retropulsion into spinal canal

2D Reformats
Vertebral Artery Dissection/Occlusion Secondary to C6 Fracture
Hyperflexion fx with ligamentous disruption and cord contusion
Nerve root avulsion

Axial

Coronal

Sagittal
Degenerative Disease
Degenerative Disc (and Facet Joint) Disease

- Normal Disc
- Degenerated Disc
- Bulging Disc
- Herniated Disc
- Thinning Disc
- Disc Degeneration with Osteophyte Formation
- Foraminal stenosis
- Thickening/Buckling of Ligamentum Flavum
Degenerative Disc (and Facet Joint) Disease
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Lumbar Spinal Stenosis
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Disc bulge, facet hypertrophy and flaval ligament thickening frequently combine to cause central spinal stenosis.

Note the trefoil shape of stenotic spinal canal.
Lumbar Spinal Stenosis

Disc bulge, facet hypertrophy and flaval ligament thickening frequently combine to cause central spinal stenosis.

Note the trefoil shape of stenotic spinal canal.
Foraminal Stenosis
Cervical Spinal Stenosis

Healthy Cervical Spine

Central Stenosis

Foraminal Stenosis

Herniated Disk
MRI - Degenerative Disc Disease

Age:

- 20-40  36% have degenerated disc
- 50    85-95% have degenerated disc
- 60-80 98% have degenerated disc
- <60   20% have asymptomatic disc herniation

Conclusion: Abnormal findings on MRI frequently DO NOT relate to symptoms (and vice versa) !!
MRI – Herniated Disc Levels

- 85-95% at L4-L5, L5-S1
- 5-8% at L3-L4
- 2% at L2-L3
- 1% at L1-L2, T12-L1
- Cervical: most common C4-C7
- Thoracic: 15% in asymptomatic pts. at multiple levels, not often symptomatic
Normal Disc  Annular Tear  Herniated Disc
"Symmetrical Bulging Disc"

"Asymmetrical Bulging Disc"

Focal Herniation
Abnormal Disc

Herniation
- < 180°
  - 90°–180°
    - Broad-based
  - < 90°
    - Focal
      - Waist*
        - Extrusion
          - Sequestered
          - Migrated
          - Neither
      - No waist
        - Protrusion
          - Neither

Bulge
- > 180°
  - Symmetric
  - Asymmetric

*(In any plane)

Central Disc Protrusion
L5-S1 Disc Extrusion Into Lateral Recess with Impingement of R S1 Nerve Root
Schmorl’s Nodes

Intervertebral disc space

Intravertebral Herniations
Cervical Radiculopathy
Lumbosacral Radiculopathy (Sciatica)

Important:
A herniated disc at (e.g.) L4-5 may impinge either the L4 or L5 nerve roots!
L5-S1 Disc Extrusion Into Lateral Recess with Impingement of R S1 Nerve Root
Spondylolysis / Spondylolisthesis
Confusing “Spondy-” Terminology

- **Spondylosis** = “spondylosis deformans” = degenerative spine
- **Spondylitis** = inflamed spine (e.g. ankylosing, pyogenic, etc.)
- **Spondylolysis** = chronic fracture of pars interarticularis with nonunion (“pars defect”)
- **Spondylolisthesis** = anterior slippage of vertebra typically resulting from bilateral pars defects
- **Pseudospondylolisthesis** = “degenerative spondylolisthesis” (spondylolisthesis resulting from degenerative disease rather than pars defects)
Tumors and Other Masses
Classification of Spinal Lesions

- **Extradural** = outside the thecal sac (including vertebral bone lesions)

- **Intradural / extramedullary** = within thecal sac but outside cord

- **Intramedullary** = within cord
Common Extradural Lesions

- Herniated disc
- Vertebral hemangioma
- Vertebral metastasis
- Epidural abscess or hematoma
- Synovial cyst
- Nerve sheath tumor (also intradural/extramedullary)
  - Neurofibroma
  - Schwannoma
Common Intradural Extramedullary Lesions

- Nerve sheath tumor (also extradural)
  - Neurofibroma
  - Schwannoma
- Meningioma
- Drop Metastasis
Common Intramedullary Lesions

- Astrocytoma
- Ependymoma
- Hemangioblastoma
- Cavernoma
- Syrinx
- Demyelinating lesion (MS)
- Myelitis
Classification of Spinal Lesions

- Extradural
- Intramedullary
- Intradural Extramedullary
- Intramedullary
Extradural: Vertebral Body Tumor
Extradural: Vertebral Metastases

T2 (Fat Suppressed)                              T1                      T1+C (fat suppressed)
Extradural: Vertebral Metastases

T2 (Fat Suppressed)  T1  T1+C (fat suppressed)
Vertebral Metastases vs. Hemangiomas

**Hemangiomas** (Benign, usually asymptomatic, commonly incidental):

- Bright on T1 and T2 (but dark with fat suppression)
- Enhancement variable

**Metastases:**

- Dark on T1, Bright on T2 (even with fat suppression)
- Enhancement
Vertebral Hemangiomas
Diffusely T1-hypointense marrow signal may represent widespread vertebral metastases as in this patient with prostate Ca.

This can also be seen in the setting of anemia, myeloproliferative disease, and various other chronic disease states.
Extradural: Epidural Abscess
Extradural: Nerve Sheath Tumor (Schwannoma)
Intradural Extramedullary: Meningioma
Intradural Extramedullary: Meningioma
Intradural Extramedullary: Nerve Sheath Tumor (Neurofibroma)
Intradural Extramedullary: “Drop Mets”

T2  T1  T1+C
Intradural Extramedullary: “Drop Mets”
Intradural Extramedullary: Arachnoid Cyst
Intramedullary: Astrocytoma
Intramedullary: Astrocytoma
Intramedullary: Cavernoma
Intramedullary: Ependymoma
Intramedullary: Syringohydromyelia

Seen with:
- congenital lesions
  - Chiari I & II
  - tethered cord
- acquired lesions
  - trauma
  - tumors
  - arachnoiditis
- idiopathic
Intramedullary: Syringohydromyelia

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Confusing “Syrinx” Terminology

- **Hydromyelia**: Fluid accumulation/dilatation *within central canal*, therefore *lined by ependyma*

- **Syringomyelia**: Cavitary lesion within cord parenchyma, of any cause (there are many). Located *adjacent to central canal*, therefore *not lined by ependyma*

- **Syringohydromyelia**: Term used for either of the above, since the two may overlap and cannot be discriminated on imaging

- **Hydrosyringomyelia**: Same as syringohydromyelia

- **Syrinx**: Common term for the cavity in all of the above
Infection and Inflammation
Infectious Spondylitis / Diskitis

Common chain of events (bacterial spondylitis):
1. Hematogenous seeding of subchondral VB
2. Spread to disc and adjacent VB
3. Spread into epidural space → epidural abscess
4. Spread into paraspinal tissues → psoas abscess
5. May lead to cord abscess
Infectious Spondylitis / Diskitis
Infectious Spondylitis / Diskitis
Pyogenic Spondylitis / Diskitis with Epidural Abscess
Spinal TB (Pott’s Disease)

- Prominent bone destruction
- More indolent onset than pyogenic
- Gibbus deformity
- Involvement of several VB’s
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Transverse Myelitis

Inflamed cord of uncertain cause
   - Viral infections
   - Immune reactions
   - Idiopathic
Myelopathy progressing over hours to weeks
DDX: MS, glioma, infarction
Multiple Sclerosis

Inflammatory demyelination eventually leading to gliosis and axonal loss

T2-hyperintense lesion(s) in cord parenchyma

Typically no cord expansion (vs. tumor); chronic lesion may show atrophy
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Cord Edema

As in the brain, may be secondary to ischemia (e.g. embolus to spinal artery)

or

venous hypertension (e.g. AV fistula)
Spine Imaging Guidelines

1. Uncomplicated LBP usually self-limited, requires no imaging

2. Consider imaging if:
   - Trauma
   - Cancer
   - Immunocompromise / suspected infection
   - Elderly / osteoporosis
   - Significant neurologic signs / symptoms

3. Back pain with signs / symptoms of spinal stenosis or radiculopathy, no trauma:
   Start with MRI; use CT if:
   - Question regarding bones or surgical (fusion) hardware
   - Resolve questions / solve problems on MRI (typically use CT myelography)
   - MRI contraindicated
4. Begin with plain films for trauma; CT to solve problems or to detail known fractures; MRI to evaluate soft-tissue injury (ligament disruption, cord contusion)

5. MRI for sx of radiculopathy, cauda equina syn, cord compression, myelopathy

6. Fusion hardware is safe for MRI but may degrade image quality; still worth a try

7. Indications for IV contrast in MRI:
   - Tumor, infection, inflammation (myelitis), any cord lesion
   - Post-op L-spine (discriminate residual/recurrent disk herniation from scar)

8. Emergent or scheduled? Emergent only if immediate surgical or radiation therapy decision needed (e.g. cord compression, cauda equina syndrome)

9. Difficult to image entire spine in detail; target study to likely level of pathology

10. CT chest/abdomen/pelvis includes T-L spine (no need to rescan trauma pts*)
    * If image data still on scanner (24-48 hours)
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