Objectives
* To detect traumatic and atraumatic pathology in the thoracolumbar spine on plain films
* To recognize subtle concerning findings for the “red flag” diagnoses in back pain
* To understand the limitations of thoracolumbar plain films & know when to order CT and MRI studies in the ED

Anatomy of Thoracolumbar Spine

Vertebral body
Superior articular process
Inferior articular process
Facet: Articulating joint between superior and inferior articular process
Transverse process
Pedicle
Lamina
Spinous process
Neural (spinal) canal: Space which contains the spinal cord and cerebrospinal fluid
  • Formed by vertebral body, pedicles, laminae
  • Relative space around spinal cord is smaller at thoracic level --> neural canal impingement at thoracic level has high risk for spinal cord compression
  • The thoracic cord is thicker than lumbar cord because lumbar fibers have not yet branched off from spinal cord.
Intervertebral disk: Comprised of nucleus pulposus (inner) and annulus fibrosis (outer)
  • Annulus fibrosis ring weakest posteriorly, predisposing to disk herniations towards the spinal neural canal
Anterior and posterior longitudinal ligaments: Ligaments that stabilize the vertebral column along anterior and posterior aspects of vertebrae, respectively
  • Posterior longitudinal line forms border between vertebrae and disks from neural canal
  • Thinnest at L1-S1, corresponding with higher incidence of lumbar than thoracic disk herniations
Ligamentum flavum: Ligament anteriorly bordering the lamina
  • Commonly hypertrophies with age and may cause spinal stenosis
Spinal cord
Cauda equina: Peripheral lumbar and sacral nerve roots distal to L2 vertebral level, where conus medullaris ends

Spinal nerve root: Peripheral nerve which exits neuroforamina from either side of the vertebral body
- Commonly compressed in disk herniation, causing radiculopathy

Differential Diagnosis of Acute Back Pain

Acute Low Back Pain (LBP):
- **Definition**: Back pain for < 6 weeks
- 70-90% have pain resolution within 6 weeks

Non-thoracolumbar pathology (aortic disease, pancreatitis, ectopic pregnancy, etc)

“Red flag” conditions (Agency for Healthcare Research and Quality guidelines, 1999)
1. **Fracture**
   - Occurs with significant blunt trauma, or with minimal trauma in the setting of age-related or corticosteroid-induced osteoporosis
   - Risk for spinal cord compression
2. **Cauda equina syndrome**
   - A neurosurgical emergency
   - Compression of multiple lumbar and sacral nerve roots in the cauda equina, causing bilateral leg symptoms, saddle anesthesia, and/or impaired bowel-bladder function
3. **Spinal infection**
   - Spinal epidural abscess and vertebral osteomyelitis (spondylitis)
4. **Vertebral malignancy**

Sub-acute conditions
1. **Spinal stenosis**
   - Impingement of the neural canal from congenital, degenerative, or hypertrophic changes
   - **Average age** = 55 years
   - Account for 3% of all LBP causes
   - **Classic symptoms**: pseudoclaudication (pain worse with walking, and better with rest AND spine flexion)
     - Spine flexion increases spinal canal diameter and relieves spinal stenosis symptoms
     - Walking uphill is less painful than walking downhill
     - Frequently misdiagnosed as vascular claudication
2. **Spondylolisthesis**
   - Slippage of one vertebral body over another
   - **Causes**: Most commonly from degenerative disease >> trauma
   - Age > 40 years old
   - **Asymptomatic** in up to 66% of cases [Kauppila et al, 1998]
   - **Radiographic classification**: Grade 1 (0-25% slippage), Grade 2 (25-50% slippage), Grade 3 (50-75% slippage), Grade 4 (>75% slippage)
3. **Ankylosing spondylitis**
   - Decreased range of spinal flexion and range of motion
   - **Classic symptoms:** Morning back stiffness, which improves with exercise
   - **Xray:**
     - “Bamboo spine” (late stage)
     - Narrowing of SI and facet joints, osteoporosis, square lumbar vertebral bodies, syndesmophytes (early signs)
   - Fractures have high risk for spinal cord injury because of spine rigidity

**Benign acute conditions**

1. **Intervertebral disk herniation**
   - Herniation of the nucleus pulposus through the annulus fibrosis into the spinal canal, most frequently posterolaterally to compress a peripheral nerve root
   - **Age predominance:** 30-50's
     - 3rd decade: Disk starts to dessicate and degenerate—higher risk for herniation
     - 6th decade: Disk shrinks—lower risk for herniation
     - Beware of diagnosing patient with disk herniation in elderly population (uncommon)
   - **Symptoms:**
     - Lower extremity pain severity often overshadows back pain
     - Worse with sitting and Valsalva (sneezing, laughing, coughing)
   - **Thoracic Disk Herniation:**
     - Accounts for <1% of all disk herniations
     - Peak age incidence = 40-70 years old
     - Only 10-15% have cauda equina syndrome findings
     - Subtle exam findings—upper motor neuron signs (clonus, abnormal Babinski reflex) from cord compression; urinary retention; posterior column findings (change in position, touch, and temperature findings); unilateral or bilateral lower extremity weakness
     - Incidence of cord compression risk is high – smallest spinal canal diameter in thoracic spine
     - Often 20 months of thoracic pain elapse before thoracic disk disease diagnosed
   - **Upper Lumbar Disk Herniation (L1-L4):**
     - Account for <5% of all disk herniations
     - Subtle exam findings, like thoracic disk herniations
     - Often positive reverse straight-leg-raise test (prone positioning with extended leg elevation reproduces pain radiating to anterior thigh)
   - **Lower Lumbar Disk Herniation (L4-L5, L5-S1):**
     - Accounts for 95% of all disk herniations
     - Often associated with an L5 or S1 radiculopathy (sciatica)
   - **Asymptomatic disk herniations** seen on MRI
     - No pain fibers supplying nucleus pulposus and inner annular layers
     - Incidence on thoracic levels = 73% *(Wood et al, 1999)*
     - Incidence on lumbar levels = 20-30% *(Paajanen et al, 1989; Jensen et al, 1994)*
   - **Complications:** Massive central disk herniation can cause cord compression or cauda equina syndrome
   - **Natural course of symptoms:** Self-resolution after 4-6 weeks with non-operative management usually

2. **Musculoskeletal back pain**
   - Back pain with possible radiation to buttocks (but no radiation beyond knee)
   - A diagnosis of exclusion, once more concerning causes of thoracolumbar pain ruled-out
The History

Use the history to risk-stratify a patient for “red flag” diagnoses (fracture, cauda equina syndrome, spinal infection, vertebral malignancy), unique subacute conditions (spinal stenosis, spondylolisthesis, ankylosing spondylitis), and disk herniation.

<table>
<thead>
<tr>
<th>Thoracolumbar Pathology</th>
<th>Historical Clues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herniated disk</td>
<td>Back pain radiates down the legs, past the knees</td>
</tr>
<tr>
<td>Spinal stenosis</td>
<td>Pain worse with walking and better with bending forward</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>Morning back stiffness which improves with exercise</td>
</tr>
<tr>
<td>Fracture</td>
<td>History of blunt trauma</td>
</tr>
<tr>
<td></td>
<td>Risk: age &gt; 50 yrs old, chronic steroid use</td>
</tr>
<tr>
<td>Spinal infection</td>
<td>Fevers, chills</td>
</tr>
<tr>
<td></td>
<td>Back pain persistent at rest</td>
</tr>
<tr>
<td></td>
<td>Back pain worse at night</td>
</tr>
<tr>
<td></td>
<td>Risk: age &gt; 50 yrs old, chronic steroid use, immunocompromised, IVDU</td>
</tr>
<tr>
<td>Vertebral malignancy</td>
<td>Persistent back pain &gt; 6 weeks duration</td>
</tr>
<tr>
<td></td>
<td>Back pain worse at night</td>
</tr>
<tr>
<td></td>
<td>Unexplained weight loss</td>
</tr>
<tr>
<td></td>
<td>Risk: age &gt; 50 yrs old, history of malignancy</td>
</tr>
<tr>
<td>Cauda equina syndrome</td>
<td>Bilateral leg pain, numbness, or weakness</td>
</tr>
<tr>
<td></td>
<td>Bowel or bladder changes</td>
</tr>
</tbody>
</table>

The Physical Exam

Abdomen: Palpate for pulsatile mass and tenderness

Back:
- Palpate for tenderness midline and paraspinous
- Percussion-induced back pain suggests spinal infection or malignancy

Straight-Leg Raise (SLR) Manuevers:
- Stretches sciatic nerve when elevate supine patient’s extended leg
- Radiation of pain distal to knee suggests radiculopathy
- Sensitivity = 80%, specificity = 40%
- More specific test for L5-S1 radiculopathy (sciatica) is crossed-SLR test, where pain radiates down affected leg when contralateral leg is raised (sensitivity 25%, specificity 90%)
- An L5-S1 radiculopathy is 95% sensitive for lumbar disk herniation (thus, the absence of radiculopathy almost rules-out a herniated disk)
- Reverse SLR: Stretches L3 and L4 nerves by elevating PRONE patient’s extended leg
  - Reproduction of pain in L3-L4 distribution with reverse SLR suggests L3-L4 radiculopathy

Neurologic:
- Sensory:
  - Light touch and pinprick testing of each nerve dermatome, and saddle distribution (inner proximal thighs and buttocks)
  - Best to perform at most distal site (foot for L4, L5, S1 – see figure below)
- Motor: Specificity of following findings for lumbar disk herniation:
  - Weakness of ankle dorsiflexion (70%)
  - Weakness of great toe extension (70%)
  - Weakness of ankle plantar flexion (95%)
  - Weakness of knee extension (99%)

Reflexes

Gait: Spinal stenosis patients often walk with spinal flexion (bending forward)

Rectal exam: For patients exhibiting severe back pain, bilateral leg symptoms, or bowel/bladder changes (to check for decreased tone, as found in cord compression and cauda equina syndrome)
Vascular:
- Check pedal pulses to help distinguish vascular claudication versus spinal stenosis pseudoclaudication
- A decreased pulse is worrisome for acute limb ischemia (thromboembolic disease, AAA, aortic dissection)

Waddell’s signs:
- SLR exam in seated position by extending knee, should also reproduce L5-S1 radiculopathy pain
- Hyperesthesia of skin along back suggests a non-organic etiology for back pain.
- Pain with axial loading on scalp should not elicit back pain (It may, however, elicit neck pain.)
- Over-exaggeration of pain suggests a non-organic etiology for back pain

Physical Exam
Dermatomal Findings for L3-S1 Nerve Roots

Imaging: Plain Radiograph

Plain radiographs should be obtained if concerned of one of the “red flag” diagnoses

Plain film views
- 2 views: AP and lateral
- No role for oblique views in the ED (Scavone et al, 1981)
  ✓ 19 (2.4%) missed diagnoses out of 972 patients when no oblique films obtained
  ✓ No acute diagnoses were missed

ABC’S approach to interpreting thoracic and lumbar plain radiographs
- A: Alignment (check anterior vertebral line, posterior vertebral line, pedicle alignment on AP view)
- B: Bones (look for cortical break of vertebral body, pedicles, lamina, and spinous processes)
- C: Cartilage (look for equal intervertebral disk height, with gradual increase in height caudally)
- S: Soft tissue (look for obliteration of paraspinous stripe in thoracic xray and psoas shadow in L-S xray)
RED FLAG #1: Thoracolumbar Fracture

Statistics:
- 90% of all thoracolumbar fractures occur in T12-L4 region, because of change of spinal curvature and more mobility than thoracic spine
- Incidence of spinal cord compression if fracture in T12-L2 region = 40%
- Incidence of non-contiguous fractures = 10.5% (Vaccaro et al, 1992)
- Incidence of concurrent intra-abdominal injury = 30%

Spine biomechanics: Three-column Denis model →
- **Anterior Column**: anterior 2/3 vertebral body, anterior longitudinal ligament
- **Middle Column**: posterior 1/3 vertebral body, posterior longitudinal ligament
- **Posterior Column**: posterior neural arch (pedicles, laminae, facets, transverse processes, spinous process), supraspinous/ interspinous ligaments, ligamentum flavum
- Definition of a “stable” fracture ranges from having 1-2 intact columns – avoid using the word “stable” vs “unstable” and describe fractures based on anatomical location and columns

Plain Radiographs:
- **Posterior vertebral line**: On lateral view, distinguishes a wedge compression fracture from a burst fracture
- **Widened interpedicular distance**: On AP view, suggests middle column interruption
- **Obliteration of lines**: On AP view, check for an abnormal paraspinous line (T4-T11 fracture) or loss of psoas shadow (L1-L5 fracture)
- **Look for a second fracture**

Classic Fracture Patterns:
1. **Wedge fracture**
   - **Mechanism**: Spinal flexion and axial loading, yielding a compressive fracture of anterior column only
   - In people >75 years old, 25% will develop an osteoporotic compression fracture
   - **Radiograph**:
     ✓ Described as % anterior height loss as compared to posterior vertebral body height
     ✓ Intact posterior vertebral line (otherwise a burst fracture)
   - **Controversy**: A plain film poorly differentiates a wedge fracture from a burst fracture.
     ✓ 14-22% of burst fractures appear as wedge fractures on xray (Ballock et al, 1992; Dai et al, 2004)
     ✓ Thus, have a low threshold to obtain a spinal CT to confirm an intact middle column
2. **Burst fracture**
   - **Mechanism**: Spinal flexion and axial loading, yielding a compressive fracture of anterior and posterior vertebral body (compromised anterior and middle columns)
   - **Incidence of neurological deficit** = 65%
     ✓ Final location of posterior vertebral body fragments does not correlate with spinal cord injury severity (Wilson et al, 2003)
3. **Chance fracture** (“Seatbelt fracture”)
   - **Mechanism**: Distraction injury, yielding fractures through posterior → middle → anterior columns
     ✓ Classically from lapbelt injury in MVC’s
     ✓ Usually see horizontal fracture through spinous process/ lamina and vertebral body
   - **Incidence of concurrent intra-abdominal injury** as high as 50% (pancreas, duodenum, mesentery)
   - **Location**: Typically in T12-L2 region
4. **Transverse process fracture**
   - Comprises 15% of all thoracolumbar fractures
   - **Incidence of concurrent intra-abdominal injury** = 21%
   - **Incidence of concurrent pelvic fractures** = 29% (especially with L5 transverse process fracture)
   - **Pearl**: L2 transverse process fracture has a high association with renal artery thrombosis
RED FLAG #2: Cauda Equina Syndrome

A neurosurgical emergency from compression of multiple lumbar and sacral nerve roots in the cauda equina

**Etiology:** Massive central disk herniation >> epidural abscess, hemotoma, trauma, malignancy, spinal surgery

**Importance of Timely Diagnosis:**
- Equivocal literature, but likely greater chance of irreversible neurological damage if surgery occurs >48 hours after onset of symptoms. (Ahn et al, 2000; Shapiro, 2000)

**Presentation:** (Deyo et al, 1992)
- 30% present acutely, but 70% present subacutely within days-weeks
- Severe back pain
- Bilateral lower extremity pain, radiculopathy, and diminished lower extremity reflexes
- Saddle anesthesia (sensitivity 75%)
- Decreased rectal tone (sensitivity 60-80%)
- **Urinary retention**
  - Most consistent exam finding with sensitivity 90%, using post-void residual>100-200 cc
  - Patients often do not notice urinary retention, but remark on urinary incontinence (from overflow)

**Plain radiographs:** Normal

RED FLAG #3: Spinal Infection (Spinal Epidural Abscess and Spondylitis)

**Classic triad of findings:** Back pain, fever, and neurologic deficits

**Spinal epidural abscess (SEA):**
- Mortality has high as 23%
- Early detection translates to preservation of neurologic function and improved mortality
- **Classic triad:** Back pain, fever, and neurological deficits found in only 15% patients (Davis et al, 2004)
- **Difficult to diagnose:**
  - 75-89% have delayed diagnosis, defined as multiple ED visits prior, admission without a diagnosis of SEA, or >24 hrs to definitive study (Davis et al, 2004; Tang et al, 2002)
- **Risk factors:** IV drug use, diabetes mellitus, trauma, alcoholism, immunocompromised status (HIV, chronic renal failure, chronic corticosteroid use), elderly, recent back trauma (includes iatrogenic epidural anesthesia needle puncture), indwelling catheter, recent bacterial infection
  - **Reilhais et al, 2000:** A meta-analysis review of 915 SEA patients showed that 3-20% of patients have zero risk factors
✓ **Davis et al, 2004:** Need to obtain 49 negative MRI’s to pick up one positive MRI for patients with at least one risk factor PLUS back pain

- **Exam:**
  ✓ Fever in only 50-67% of patients
  ✓ Neurologic exam can range from normal (grade 1), radiculopathy (grade 2), sensory or motor deficit (grade 3), or paralysis (grade 4)

- **Laboratory tests:**
  ✓ Average serum WBC = 12-16K
  ✓ Average ESR = 77-87 mm/hr
  ✓ Sensitivity of ESR >30 is 81% *(Sidman et al, 2002)*
  ✓ Sensitivity of ESR >20 is 98% *(Davis et al, 2004)*
  ✓ ESR is more sensitive and specific than serum WBC result
  ✓ Poor prognostic indicators: Thrombocytopenia<100K, ESR>110, abscess in cervical spine *(Tang et al, 2002)*
  ✓ Blood cultures: Organism is *Staphylococcus aureus* (90%) >> streptococcus, enteric gram-negative bacilli

- **Plain radiograph:**
  ✓ Only 25% do have associated spondylitis—otherwise normal films

- **MRI:** Definitive diagnostic imaging

---

**Spondylitis (vertebral osteomyelitis):**
- Starts as diskitis, then spreads by direct extension into vertebral endplates
- Similar risk factors as spinal epidural abscesses
- **Exam:** Sensitivity of fever is only 27-50%
- **Plain radiograph:**
  ✓ May appear normal for the first 2-3 weeks of osteomyelitis
  ✓ Classic appearance: First, narrowing and obliteration of disk space followed by irregular vertebral endplates erosion by direct extension
- **MRI:** Definitive diagnostic imaging, obtained emergently only in setting of neurological deficit

---

**Teaching points on spinal infections**

1. Only about 50% of spinal epidural abscess and spondylitis patients will present with a fever.
2. Only 15% of spinal epidural abscess patients have the classic triad of fever, back pain, and neurological deficit.
3. ESR can be used as a risk-stratifier in low-risk patients (better than a serum WBC value), using a cutoff of 20-30 mm/hr.
RED FLAG #4: Vertebral Malignancy

Patient case:
History: 68 y/o healthy man c/o subacute back pain for 2 months. No history of trauma, fevers, or prior back pain. Has a 20-lb weight loss in 2 months.
Physical: Vital signs and exam are normal except moderate paraspinous and midline lumbar tenderness.
Laboratory: ESR 90, serum WBC 8, UA normal
Xray: Normal lumbar spine except for mild osteoarthritis

Question #1: Is an MRI indicated? If so, as an outpatient or in the ED?
Question #2: Would your decision change if this patient had a known history of prostate cancer?
Question #3: Would your decision change if this patient had prostate cancer AND a radiculopathy?

Etiology:
- Metastatic disease 25x more likely than primary malignancy (eg. multiple myeloma)
- 60-70% of all vertebral metastases occur in the thoracic spine
- Most common metastatic malignancy: Prostate, Breast, Kidney, Thyroid, Lung, Lymphoma (“Lead kettle” mnemonic = PB KTLL)
  - Important to perform prostate, breast, and lung exam

Classic symptoms: Pain worse at night and at rest
Risk factors for vertebral malignancy: (Deyo and Diehl, 1998)
- Known cancer (98% specificity)
- Unexplained weight loss (94% specificity)
- Persistent pain despite bed rest (90% specificity)
- Pain for >1 month (specificity 81%)

Plain radiograph:
- Classic findings: Blastic or lytic lesions in vertebral body or pedicle (“winking owl” sign), sparing the intervertebral disk
- Note: Vertebral osteomyelitis involves vertebral body AND disk space
- Note: Radiographic evidence of bony erosion requires >50% of vertebral bone loss. There is a false negative rate of 10-17% in detection of vertebral bony metastasis.

Laboratory:
- The ESR can help risk-stratify a patient with concerning risk factors for a malignancy, especially if very high (>100 mm/hr)

MRI:
- The ideal imaging modality to assess spinal canal and spinal cord integrity
- Expediency of ordering MRI based on risk of spinal cord compression

Algorithm to determine MRI imaging for a patient with concerning findings for vertebral malignancy:
- Question #1: Does the patient have a history of cancer?
- Question #2: Does the patient have evidence of a radiculopathy?
- Question #3: Does the patient have a concerning plain radiograph and/or extremely elevated ESR?
- See figure on next page for decision algorithm
Pearl: In patients with known cancer and a radiculopathy, an emergent MRI is necessary. (Byrne, 1992)
- Incidence of spinal cord compression = 25% (despite normal plain films)
- Incidence of spinal cord compression = 88% (if plain films should evidence of vertebral metastasis)

<table>
<thead>
<tr>
<th>Teaching points on vertebral malignancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Metastatic malignancies spare the disk space and preferentially invade the vertebral body and pedicles.</td>
</tr>
<tr>
<td>2. A cancer patient with back pain has a high likelihood for vertebral metastasis and spinal cord compression, despite a normal plain radiograph, especially if a radiculopathy is present.</td>
</tr>
</tbody>
</table>

Take-Home Points
- The great majority of patients with back pain do not require any imaging—only supportive pain management.
- Understand the subtleties in the history, physical, and diagnostic testing for can-not-miss “red flag” diagnoses:
  - Fracture
  - Cauda Equina Syndrome
  - Spinal Infection
  - Vertebral Malignancy
- Avoid common pitfalls of under-appreciating a patient’s potential to have a “red flag” diagnosis or complication

References


