Thoracolumbar Trauma

- Anatomy
- Stability / instability
- Basic trauma vectors
- Fracture patterns
- Post-operative evaluation
Anatomy

- **Three biomechanical regions**

  - **T1-T8**: relatively rigid (ribcage)
  - **L3-sacrum**: mobile
  - **T9-L2**: transition: immobile - mobile, most injuries occur here
Anatomy

• L-spine: center of gravity - shifted relatively posteriorly
  – posterior elements - approx 30% weight-bearing
  – motion: flexion/extension/rotation
  – lordosis - flexion mechanism straightens L-spine, results in axial load type injury
Anatomy

- **Ligaments**
  - Allow motion, confer stability
  - ALL, PLL, ligamentum flavum, interspinous ligament
Anatomy

- Spinal canal
  - T-spine: 16 x 16 mm avg.
  - L-spine: 26 x 17 mm avg.
  - cord terminates L1

- Relatively minor injuries to T-spine can result in significant neuro injury

- Canal encroachment in L-spine may not cause neurologic impairment
Anatomy

- Neural foramina
  - Nerve roots susceptible to injury by:
    - facet, pedicle, laminar or transverse process fx
    - retropulsion of vertebral body fragments
    - traumatic spondylolisthesis
Spine Injury and Instability

*Three Column Theory*

- **Anterior column**
  - ALL, anterior annulus
  - anterior vertebral body
- **Middle column**
  - posterior vertebral body
  - posterior annulus, PLL
- **Posterior column**
  - posterior elements (pedicles, facets, lamina, spinous processes)
  - posterior ligaments

Denis F. Spine 1983; 8:817-831
Mechanical Instability
Two ‘Columns’ Disrupted

• Burst fracture
  – anterior and middle columns, +/- posterior column

• Anterior wedge compression with posterior ligament tear
  – anterior and posterior columns
Mechanically Stable

- Only one column disrupted
  - Anterior wedge compression fracture with intact posterior ligaments
  - Isolated posterior element fracture
Force Vectors

- Most spine injuries: MVA or fall
- Complex combination of forces
- Force vectors applied to certain areas of the spine result in predictable patterns of fracture
- Understanding of basic vectors aids radiologic interpretation
Basic Spine Trauma Forces

- Axial load
- Flexion / compression
- Flexion / rotation
- Flexion / distraction
- Lateral compression
- Shear
- Extension
AXIAL LOAD

Fall from height
Axial Load

- T-L junction - most common site of injury
- T-spine - may result in flexion force, anterior wedge compression or burst
- 43% fx at another level
- 10% non-contiguous: need to survey whole spine

Step off, slight loss of height

Slight dent

3 contiguous levels

3 contiguous levels
Burst Fracture

• Anterior and middle column disrupted
  
  – posterior bowing of vertebral body - **anything other than concavity**
  
  – retropulsion of fragments into spinal canal
Burst Fracture

• Retropulsed fragment from superior endplate – may rotate, migrate

• Attached to anulus, PLL - *distraction helps reduce*

widening of distance between pedicles on AP view
Burst Fracture

- Sagittal split through vertebral body, posterior elements
  - dural laceration

Lower lumbar burst fx
- May not require decompression
Burst vs. Anterior Wedge Fx

- Anterior wedge - anterior column - stable
- Burst - 2-3 columns - unstable
- Important to differentiate
  - Look for posterior vertebral concavity
  - CT for evaluation of posterior vertebral body, fracture of posterior elements
  - As many as 20% of burst fractures may be missed if radiographs alone are used
  - MRI for ligamentous disruption / neuro sx

Anterior Wedge Compression Fracture

Importance of posterior vertebral body line: Anything except concavity = burst

Daffner et al. AJR 1987; 148:93-96
FLEXION COMPRESSION INJURY

Fall with anterior bending
Flexion / Compression

- Anterior wedge compression vs. burst fracture
- Higher risk of posterior ligamentous disruption
- Loss of height anterior > posterior

Flexion / Compression Injury

Anterior >> posterior loss of height
Flexion Compression Injury: Burst Fracture

-No interspinous widening; posterior ligs intact
Flexion / Compression

• Posterior ligamentous disruption may not be apparent radiographically
  – CT or MRI
  – On Xray: if anterior compression 50% or greater, assume posterior lig disruption and instability

• If unrecognized
  – progressive anterior collapse, deformity (middle column - fulcrum)
Measure anterior body
- compare to body above and below
- if > 50% loss of height, presume posterior ligament disruption
- MRI to confirm
Burst fracture with posterior ligament disruption
Anterior wedge compression fracture with posterior ligament disruption - delayed instability
Flexion / Rotation

- T/L junction
- Flexion vector: anterior wedge or burst
- Rotation: addition of this vector tends to result in instability
  - disruption of posterior ligaments
  - posterior element fracture
  - can lead to dislocation
- High incidence of neurologic deficit
FLEXION-ROTATION INJURY

Anterior bending with twisting at the waist
Rotation of one vertebral body on another
- Burst fracture
- Rib fracture/dislocation
- Visceral injury

- Posterior element fractures
- Severe spinal canal compromise
Flexion / Distraction

- Axis of flexion is moved anteriorly (seatbelt injury)
- Results in distractive force as flexion is applied, posterior > anterior
- Neuro usually preserved (approx. 10% with neuro deficit)
- Chance fracture and variants
  - pure osseous
  - combined osseous and ligamentous
  - pure disc / ligamentous
Lapbelt Injury

FLEXION-DISTRACTION INJURY
Classic Chance Fracture

- Pure osseous
  - Most common (approx. 50%)
  - Technically unstable
  - But excellent prognosis for healing / long term stability

- Xray: horizontal split - spinous process, lamina, pedicles, vertebral body with distraction posterior > anterior
Chance Variants

- Combined osseous / ligamentous
- Pure ligamentous / discal
- Both with worse prognosis for healing / stability than pure osseous

Mechanism: abdominal organ injury
Chance fracture - pure osseous
Chance variant
-part osseous
-part ligamentous
Chance variant
- pure ligamentous
- analogous to bilateral interfacet dislocation (BID) in C-spine

Increased risk of instability compared to osseous type
Pediatric patient

Chance variant
- pure ligamentous
- dural tear

Leakage of myelographic contrast
Lateral Flexion/Compression

- Similar to flexion injury, but force is applied to lateral aspect of vertebra
- Loss of height of lateral vertebral body with acute scoliotic deformity
- Posterior elements often fractured
- Asymmetric burst fracture
LATERAL COMPRESSION INJURY

Axial load applied on one side
LATERAL FLEXION INJURY

Struck from side
Lateral flexion/compression injury

Focal scoliosis
Asymmetric burst fx
Shear Injury

- Results in severe ligamentous disruption
- Listhesis, anterior / posterior or lateral
- Fracture of posterior elements common, especially at facets
- Can result in dislocation
- Severe neurologic compromise common
SHEAR INJURY

Upper body goes one way, lower goes another
Shear Injury

Lateral dislocation
Severe compromise of spinal canal - blockage of myelographic contrast
Extension

• Anterior distraction
  – *ALL, anterior annular fibers injured*
  – *avulsions anterior endplate*

• Posterior compression
  – *‘crush’ fracture*

• Usually neuro intact, but with more severe injury - retrolisthesis, posterior crush
  – *‘lumberjack fracture / dislocation’*

• Xray: anterior disc widening - can be subtle - CT for posterior element fx
EXTENSION INJURY

Struck in back
Extension injury

- Anterior disc widening
- Focal lordosis
Extension injury

- Anterior ST edema
- Anterior disc widening
  /anular disruption
- Focal lordosis
Acute Extension Injury

- Fracture in elderly osteoporotic patient
Transverse process fracture

- Often at multiple adjacent levels
- If isolated, stable - usually a result of avulsive stress from psoas / paraspinal muscle contraction
- Can signify more severe injury
  - L5 transverse process fracture associated with sacral fracture
  - nerve root injury (esp L5)
Old transverse process fxs - psoas avulsion

-Sacral fx
-L5 transverse process fx

Iliolumbar ligament
L5 nerve root
Edema – lumbosacral plexus

Sacral fracture
Multidetector CT
Diagnosis - T/L trauma

• Checklist
  – cortical discontinuity
  – abrupt transition
  – spondylolisthesis
  – focal kyphosis/lordosis/scoliosis
  – facet widening
Diagnosis - T/L trauma

• Checklist
  – disc widening anterior or posterior
  – widening of interpedicle distance
  – widening / offset spinous processes
    (unreliable - variation)
  – focal soft tissue prominence (T-spine), loss of psoas shadow (L-spine – insensitive)
Summary

• Compare with levels above and below - transition of morphology and height should be smooth

• Remember mechanisms of injury - knowing patterns of injury can help with detection of subtle fractures, and ‘second fracture’

• CT any suspicious areas
Thank You!
Complications of Fixation

• Placement
  – fracture
  – laminar wires / hooks - neural foramen
  – pedicle screws - canal/lateral soft tissues
  – nerve impingement, pain, abnormal motion/instability, progressive collapse/deformity, penetration of adjacent structures
  – overdistraction/overcompression
Complications of Fixation

- Loosening / instability
  - rod / screw / hook detachment, fracture
  - inadequate fixation
  - progressive deformity
- Infection - direct implantation
- Disc protrusion with compression
- Dural tear - CSF leak
Post-operative evaluation

- Hardware placement - canal/NF/disc/soft tissues/vascular
- fractured fixation - can be subtle
  - ANY angulation / offset
- rod / hook separation / displacement
- loosening - lucency around fixation, motion on flexion / extension
- infection - bone destruction, lucency around fixation, neurologic deterioration, soft tissue abscess
- progressive collapse / deformity
- comparison with prior radiographs essential - esp post-op