Cervical Spine Trauma

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Trauma Cx Spine Protocols

• Issues
  • The clinically negative Cx-spine
  • Does everyone need a CT
  • Acute Flex/Ext in alert patients with a painful neck, negative x-rays
  • Supine Flex/Ext
  • Fluoro Flex/Ext in obtunded patients

Who to Image

• CCR and Nexus
  • CCR more sensitive and specific
  • CCR criteria more complicated

Who to Image

• NEXUS
  • Fulfill all criteria
    • No tenderness at the posterior Cx spine midline
    • No focal neurological deficit
    • Normal level of alertness
    • No evidence of intoxication
    • No painful injury that might distract from CSI
    • No radiography

Who to Image

• CCR
  • Different approach
  • Identifies those who should always be imaged
  • Those at low risk who can have ROM tested
  • 45 degrees rotation each way - no X-ray

Who to Image

• CCR
  • High risk
    • >= 65 years
    • Mechanism
      • Fall >1m
      • Axial load to head
      • MVA > 100km/hr, rollover, ejection, ATV, Bike collision
      • Parasthesia in extremities
Who to Image

- CCR
  - Can assess ROM
  - No high risk
    - Simple rear end MVA
    - Sitting in ED
    - Ambulatory since accident
    - Delayed onset of neck pain
    - Absence of midline Cx spine tenderness

How to Image

- Alert, but tender
  - 3 views Cx spine
    - +/- Swimmers, Fuchs, Trauma obliques
  - 39% of Cx spine injuries not seen on plain films - NEXUS
  - Head injury – having head CT
    - CT Cx
      - 1.25mm cuts (or less) base of skull to T1
      - Minimal reconstructions prior to reformats
      - Bone and ST algorithms
      - Reformats in sagittal and coronal planes

Top 10 Missed Fractures

1. Base of skull
2. Odontoid process
3. Zygomatic arch and orbit
4. C7 Fracture dislocation
5. Posterior dislocation of humerus
6. Scaphoid, lunate and perilunar dislocation
7. Sacroiliac fractures
8. Undisplaced neck of femur
9. Dislocated hip with ipsilateral femoral fracture
10. Tibial plateau fractures

Spinal trauma

- Excellent visualization of fractures
- Must be optimized
  - Thin slices 1 - 1.25 - 2mm
  - Bone and soft tissue algorithm / window
  - Orthogonal planes
    - Thin recons
  - Use workstation
  - 3D for alignment

- Poor visualization of fractures
  - Good for soft tissue injury
  - Good for spinal cord injury assessment
  - Good for spinal cord injury prognosis
  - Good for root avulsion
Flexion Extension - Supine

- All radiographic texts describe obtaining F/E views with the patient standing or sitting.
- There are no articles on obtaining flexion extension views in a supine patient.

Obtunded Flexion - Extension

Dangers

- Causing paraplegia/quadruplegia
  - Can only see part of Cx spine
  - Could be causing a disc herniation
- Rise in ICP
  - I have seen rise to over 80 mmHg
- Rise in BP
  - I have seen rise to over 200 systolic

Obtunded Flexion - Extension

- I cannot find any reference to dynamic passive flexion/extension studies finding an unstable ligamentous injury, without fracture, that needed to be surgically fixed.

Unconscious Patient

- In persons with decreased mental status, flexion/extension views in experienced hands can probably exclude instability in adults. This can be done at the bedside even in ICU. However, this method does not exclude significant soft tissue or spinal cord injuries, and manipulation and mobilization can cause secondary spinal cord trauma. On this basis the practice is not recommended.

Cx-Spine - Stability

- Instability is a function of ligamentous injury, or fracture pattern
- Can be inferred from radiographs for certain fracture patterns
- Not 100% accurate
  - Eg. Delayed flexion subluxation

Cx-Spine Stability

An unstable injury, is one which can progress and cause cord injury.

<table>
<thead>
<tr>
<th>Flexion</th>
<th>Anterior Subluxation</th>
<th>Stable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unilateral facet dislocation</td>
<td>Stable</td>
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<tr>
<td></td>
<td>Bilateral facet dislocation</td>
<td>Unstable</td>
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<tr>
<td></td>
<td>Wedge compression fracture</td>
<td>Stable</td>
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<tr>
<td></td>
<td>Flexion teardrop fracture</td>
<td>Unstable</td>
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<tr>
<td></td>
<td>Clay-shoveler’s fracture</td>
<td>Stable</td>
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<tr>
<td>Extension</td>
<td>Posterior arch C1 fracture</td>
<td>Stable</td>
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<tr>
<td></td>
<td>Hangman’s fracture</td>
<td>Unstable</td>
</tr>
<tr>
<td></td>
<td>Lamina fracture</td>
<td>Stable</td>
</tr>
<tr>
<td></td>
<td>Pillar fracture</td>
<td>Stable</td>
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<tr>
<td></td>
<td>Extension teardrop fracture</td>
<td>Stable</td>
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<tr>
<td></td>
<td>Hyperextension dislocation fracture</td>
<td>Unstable</td>
</tr>
<tr>
<td>Compression</td>
<td>Jefferson fracture</td>
<td>Unstable</td>
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<tr>
<td></td>
<td>Burst fracture</td>
<td>Stable</td>
</tr>
<tr>
<td>Complex</td>
<td>Odontoid fractures</td>
<td>Unstable</td>
</tr>
<tr>
<td></td>
<td>Atlantooccipital disassociation</td>
<td>Unstable</td>
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</table>
Cx-Spine - Stability

- MRI
  - Shows
    - Edema of soft tissues
    - Paravertebral hematoma
    - Ligamentous disruption
  - Still does not indicate instability
  - Negative study does not indicate stability

Cx-Spine - Stability

- Flexion Extension views
  - Patient should be erect
  - Should wait 2w for spasm to resolve
  - Must see to T1
  - Must move > 30 degrees

Cx-Spine

Signs of Instability F/E

- Subluxation greater than 3.5mm
- Angular deformity of more than 11 deg.
- Compression fx more than 25% loss of height
- Narrowing of the disk space.
- Widening of the interspinous distance 1.5X
- Facet joint widening

Reading Algorithm

- Soft tissues first, so you don't forget
- Bony alignment
- Facet joint alignment
- Look at common sites of fractures
- Find the second fracture
- Fluid levels
- Ribs, skull, clavicles etc
- Lines and tubes

Reading Algorithm – Bony alignment

Life Lines

1. Anterior vertebral body line
2. Posterior vertebral body line
3. Spinolamina line
4. Posterior spinous process line

Maximum Allowable Thickness

Soft Tissues

- Nasopharyngeal space (C1) - 10 mm (adult)
- Retropharyngeal space (C2 - C4) - 5-7 mm
- Retrotracheal space (C5 - C7)
  - 14 mm (children)
  - 22 mm (adults)
**Reading Algorithm – Bony alignment**

**Pseudo (physiologic) Subluxation**

- In children
- Ligament laxity
- Check Posterior Spinal (cervical) Line
- More than 2-3mm offset (C2 SLL anterior to PSL) must be considered traumatic.

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**CranioAtlas Assimilation**

- Occipitalization of the atlas
- 0.75% of population
- Usually asymptomatic
- Usually anterior arch fusion
- 50% have C2-3 fusion
- Associated anterior atlantoaxial subluxation
- Associated middle ear anomalies
- Associated Chiari 1

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**Craniocervical Ligaments**

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**Atlanto Occipital Dislocation**

- 40% missed dx at presentation
- STS +/- Retropharyngeal air
- Avulsion fractures occipital condyle or lower tip of clivus

**Classification:**

- Normal
- I
- II
- III

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**Atlanto Occipital Dislocation**

**Causes:**

- Traumatic
- Nontraumatic
  - Congenital Skeletal Abnormalities
  - Down’s
  - Infection
  - CPPD

**Prognosis not good**

- (but 20% may have no deficit!)
Atlantooccipital subluxation

- Powers ratio:
  - Basion to C1 Posterior lamina line / Opisthion to posterior cortex of the anterior C1 tubercle <1
- X method of Lee
- Clival line
- BAI (Basion Axial Interval)
  - Anterior distance of basion from PSL -4 – +12 mm
- BDI (Basion Dental Interval)
  - Vertical distance of basion above dens <12 mm

Jefferson Fracture
(Burst Fracture of C1)

- Radiographic findings
  - AP open mouth is key
  - C1 lateral masses laterally displaced
  - >2mm bilaterally always abnormal
  - 1-2mm unilaterally may be head tilt

- Compression to vertex
- Diving injury
- Rx. Halo for 3m

Vertical Compression – Unstable

1. Unilateral or Bilat FX’s of both ant and post arches of C1
2. Displacement of lateral masses.
3. CT required for defining full extent of fracture and detecting fragments in spinal cord/canal
4. Treatment: Halo placement for 3 months

Isolated Fracture posterior ring of C1

- Hyperextension injury
- Stable
Embryology (C2)
- C2 multiple ossification centers
- Body ossified at birth
- Fuse posteriorly by 2nd/3rd yr
- Unite with body by 7yr.

Embryology (Dens)
- Dens:
  - 2 vertical ossification centers
  - Fuse by 7th fetal month
  - Os terminale unites by age 11-12
  - Cleft dens tip

Dens Fractures
- TYPE I - Avulsion fx of the tip.
  - Considered Stable
- TYPE II - Fx at Base of Dens.
  - Most Common
  - Poor blood supply
  - Unstable
- TYPE III - Fx into body of axis
  - Best Prognosis
  - Unstable

Hanggee Fracture - Unstable
- Traumatic Spondylolisthesis of the Axis
- Bilateral C2 pars (common) or Pedicle (less common)
- Hyperextension and traction injury of C2
  - MVA (chin to dashboard)
  - Hanging
- The odontoid and its attachments are intact.
- Nerve damage is uncommon owing to the width of the canal at this level

Hangman’s Fracture

Effendi classification
- Grade 1:
  - Extension injury, displacement < 2mm. Rx flexion.
- Grade 2:
  - Extension injury, displacement >2mm and angulation. Rx flexion.
- Grade 3:
  - Flexion injury, C2-3 facet joint subluxation/ dislocation. Rx extension.

Levin and Edward’s
- Type 1:
  - Neural arch fracture, < 3mm displacement, no angulation
- Type 2: A:
  - + angulation
- Type 2: B:
  - + >3mm displacement
- Type 3:
  - + bilateral facet dislocation C2-3
<table>
<thead>
<tr>
<th>C3-7</th>
<th>Wedge Compression Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fractures</strong></td>
<td><strong>Dislocations</strong></td>
</tr>
<tr>
<td>• Tear drop</td>
<td>• Unilateral</td>
</tr>
<tr>
<td>• Flexion</td>
<td>• Bifacet</td>
</tr>
<tr>
<td>• Extension</td>
<td>• Extension</td>
</tr>
<tr>
<td>• Posterior</td>
<td>• Posterior arch</td>
</tr>
<tr>
<td>• Burst</td>
<td>• Clayshoveller’s Fracture</td>
</tr>
<tr>
<td><strong>Dislocations</strong></td>
<td><strong>Fracture Dislocations</strong></td>
</tr>
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<td>• Posterior arch</td>
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<tr>
<td><strong>Wedge Compression Fracture</strong></td>
<td><strong>Floating lateral mass</strong></td>
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<td><strong>Posterior arch</strong></td>
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<td>• Flexion Fracture Dislocation</td>
<td><strong>Clayshoveller’s Fracture</strong></td>
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<tr>
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<tr>
<td>• Bilateral</td>
<td><strong>Bifacet</strong></td>
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<tr>
<td><strong>Flexion Teardrop</strong></td>
<td><strong>Floating lateral mass</strong></td>
</tr>
<tr>
<td>• Teardrop fracture – anteroinferior</td>
<td>• Posterior arch</td>
</tr>
<tr>
<td>• All ligaments and disc disrupted</td>
<td><strong>Clayshoveller’s Fracture</strong></td>
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<tr>
<td>• Posterior subluxation of vertebral body</td>
<td><strong>Unilateral</strong></td>
</tr>
<tr>
<td>• Bilateral subluxated or dislocated facets</td>
<td><strong>Bifacet</strong></td>
</tr>
<tr>
<td>• Spinal canal compromise</td>
<td><strong>Floating lateral mass</strong></td>
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<td><strong>Extension Teardrop Fracture</strong></td>
<td><strong>Posterior arch</strong></td>
</tr>
<tr>
<td>• Avulsion fracture of anteroinferior corner of C2&gt;C3&gt;C4</td>
<td><strong>Clayshoveller’s Fracture</strong></td>
</tr>
<tr>
<td>• Radiographic findings</td>
<td><strong>Unilateral</strong></td>
</tr>
<tr>
<td>• Teardrop pulled off by ALL</td>
<td><strong>Bifacet</strong></td>
</tr>
<tr>
<td>• Vertical height of fragment &gt;= width</td>
<td><strong>Floating lateral mass</strong></td>
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<td><strong>Burst Fractures</strong></td>
<td><strong>Posterior arch</strong></td>
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<tr>
<td>• Same mechanism as Jefferson Fx but located at C3-C7.</td>
<td><strong>Clayshoveller’s Fracture</strong></td>
</tr>
<tr>
<td>• Injury to spinal cord (due to displacement of posterior fragments) is common.</td>
<td><strong>Unilateral</strong></td>
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<tr>
<td>• Requires CT to evaluate.</td>
<td><strong>Bifacet</strong></td>
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<td>• Stable</td>
<td><strong>Floating lateral mass</strong></td>
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### Facet Dislocation - Subluxations
- **Anterior subluxation (hyperflexion strain)**
  - The Posterior Ligament complex is disrupted. (30-50% can show delayed instability)
- **Unilateral facet dislocation (stable)**
  - Results from simultaneous flexion and rotation
- **Bilateral Facet Dislocation (unstable)**
  - Results from extreme flexion of head and neck without axial compression

### Unilateral Facet Dislocation
- **Simultaneous flexion and rotation**
- **Best seen on lateral and oblique views**
- Vertebral body subluxation < ½ of AP width
- **Vertebral body subluxation**
- **Facet within foramen on oblique view**
- **Disrupted posterior ligaments**
- **Disrupted SP line on AP**
- **Butterfly appears**

### Bifacet Dislocation
- **Extreme flexion without compression**
- **Unstable**
- Vertebral body anterolisthesis > ½ AP body
- Batwing or bowtie appearance of adjacent facets
- Wide SP on AP view
- Disrupted ALL, disc and posterior ligaments

### Unifacet Fracture Dislocation
- **More common than pure dislocation**
- **Signs as before + fracture**
- Fracture of facet often not seen on radiographs

### Bifacet Fracture Dislocation
- **Higher energy than bifacet dislocation**
- **MVA**

### Clay Shoveler’s Fracture
- **Oblique avulsion fx of spinous process**
- C7 > C6 > T1 levels
- **Due to powerful hyperflexion**
Clay Shovelers Fracture

- Best seen on lateral view
- Double spinous process on AP

Anterior Subluxation

- Hyperflexion sprain
- Posterior ligament complex disrupted
- 20-50% show delayed instability

Anterior Subluxation

- Radiographic findings
  - Localized kyphotic angle
  - Fanning
    - Widened interspinous/interlaminar distance
  - Posterior widening of disc space
  - Subluxation of facet joints
  - Anterior subluxation

Follow up studies

- Look for occult fractures
- Check fixation
- Check for progressive flexion subluxation

PEARLS

- One view is no view.
- 20% of spinal fractures are multiple
- 5% of spinal fractures are at discontinuous levels
- Most spinal fractures occur in upper (C1-C2) or lower (C5-C7) regions

PEARLS (Cont)

- Spinal cord injury occurs
  - At time of trauma 84%
  - As a late complication 15%
- Any signs/symptoms of cord injury require MRI.
- Get CT in patients with unexplained prevertebral soft tissue swelling.