Imaging of Cervical Spine Trauma

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Objective

• Introduce evidence-based imaging approach
  – Role of CT
  – Who?, How?, Why?
• Injury patterns in upper C-Spine
  – Craniocervical junction
• Injury patterns in lower C-Spine
  – Biomechanical stability
Who?

- Clinical criteria exclude injury
  - NEXUS
  - Canadian C Spine Rule
- Sensitivity ~100%
  - Specificity lower
- Awake, alert, not intoxicated
- No distracting injury
- No focal pain/tenderness over spinous processes
- No neurological deficits
- Normal head turning

How?
Cervical Spine Radiography
High Risk Patients

- Difficult to perform
  - Backboards
  - Other injuries
  - Non-cooperative

- Time consuming
  - 10 minutes to 1 hour

- Often inadequate or incomplete
### Balance Radiography vs. CT

<table>
<thead>
<tr>
<th>Feature</th>
<th>Radiography</th>
<th>CT Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>94%</td>
<td>99%</td>
</tr>
<tr>
<td>Specificity</td>
<td>78-89%</td>
<td>93%</td>
</tr>
<tr>
<td>Time</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Cost</td>
<td>+</td>
<td>+++</td>
</tr>
</tbody>
</table>

*Based on critical literature review 3/2004*
Cost-Effectiveness

- **CT cost-effective** if fracture risk > 4%

  **Why?**
  - Frequency of inadequate radiographs
  - Extreme cost of missed fracture
    - small percentage develop paralysis
  - Higher cost of radiography in high-risk


Validated High Risk Criteria

- Focal neurological deficit
- Severe head injury
  - unconscious, skull fracture, intracranial hemorrhage
- High energy mechanism
  - MVC speed > 35mph
  - auto vs. pedestrian
  - death at scene
  - pelvic fracture

- **Logistical**

Hanson, et al, *AJR* 2000;174:713-718
Special Populations

- Elderly
- Children
- Head injured

Location of Fractures

KF Linnau, report in progress
Elderly Subjects with Cervical Spine Fractures

From Lomoschitz, AJR 2002, 178, 573-577

**Elderly**

- Same risk factors
  - Other injuries
  - High energy mechanism
- Fall from standing common
  - 11% of fractures
  - harder to predict
- Type 2 dens fractures

Bub, RSNA 2003
Lomoschitz, AJR, 178: 573-577
Elderly

- Same prediction rule
- Low threshold for CT
  - Focal pain/tenderness
  - Limited exam
  - Findings on radiography
- Focus evaluation on C2
Cervical Spine Injuries in Children

HMC Pediatric Protocol

- Under 4 years
  - AP and lateral radiographs
  - C0-C2 on head CT
- 4-8 years
  - AP, lateral, open mouth, (swimmers)
- 9 and over=adult
- Attending (surgeon/ER/radiol.) required for CT under 9
  - Unless fracture identified
Radiation Reduction

- Limit to high risk patients
- No children
  - Higher radiosensitivity
  - Lower fracture probability
- Lowest mAs
  - Neck/shoulders

Unconscious

- Head Injury
  - Normal cervical spine CT
  - Clinically unexaminable
- Further imaging?
  - Eastern Association for Surgery of Trauma
  - Ligamentous injury
  - MRI, Fluoroscopic flexion/extension, upright
- ? Necessary
Conclusions

• CT is accurate, rapid, effective c-spine screening strategy
• CT c-spine screening is cost-effective in high risk trauma patients
• Radiography optimal for low-risk, or if rapid CT not available

Cervical Spine Imaging Recommendations

• Sigtuna Consensus Conference
• November 2005
• Different scenarios
• www.nordictraumarad.com
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Upper Cervical Spine
Craniocervical Junction

- Complex anatomy
- Difficult to visualize with radiography
- CT screening
  - Increase injury detection
  - Higher sensitivity
  - Uncertain significance of some injuries

Injuries at CT versus XRay

<table>
<thead>
<tr>
<th>Injury</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occipital Condyle</td>
<td>2.1</td>
<td>1.3, 3.5</td>
</tr>
<tr>
<td>C3-C6 Transverse Process (only)</td>
<td>12.5</td>
<td>3.0, 52.0</td>
</tr>
<tr>
<td>C6-C7 Spinous Process (only)</td>
<td>3.8</td>
<td>1.6, 9.1</td>
</tr>
<tr>
<td>Facet Fracture (only)</td>
<td>3.2</td>
<td>1.1, 9.4</td>
</tr>
</tbody>
</table>

Linnaeus et al, RSNA, 2004
Missed Fractures

- Resident misses
  - Found by attending
  - At or below national averages (1.0%)
  - 128 cases
- Attending misses
  - Harder to quantify

Missed Fractures-Cervical Spine

- Upper cervical spine 43%
  - Occipital condyle 26%
  - Dens fractures 17%
- Lower cervical spine 57%
  - Posterior column 47%
  - Lamina/pedicle/articular mass/transverse process

Bittles and Ghoradia, Report in progress
How NOT to Miss Fractures

- Occipital condyles
- Dens
- Posterior elements lower c-spine

How NOT to Miss Fractures

- Occipital condyles
  - 5% of fractures
  - Most commonly missed
- Dens
  - Elderly
- Posterior elements lower c-spine
Occipital Condyle Fractures

- Type 1: Burst fractures
- Type 2: Extension from occiput
- Type 3: Avulsion
- Stability related to ligaments
- Assess atlanto-occipital joint
C1 Ring Fractures

- Frequency: 2-10%
- Neurologic sequelae < 30%
- Mechanism
  - Axial load
  - Axial load with lateral flexion (coupling)

C1 Ring Fractures - Classification

- Jefferson (Burst)
  - “Stable” = no transverse ligament injury
  - “Unstable” = transverse ligament injury
  - ≥ 7 mm displacement C1 lateral masses
Dens Fractures

Type I

Type II

Type III
Type 1 Dens Fracture
Type 2 Dens Fracture

- Common
- Delayed & non-unions
- Elderly (20%)
  - Osteopenia
  - Diagnostic challenge
  - CT limitation
Type III Dens fractures
Hyperextension Teardrop

• Avulsion of ALL
  – Ant-inf corner of C2
• Stable
  – alignment
• DDX: Dislocation of C2-C3 disk and annulus fibrosis
C2: “Hanged-man” Fracture

- Frequency: 5-25%
- Myelopathy: < 25%
- Canal enlarged
  - Unless body fragment
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Lower Cervical Spine
Biomechanical Stability
Biomechanical Stability

• “Loss of ability of the spine under physiological loads to maintain relationships” without cord or nerve root damage or irritation

White and Punjabi, 1990

Biomechanical Stability

• Anterior and posterior columns
  – All plus one
• Instability: 3.5mm or 11 degrees
• No universal classification
Lower Cervical Spine

- Isolated minor fractures
- Vertebral body injuries
- Facet injuries
- Fracture dislocations

Lower Cervical Spine

- Isolated minor fractures
  - Spinous process
  - Transverse process
  - Lamina
- Vertebral body injuries
- Facet injuries
- Fracture dislocation
Lower Cervical Spine

- Isolated minor fractures
- Vertebral body injuries
  - Hyperextension teardrop
  - Anterior compression
  - Burst fracture
  - Flexion distraction
- Facet injuries
- Fracture dislocation
Hyperextension Teardrop

Anterior Compression Injury
Burst Fracture

Flexion Distraction Injury
(Flexion Teardrop)
Lower Cervical Spine

- Isolated minor fractures
- Vertebral body injuries
- Facet injuries
  - Facet fractures (with normal alignment)
  - Lateral mass fracture
  - Unilateral facet dislocation
  - Bilateral facet dislocation
- Fracture dislocation
Articular Facets

Isolated Facet Fracture
Facet Fracture with Displacement (Nerve Root Compression)
Lower Cervical Spine

- Isolated minor fractures
- Vertebral body injuries
- Facet injuries
  - Facet fractures (with normal alignment)
  - Lateral mass fracture
  - Unilateral facet dislocation
  - Bilateral facet dislocation
- Fracture dislocation
Unilateral Facet Dislocation

Facet Fracture/Dislocation
Bilateral Facet Dislocation

Lower Cervical Spine

- Isolated minor fractures
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