Cervical Spine Trauma

Screening the Patient with Neck Pain

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Cervical Spine Injury

- 7000-10,000 present for treatment
- 5,000 die at the scene

NEXUS Study
- 33,922 BTP → 818 Injuries (2.4%)
- Male, 71%

Distribution of Cervical Spine Injury


Neurologic Deterioration Secondary to Unrecognized Spinal Instability Following Trauma

- 8 Level I trauma centers
- Incidence
  - 0.21% among patients with spine fractures
  - 0.025% among all trauma patients


Neurologic Injury

- Significant Source of Morbidity for the patient
- High cost to the Society
  - Medical Care
  - Litigation

Life time Cost of Spinal Cord Injury

- Mean cost of litigation $2.9 million
  - $153,000 – $8.9 million
- Type I Error: Tests were inadequate/improper
- Type II Error: Tests were adequate but misread/not read
- Type III Error: Tests were adequate and read correctly but not sensitive enough

Lekovic et al, Neurosurgery, 2007 Mar;60(3):516-22

Litigation of unrecognized cervical spine injuries

- www.spinalcord.uab.edu/factsandfiguresataglance

Orthopaedic Trauma Institute
**Cost to Society**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>ED Visits in CA</td>
<td>52,000</td>
</tr>
<tr>
<td>Missed injury rate</td>
<td>0.03%</td>
</tr>
<tr>
<td>Litigation Cost</td>
<td>$2,900,000</td>
</tr>
<tr>
<td>Medical Care</td>
<td>$3,100,000</td>
</tr>
<tr>
<td><strong>Total Cost to CA</strong></td>
<td><strong>$90 M</strong></td>
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**C-Spine Clearance Protocols**

- Improve evaluation of patients at high risk
- Decrease (eliminate) missed injuries
- Standardize the clearance process

**EAST PROTOCOL**

**Cervical Spine Injuries**

- **Boney Injuries**
  - Occipital Condyle Fractures
  - Atlas Fractures
  - Axis Fracture
  - Flexion-Compression Injuries
  - Extension Compression injuries
  - Transverse foramen fractures
  - Lateral Mass fractures
  - Lamina fractures
  - Spinous process fractures
- **Ligamentous Injuries**
  - Atlantooccipital dislocation
  - Transverse atlantal ligament injury
  - Flexion-distraction injuries

- Remove Hard Collar as soon as feasible after trauma

**3 Common Scenarios**

- **Mental Status**
  - Alert, awake GCS=15
  - Obtunded GCS <14

- **Symptomatic**
  - Asymptomatic

- **Asymptomatic**
Cervical Collar in ICU

- Increased ICP (5 mmHg)
- IV access
- Difficulty in airway management
- Gastrostasis and aspiration with associated prolonged supine positioning
- Increased likelihood of thromboembolism
- Nerve palsy
- Increased nursing needs


Collar Type

- Restriction of ROM
  - Philadelphia = Miami J
- Occipital pressure
  - Miami J, Miami J Occian < Philadelphia, Aspen
- 89% decrease in CRU

Jacobson TM et al, J Nurs Care Qual, 2008

TAKE HOME MESSAGE #1

- Use MIAMI-J or ASPEN if you need to use collars long term
- Philadelphia should be replaced as soon as possible
Physical Examination

Part of Clearance Process

- Inspection
- Palpation
- Detailed neurologic examination
- Associated injuries

Why?

- 36 y.o. F, fell from a bike
- Presented with neck and shoulder pain

3 Common Scenarios

- Mental Status:
  - Alert, awake: GCS=15
  - Obtunded: GCS <14
- Asymptomatic
- Symptomatic

Who needs Imaging?

- Algorithms to identify patients who can undergo clinical clearance
  - NEXUS Criteria
  - Canadian C-Spine Rules
NEXUS Criteria

- Normal level of alertness (GCS 15)
- No evidence of intoxication
- Absence of tenderness in the posterior midline
- Absence of a neurological deficit
- No distracting pain elsewhere


Distracting Injury

- a long bone fracture;
- a visceral injury requiring surgical consultation;
- a large laceration, degloving injury, or crush injury;
- large burns;
- any other injury producing acute functional impairment.


778 patients
- 34% had DI
- 37 patients had CSI
  - 54% had DI
  - 8% DI was the only indication for X-ray

406 patients
- 40 patients had CSI
  - 7 had normal CE = All had upper torso DI
- Incidence of CSI in patients with neck pain
  - 18.9%
**Canadian C-Spine Rules**

- **Any high-risk factor that mandates radiography?**
  - Age > 65yrs, or
  - Dangerous mechanism, or
  - Paresthesias in extremities

- **Any low-risk factor that allows safe assessment of range of motion?**
  - Simple rear-end MVC, or
  - Sitting position in ED, or
  - Ambulatory at any time, or
  - Delayed onset of neck pain, or
  - Absence of midline C-spine tenderness

- **Able to actively rotate neck?**
  - 45 degrees left and right

**Decision Tree:***

- Yes: **Radiography**
- No: **None**
- **YES**
- **NO**
- **NONE**

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**Clearance of the Asymptomatic Cervical Spine: A Meta-analysis**


This meta-analysis sought to compile data from multiple high-quality studies to more conclusively define the blunt trauma patient who is able to be cleared of cervical spine injury without radiographic evaluation. Fourteen studies met selection criteria and a meta-analysis performed calculated a NPV of 99.3% and sensitivity of 98.1% for protocols safely clearing the cervical spine in this patient population. The missed injuries occurred only in study populations in which a functional test was not used or distracting injury criterion not applied and no neurologic deficits resulted. Thus, an alert, asymptomatic patient without a distracting injury or neurologic deficit who can perform a functional range-of-motion examination is able to be safely cleared from having a cervical spine injury without radiographic evaluation.

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**TAKE HOME MESSAGE #2**

Alert patient with normal cervical spine exam and painless ROM

*(Mechanism of Injury)*

C-Spine can be cleared on clinical basis


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8924 patients enrolled

- 100% sensitivity
  - identifying 151 clinically important C-spine injuries
- 42.5% specificity

Deemed a highly sensitive decision rule for use of C-spine radiography in alert and stable trauma patients

Stiell IG et al, JAMA, 2001
Patient with Neck Pain

Mental Status
- Alert, awake
  GCS = 15
- Obtunded
  GCS < 14
- Asymptomatic
- Symptomatic

Radiographic Evaluation
- The standard 3 view plain film series
  - Lateral
  - AP
  - Odontoid

Plain X-rays
- Advantages
  - Simple
  - Low Cost
  - Sensitive
- Disadvantages
  - Inadequate studies
  - Difficulty in interpretation
  - Low sensitivity when compared to CT

Advantages of CT Scan
1. Excellent for characterizing fractures and identifying osseous compromise of the vertebral canal
2. The higher contrast resolution provides improved visualization of subtle fractures.
3. Provides patient comfort by being able to reconstruct images in the axial, sagittal, coronal, and oblique planes from one patient positioning.
4. Higher rate of adequate studies
Disadvantages of CT Scan

1. difficult to identify those fractures oriented in axial plane (e.g. dens fractures)
2. unable to show ligamentous injuries
3. relatively high costs

CT vs X-Ray

121 patients with CSI
- Only 74 detected by plain films

Sensitivity
- X-ray: 64%
- CT: 100%

19.1% required surgical intervention
**Computed Tomography Versus Plain Radiography to Screen for Cervical Spine Injury: A Meta-Analysis**

Holmes & Akenepalli, J Trauma 2005

- Pooled sensitivity 52% vs 98%

Cost Effectiveness

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference case</th>
<th>Range in Iteration</th>
<th>Range for sensitivity analysis</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of fracture, %</td>
<td>7.75</td>
<td>4.11-15</td>
<td>0.15</td>
<td>2.10</td>
</tr>
<tr>
<td>Sensitivity of radiograph, %</td>
<td>64</td>
<td>64-74</td>
<td>0.10</td>
<td>2.15</td>
</tr>
<tr>
<td>Specificity of radiograph, %</td>
<td>80.5</td>
<td>72-88</td>
<td>0.10</td>
<td>8.9</td>
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<tr>
<td>Sensitivity of CT scan, %</td>
<td>96</td>
<td>95-97</td>
<td>0.10</td>
<td>2.9, 16</td>
</tr>
<tr>
<td>Specificity of CT scan, %</td>
<td>96</td>
<td>93-100</td>
<td>0.10</td>
<td>2.9, 16</td>
</tr>
<tr>
<td>Probability of paralysis, %</td>
<td>14.5</td>
<td>0-20</td>
<td>0-20</td>
<td>3.6, 12, 15</td>
</tr>
<tr>
<td>Cost of CT scan, $</td>
<td>328.93</td>
<td>NA</td>
<td>NA</td>
<td>Institutional data</td>
</tr>
<tr>
<td>Cost of radiograph, $</td>
<td>139.05</td>
<td>NA</td>
<td>NA</td>
<td>Institutional data</td>
</tr>
<tr>
<td>Cost of paralysis, $</td>
<td>500,000</td>
<td>0-80,000</td>
<td>0-1,000,000</td>
<td>Institutional data, 11, 12</td>
</tr>
</tbody>
</table>

Helical CT was found to reduce the risk of missed injuries and minimize overall institutional costs in patients with at least a moderate risk of CSI.

Grogan et al, Am Coll Surg, 2005

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**Is The Lateral Cervical Spine Plain Film Obsolete?**


Division of Trauma, Critical Care, and Emergency General Surgery, Virginia Commonwealth University Medical Center, Richmond, Virginia

- 1004 patients
- 84 cervical spine fractures
  - 68 had inadequate/negative LCS
- Elimination of LCS results in cost saving of $265,000


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**TAKE HOME MESSAGE #3**

Primary Screening Modality for suspected C-Spine Injury:

- Multi detector CT Scan +
  - Coronal and Sagittal reconstructions
Patient with neck pain but negative CT Scan

Can we clear the C-Spine based on the CT alone?

MDCT

Ligamentous Injuries
- Atlantooccipital dislocation
- Transverse atlantal ligament injury
- Flexion-distraction injuries

Reduced
Ligamentous Injuries !!!

Nonskeletal Cervical Spine Injuries: Epidemiology and Diagnostic Pitfalls
Demetriades Demetriades, MD, PhD, Eriakos Charalambides, BS, Santiago Chahuan, MD, David Harper, MD, Kathleen Alo, RN, George Velmahos, MD, James Murray, MD, and Juan Asensio, MD

- 14755 BTP
- 31 (0.2%) patients had subluxations without fracture
  - Plain x-ray and CT diagnosed 30 of them
- 14 patients had neurologic findings
  - 12 recovered completely

Demetriades et al, J Trauma, 2000

Ligamentous Injuries of the Cervical Spine in Unreliable Blunt Trauma Patients: Incidence, Evaluation, and Outcome
William C. Chiu, MD, James M. Haan, MD, Brad M. Cushing, MD, Mary E. Kramer, RN, and Thomas M. Scala, MD

- 14,577 BTP
- 2603 OBTP → 143 CSI
  - 14 (0.5%) had pure ligamentous injury
  - 50% had neurological deficit
- 14 patients
  - 4 had fusion
  - 6 had hard collar

Chiu WC et al, 2001, J Trauma
How can we evaluate Ligamentous Stability?

- **Dynamic Studies**
  - Flexion-Extension X-rays
  - Flexion-extension under fluoroscopy
  - Upright lateral cervical x-ray

- **Static Studies**
  - MRI

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**Case**

- **Flex-ext views in alert patients**

  - 106 patients with negative x-ray +/- CT
  - Adequate views require 30° motion
    - 74 (70%) had adequate studies
    - 5 patients had injury
  - When the study is adequate, false negative rate is zero

- Insko et al, J Trauma, 2002
What is adequate?  
Khan et al, JOT, 2011

Flex-ext views in alert patients  
- 290 patients had flexion-extension x-rays  
- 193 (66%) were adequate  
  - Only one (0.5%) patient had instability  
- Long term follow up available in 116 patients  
- Flexion-extension x-rays in the ED should not be obtained  
Wang et al, CORR, 1999

Flex-ext views in alert patients  
- 311 patients  
  - 31% adequate,  
  - 69% were inadequate, but yet interpreted normal  
- 55% had follow-up  
  - One (0.5%) patient required surgery  
- Flex-ext radiographs are not clinically useful  
Khan et al, JOT, 2011

Static Flexion-Extension X-ray in obtunded patients  
Anekstein Y et al, Injury, 2008
Safety in obtunded patients

- 301 OBTP had fluoroscopic evaluation
- Two true positive (0.07%)
- One false negative
  - Quadriplegia

Davis JW, J Trauma, 2001

TAKE HOME MESSAGE #4

Flexion-Extension X-rays in obtunded patients is contraindicated

Module: Cervical Dynamic Screening in Spinal Clearance: Now Redundant

Alert Patients

- an adequate and negative study appears to rule out CS instability in the patient with CS pain after acute trauma.
- Clinical Degree of suspicion


MRI

1. excellent soft tissue contrast,
   - the study of choice for spinal cord survey, hematoma, and ligamentous injuries.
2. provides good general overview
3. ability to demonstrate vertebral arteries
4. no ionizing radiation.
MRI

1. Loss of bony details
2. Relatively high cost
3. Travel and support at the MRI suite
4. Compatibility
5. Supine position
   ■ ICP
   ■ Ventilator associated pneumonia
Exclusion of Unstable Cervical Spine Injury in Obtunded Patients with Blunt Trauma: Is MR Imaging Needed when Multi-Detector Row CT Findings Are Normal?¹

- 366 OBTP who had MDCT and MRI
- 12 (3.3%) had injuries on MRI
  - Did not change the management
  - NPV 98.9% for ligament injury
  - NPV 100% for unstable C-spine injury
- CT alone is adequate to clear C-spine

Menaker J et al, J Trauma, 2008

Computed Tomography Alone for Cervical Spine Clearance in the Unreliable Patient—Are We There Yet?

- 203 obtunded patients with both MDCT and MRI
- 18 (8.9%) had abnormal MRI
  - 2 (1%) required surgery
    - C1-C2 PLL,LF rupture; C4-5 contusion
  - Delay: 9.9 days
- CT scan continues to miss both stable and unstable injuries

Menaker J et al, J Trauma, 2008

40-Slice Multidetector CT: Is MRI Still Necessary for Cervical Spine Clearance after Blunt Trauma?

- 203 obtunded patients with both MDCT and MRI
- Abnormal MRI that changed management: 17.8%
  - Obtunded: 8.3%
  - Reliable: 25.6%

Menaker J et al, Am Surg, 2010


Conclusions: Reliance on CT imaging alone to “clear the cervical spine” after blunt trauma can lead to missed injuries. This study supports a role for the addition of MRI in evaluating patients who are obtunded, or unexaminable, despite a negative CT scan.

The value of information provided by MRI is still questioned
- May be oversensitive

There are reports that show MDCT might be used alone to clear cervical spine
- Reduced ligamentous injuries remains a problem !!!

MDCT vs MRI is left to institution’s discretion

**TAKE HOME MESSAGE #5**

**The Eastern Association for the Surgery of Trauma**

- Practice Management Guidelines
  - 1998
  - 2000
    - add flex-ext views
  - 2009
    - MDCT as the primary screening modality
    - d/c flex-ext views
    - MDCT vs MRI


**What is the Standard of Care?**

The caution that a reasonable person in similar circumstances would exercise in providing care to a patient
What is the standard of Care?

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<thead>
<tr>
<th></th>
<th>California</th>
<th>U.S.A</th>
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</thead>
<tbody>
<tr>
<td>Response Rates</td>
<td>91%</td>
<td>87%</td>
</tr>
<tr>
<td>Official Protocol in Level I</td>
<td>93%</td>
<td>66%</td>
</tr>
<tr>
<td>Official Protocol in Level II</td>
<td>60%</td>
<td>.</td>
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</table>

Asymptomatic Patient

<table>
<thead>
<tr>
<th></th>
<th>California</th>
<th>U.S.A</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEXUS</td>
<td>50%</td>
<td>54%</td>
</tr>
<tr>
<td>NEXUS + Active ROM</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Overall</td>
<td>83%</td>
<td>89%</td>
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First line of Imaging

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<tr>
<th></th>
<th>California</th>
<th>U.S.A</th>
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<tbody>
<tr>
<td>CT</td>
<td>67%</td>
<td>58%</td>
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Neck pain after negative CT

<table>
<thead>
<tr>
<th></th>
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<th>U.S.A</th>
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</thead>
<tbody>
<tr>
<td>Flex-Ext</td>
<td>8%</td>
<td>23%</td>
</tr>
<tr>
<td>MRI</td>
<td>16%</td>
<td>13%</td>
</tr>
<tr>
<td>Either</td>
<td>42%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Alert patient with normal cervical spine exam

- NEXUS criteria + Active ROM
  - Mechanism of Injury
- C-Spine can be cleared on clinical basis


Alert patient with cervical pain without neurological symptoms

Patient with unreliable physical examination or ability to assess cervical pain

MDCT C0-T2

<table>
<thead>
<tr>
<th>Normal</th>
<th>Normal</th>
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<tbody>
<tr>
<td>Flexion/Extension views</td>
<td>D/C Collar</td>
</tr>
<tr>
<td>Maintain Collar until a reliable exam can be obtained</td>
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THANK YOU