Cervical Spine Trauma

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Topics to Review

- Definition of stability
- Craniocervical distraction
- Hyperflexion “sprain”
- MRI Applications
2-column method

- Supraspinous ligament to PLL
- ALL column to PLL
- Complete column injury produces instability
Defining Stability

- *Mechanical* - spine able to resist non-physiologic movement under physiologic load

- *Neurologic* – injury will not cause or worsen a neurologic injury under physiologic load

- Most mechanically unstable injuries are neurologically unstable. (Exceptions... lo-grade Hangman, Jefferson)

- To be considered *stable* an injury must not led to chronic pain, deformity, neurologic damage
Stability can be inferred from static imaging, but only verified by application of physiologic stress.

Mechanical stability is a continuum, some injuries permit greater disturbance of alignment than others and are more likely to create/exacerbate neurologic injury.

Any patient with a neurologic deficit should be considered mechanically unstable.
Methods of Diagnosis

- Most unstable injuries can be diagnosed from radiographs – but sometimes misleading
- More (almost all) unstable injuries diagnosed by MDCT
- MRI can show ligament injuries, but does not correlate well with surgical findings (tears, partial tears, stripping, stretching)
- **Flexion stability** determined by ligament status (posterior and middle column)
- May appear in anatomic alignment in neutral view but still may be unstable
- Signs:
  - widened facet joints
  - widened lamina
  - widened posterior disc space
  - loss of facet coverage
  - flared spinous processes
C4-5 Hyperflexion Sprain – Ligament

STABLE?
Hyperflexion – Subluxation (unstable)
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Unstable Whiplash
Multi-level distraction injuries
Spinal stenosis
Disc herniation
Anterior distraction (hyperextension)
Posterior axial loading
Cord contusion
Unstable
Occipital Condyle Fractures

Type 1

Type 2

Type 3
Non-congruent arcs

Increased basion-dental distance

Increased C1-C2 posterior distance
<table>
<thead>
<tr>
<th>Metric</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basion-Dens CT &gt; 9.5 mm</td>
<td><img src="image1" alt="Normal Image" /></td>
<td><img src="image2" alt="Abnormal Image" /></td>
</tr>
<tr>
<td>Radiograph &gt; 12 mm</td>
<td><img src="image3" alt="Normal Image" /></td>
<td><img src="image4" alt="Abnormal Image" /></td>
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<tr>
<td>PAL &gt; 5.5 mm</td>
<td><img src="image5" alt="Normal Image" /></td>
<td><img src="image6" alt="Abnormal Image" /></td>
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<tr>
<td>Radiograph &gt; 12 mm</td>
<td><img src="image7" alt="Normal Image" /></td>
<td><img src="image8" alt="Abnormal Image" /></td>
</tr>
<tr>
<td>Occ-C1</td>
<td><img src="image9" alt="Normal Image" /></td>
<td><img src="image10" alt="Abnormal Image" /></td>
</tr>
<tr>
<td>Occ-C1 &gt; 7.8 mm</td>
<td><img src="image11" alt="Normal Image" /></td>
<td><img src="image12" alt="Abnormal Image" /></td>
</tr>
<tr>
<td>C1-C2 &gt; 7.8 mm</td>
<td><img src="image13" alt="Normal Image" /></td>
<td><img src="image14" alt="Abnormal Image" /></td>
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</table>


C1-C2 spinolaminar line > 7.8 mm (p=0.02)
Basion to posterior axial line > 5.5 mm (p=0.0007)
Basion-dental interval > 9.5 mm (p < 0.0001)
Summed condyle to C1 > 4.3 mm (p=0.001)
“V” –shaped atlanto-dental space - trended
Multi-level Injuries
AOD; C1-C2; tectorial membrane; post atlanto-occipital lig; atlanto-dental interval; C5-C6 ligamentum flavum
Type 3 occipital condyle and atlanto-axial distraction

2 –levels of injury
Minor distraction? Cervico-medullary disruption (2-level)
Bilateral type 3 occipital condyles: Grade 3 left ICA injury
MR Verification

> 9.5 mm

> 7.8 mm
Craniocervical Distraction - bleed
Trauma MRI Indications

- Pre-surgical planning
- Assess stability for management (MRI overcalls some ligament injuries)
- Neurologic deficit
- ?? Neck pain with normal exam and high image quality CT
- Normal appearing CT with neuro deficit
  - herniated disc,
  - epidural hematoma,
  - traumatic syrinx
- Prognostic assistance ? (blood, degree of stenosis, compression?, injury extent, injury progression)
- Detect less apparent concurrent injuries
- Assess vessels – especially with selected C-spine injuries (vs. CTA)
- ?? Obtunded – unexaminnable patient with mechanism with normal quality CT
Minimal displacement
Acute traumatic disc herniation

- Central cord syndrome - most common
- Axial or flexion loading of disc
- Edema or hemorrhage in disc space (non-desiccated)
- Associated spinal and soft tissue injury
- C-spine > T-spine > L-spine
Cervical spine spondylosis with canal stenosis

AP mid-sagittal diameter less than 10 mm

Baseline chronic myelopathy and decreased reserve

Central canal syndrome due to extension with grey matter compression
Stab Wounds
Posttraumatic EDH

- Most posterior to dural sac cervico-thoracic as dural sac is tightly adherent to PLL
- Venous- able to transmit increase in pressure – no valves
- Acute stage hematoma is isointense relative to spinal cord on T1-weighted images and hyperintense relative to spinal cord on T2-weighted images
- Subacute stage, such as 30 hours after symptom onset, the hematoma usually has a heterogeneous hyperintensity on both T1- and T2-weighted
- SDH are ventral to cord
- Requires urgent laminectomy and drainage
Epidural hematomas
Cervical spine trauma and vertebral artery injury
Bullet fragments to neck and cervical spine MRI

- 17 pts. (3 fragments in canal)
- CT before and after MRI to assess for movement
- Neurologic exam before and after MRI
- No migration or neurologic decline at median 8 weeks F/U
- MRI can be effective to assess neck GSWs without complications related to metal fragments

Exclusion of Unstable Cervical Spine in Obtunded Patients with Blunt Trauma: Is MR Imaging Needed When MDCT Findings are Normal?

- N=1400 patients with no overt neuro. Deficits had 4 and 16-detector row MDCT negative for instability. 366 also had f/u c-spine MRI – study group
- MRI found 7 cord contusions, 4 ligament injury (one-column/stable), 3 disk edema, 1 patient with all three
- MDCT had 98.9% NPV for ligament injury and 100% NPV for unstable spine.
- No need for c-spine MR in obtunded patient with no overt neuro deficit with high quality negative CT.

Is MRI needed after negative admission c-spine CT?

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Neck pain or neuro deficit</th>
<th>Significant injury = Halo or surgery</th>
<th>681 pts had normal CT; none had significant injury by MR or change in Rx</th>
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<td>Resnick S. et al. JAMA Surg 2014;149(9):934-9</td>
<td>830</td>
<td>Neck pain or neuro deficit</td>
<td>Significant injury = Halo or surgery</td>
<td>681 pts had normal CT; none had significant injury by MR or change in Rx</td>
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<td>Badhiwala JH, et al. Ann Intern Med. 2015;162(6):429-37</td>
<td>1686</td>
<td>Obtunded pts.</td>
<td>Of all patients 3627: 0-1.5% instabilty.0-7.3 op. fixation;0-29.5% prolonged collar use.</td>
<td>MRI showed 0% significant injuries with negative high-quality CT</td>
</tr>
<tr>
<td>Liu, et al. Spinal Cord. 2015:53(10):750-3</td>
<td>59</td>
<td>Neck pain or neuro deficit</td>
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<td>MRI showed 0% significant injuries with negative high-quality CT</td>
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<td>James IA, et al. J Emerg Trauma Shock. 2014:7(4):251-5</td>
<td>1535</td>
<td>Obtunded patients</td>
<td>256 (16.6%) injured by MRI had prolongation rigid c-collar. 11 (0.7%) had unstable injury with neg. CT</td>
<td>In obtunded pt. with unreliable exam and normal CT … still a role for MR. If reliable exam reveals grossly intact motor function MRI may be unnecessary</td>
</tr>
<tr>
<td>Study</td>
<td>N</td>
<td>Description</td>
<td>Follow-up</td>
<td>MRI Needed after High Quality Negative Admission CT</td>
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<td>Raza, M, et al. Injury 2013;44(11):1589-95</td>
<td>1850</td>
<td>Altered sensorium (clear C-spine)</td>
<td>Prolonged follow-up or MRI</td>
<td>NPV (CT) =99.7% PPV 93.7%; CT rules out clinically significant injury. Perform MR on case-to-case basis</td>
</tr>
<tr>
<td>Mavos MN, et al. World J Surg. 2015;39(11):2685-90</td>
<td>383</td>
<td>GCS=15 -C-spine tenderness without neuro signs -Negative CT</td>
<td>Follow-up physical exam, MRI (36) and or Flex-ext. films (19)</td>
<td>No neuro.signs after collar removal. Can withdraw CT precautions in pts. with neck pain but neg. high quality CT</td>
</tr>
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<td>Pancyzkowski DM, et al. J Neurosurg. 2011;115(3):541-9</td>
<td>14,327</td>
<td>Positive is injury requiring orthotic or surgical stabilization</td>
<td>Imaging or clinical f/u for unstable C-spine</td>
<td>Negative likelihood of unstable c-spine with neg. CT &lt;.0001. NPV of normal CT= 100%</td>
</tr>
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<td>Tan LA, et al. Clin Neurol Neurosurg 2014;120:23-6</td>
<td>83</td>
<td>GCS 14 or less = obtunded. Not high impact</td>
<td>CT and MR to clear c-spine</td>
<td>CT &amp; MRI + 34% 4 – CT with + MR (all stable had decompression) CT &amp; MRI – in 61% all collars safely removed</td>
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Intramedullary Lesion Expansion on MRI with Complete Cervical Cord Deficit

- 42 patients with ASCI had 2 consecutive MR scans (1\textsuperscript{st} MR ave. 7 hr, 2\textsuperscript{nd} ave. 55 hr)
- Rostrocaudal length of cord lesion went from on ave. from 60mm on first to 89mm on second MRI.
- Intramedullary length was assoc. with time from injury to 1\textsuperscript{st} MRI (p=0.05) and time to decompression (p=0.03)
- Factors influencing expansion rate (0.9 +/- .8 mm/hr) were the maximum amount of cord compression (p=0.03) and mechanism of injury (p=0.05).

Correlation of MR Diffusion Tensor Imaging Parameters with ASIA Motor Score in Hemorrhagic and Nonhemorrhagic Spinal Cord Contusion

- 25 patients in blunt spinal cord injury (12 – hemorrhagic) and 12 volunteers
- Mean diffusivity, fractional anisotrophy, radial diffusivity, longitudinal diffusivity compared to controls measured at 3 regions of injury.
- Asia score versus DTI showed pts. with hemorrhagic and non-hemorrhagic contusion (sign. reduced FA and longitudinal diffusivity). Values increased for radial diffusivity with non-hemorrhagic contusions.
- In NHC group had strong correlations between ASIA score and average mean diffusivity, fractional anisotrophy, and radial and long. diffusivity.
- No correlation with hemorrhagic contusion and ASIA score and DTI parameters

Thank you for your attention!