Improving Spinal Cord Injury Acute Management

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Trauma Echo PVA

- 86 yo PVA 35 MPH struck head on – landed on hood and windshield
- Field Vitals: Bp 80/30 HR 64 GCS 8
- In ED Bp 76/50 HR 70 Resp: 16 Temp 34.7 Sat 96 percent 2 Liters
- Hematoma with Lac R orbit, neck no ttp, chest decreased bs left, Abd, non tender with ecchymoses L hip, not moving lower extremities
Spinal Cord Contusion

• In animal models, motor function can recover to normal levels after spinal cord injury if as few as 4-6% of cortical motor neurons regain physiologic connection through injured cord segment.
• An increase in axonal survival at injury site of from <3% to >6% allows function to return through the site and converts paralyzed muscles to those with normal function.
• Sparing 5-10% of fibers at lesion center can drive segmental circuits in production of locomotion.

ASIA

A Complete; no sensory or motor function preserved in S4-S5
B Incomplete; sensory but not motor function preserved below neurological level and extending through S4-S5
C Incomplete; motor function preserved below neurological level. Most key muscles have < grade 3 power
D Incomplete: motor function preserved below neurological level. Most key muscles have > grade 3 power
E Normal motor and sensory function

Spared Spinal Tissue

• Improvement after injury

Complete cord lesion at 72 h: 10-15% improve. Only 3% improve to attain class D
* Class B at 72 h: 54% will improve to a lesser degree of weakness
* Class C and D at 72 h: 86% will achieve useful motor function below the level of the lesion
Is SCI Treatment Time Sensitive

- The Golden First Hours of Trauma
- The golden first 24 hours after spinal cord trauma. Does “Time = Neurons” “Cord Attack”
- Steroid Data
- Decompression Data
- Recognizing and Preserving “Spared Cord”
Role of EMS

Pre-hospital Immobilization

- Standards: None
- Guidelines: None
- Options: It is suggested that all trauma patients with a cervical spinal column injury or with a mechanism of injury having the potential to cause cervical spinal injury should be immobilized at the scene and during transport using one of several available methods. A combination of a rigid cervical collar and supportive blocks on a backboard with straps is very effective in limiting motion of the cervical spine and is recommended. The longstanding practice of attempted cervical spinal immobilization using sandbags and tape alone is not recommended.

Has EMS Helped

- Estimated 3% to 25% of spinal cord injuries occur after initial traumatic insult
- Multiple cases of poor outcome from mishandling
- 20% of injuries involve multiple non-continuous levels
Has EMS Helped?

- Over last 30 years there has been dramatic improvement in neurologic status of spinal cord injured patients arriving to ED.
- In 1970's 55% of patients referred to Regional Spinal Cord Injury Centers arrived with complete lesions
- In 1980's 39%
- EMS initiated in 1971

Radiographic Assessment
Asymptomatic Patients

- Standards: Radiographic assessment of the cervical spine is not recommended in trauma patients who are awake, alert, and not intoxicated, who are without neck pain or tenderness, and who do not have significant associated injuries that detract from their general evaluation.
- Guidelines: None
- Options: None

NEXUS TRIAL

- Prospective study at 21 centers across U.S.
- No midline cervical tenderness, no focal neurologic deficit, normal alertness, no intoxication and no painful distracting injury.
- 34,069 patients. 818 with C-Spine injury.
- Negative predictive value 99.8 percent.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>99.0 (98.6–99.6)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>99.8 (99.6–100)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>2.7 (2.6–2.8)</td>
</tr>
<tr>
<td>Specificity</td>
<td>12.9 (12.8–13.0)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td></td>
</tr>
<tr>
<td>Patients with clinically significant injuries</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>99.6 (98.6–100)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>99.9 (99.8–100)</td>
</tr>
<tr>
<td>Specificity</td>
<td>12.9 (12.8–13.0)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>1.9 (1.8–2.0)</td>
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</tbody>
</table>

*CI denotes confidence interval.
Mechanism is Important

Table 4. Sensitivity, Specificity, and Negative Predictive Value of the Two Rules for 162 Cases of “Clinically Important” Injury among 7438 Patients.a

<table>
<thead>
<tr>
<th>Result of Assessment</th>
<th>Canadian C-Spine Rule</th>
<th>NEXUS Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Injury</td>
<td>No Injury</td>
</tr>
<tr>
<td>Positive (no.)</td>
<td>161</td>
<td>3995</td>
</tr>
<tr>
<td>Negative (no.)</td>
<td>1</td>
<td>3281</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>99.4 (95% CI, 96–100)</td>
<td>90.7 (95% CI, 85–94)</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>45.1 (95% CI, 44–46)</td>
<td>36.8 (95% CI, 36–38)</td>
</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>100</td>
<td>99.4</td>
</tr>
</tbody>
</table>

a A total of 845 cases were classified as indeterminate and are therefore omitted from this analysis. † P<0.001. CI denotes confidence interval.

Table 5. Characteristics of Patients with Cervical Spine Injury Not Identified by Decision Rules.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Mechanism of Injury</th>
<th>CCR-Positive Criterion</th>
<th>Injury</th>
<th>Hospitalized</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinically Important Injuries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>M</td>
<td>Fall—fall on head</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>No</td>
<td>Hard collar</td>
</tr>
<tr>
<td>2</td>
<td>67</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
<td>Dangerous mechanics</td>
<td>C1 arch fracture</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>M</td>
<td>Fall—fall on head</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>No</td>
<td>Hard collar</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
<td>Dangerous mechanics</td>
<td>C1 arch fracture</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>5</td>
<td>71</td>
<td>F</td>
<td>Pedestrian struck and thrown</td>
<td>Age 65 y, dangerous mechanics</td>
<td>N1</td>
<td>No</td>
<td>Hard collar</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
<td>Dangerous mechanics, paresthesias</td>
<td>N1</td>
<td>Yes</td>
<td>Internal fixation</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
<td>M</td>
<td>Fall—5 stairs</td>
<td>Dangerous mechanics, paresthesias</td>
<td>N1</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
<td>M</td>
<td>Contact sports, fall on head</td>
<td>Dangerous mechanics, paresthesias</td>
<td>N1</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>9</td>
<td>24</td>
<td>M</td>
<td>Fall—fall on head</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>Yes</td>
<td>Internal fixation</td>
</tr>
<tr>
<td>10</td>
<td>28</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>Yes</td>
<td>Halo</td>
</tr>
<tr>
<td>11</td>
<td>71</td>
<td>M</td>
<td>Fall—fall on head</td>
<td>Age 65 y, dangerous mechanics</td>
<td>N1</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>12</td>
<td>29</td>
<td>M</td>
<td>Contact sports, fall on head</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>Yes</td>
<td>Halo</td>
</tr>
<tr>
<td>13</td>
<td>31</td>
<td>M</td>
<td>All terrorist, ejected</td>
<td>Dangerous mechanics</td>
<td>C1 arch fracture</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>14</td>
<td>56</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
<td>Dangerous mechanics</td>
<td>C1 arch fracture</td>
<td>Yes</td>
<td>Hard collar</td>
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<tr>
<td>15</td>
<td>49</td>
<td>F</td>
<td>Fall—5 stairs</td>
<td>Dangerous mechanics</td>
<td>N1</td>
<td>Yes</td>
<td>Hard collar</td>
</tr>
<tr>
<td>16</td>
<td>35</td>
<td>M</td>
<td>Motor vehicle collision on head</td>
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PECARN 2400 Kids

- AMS
- Focal Neuro Deficit
- Complaint of Neck Pain
- Torticollis
- Substantial Torso Injury
- Predisposing Condition
- Diving
- High Risk MVA
Stable Fractures

- Anterior Subluxation
- Clay Shoveler’s
- Posterior arch C1
- Unilateral facet dislocation
- Wedge Fracture
Unstable Fractures

- Jefferson (C1 Burst)
- Bifacet dislocation
- Odontoid types II and III
- Any Fracture/Dislocation
- Hangman’s Fracture (posterior C2)
- Teardrop Fracture

CT versus Plain Films

- 3 View Missed injuries in up to 57% high risk and 7-35% overall.
- Inadequate visualization in 50-80% of initial series and 25% of repeat radiographs
- High false positive rate (between 18 and 63%) especially when used in elderly patients.

CT versus Plain Films

- High Risk (>5%) Harborview Criteria: MVA > 35 mph, death at scene, fall > 10ft, Significant head injury, Neurological signs or Sxs, Pelvic or multiple Extremity Fractures.
- Validation Study 14% patients high risk with 8.7% cspine injury.
- Remaining 86% patients low risk with injury in only 0.2%
CT Radiation

- Total Radiation is 1/35th that of Abdominal CT
- BUT Thyroid receives 14 times greater radiation from CT than 3 view plain films
- Peds CT exposes thyroid 90-200 times radiation
- Peds more sensitive to radiation
- 1 year old 59.28 mGy, 5 year old 52.3 mGy in thyroid region
- Relative risk of thyroid cancer doubled in age <4

Initial Management

Airway Management - ABC
1. The most immediate threat to patients with injury of the cervical spinal cord is hypoxemia from hypoventilation or aspiration of gastric contents.
2. Patients with spinal cord injuries in the upper cervical region may require early intubation and assisted ventilation - 80% C1-4, 52% T1-6.
3. In-Line traction should be used during intubation
4. Glidescope, and Airway scope probably produce less c-spine motion than Macintosh Blade
5. Low tidal volumes if ALI, ARDS.

Cardiovascular Effects

1. Loss of sympathetic tone after cervical injury may result in vasodilatation, increased venous capacity, and hypotension.
   - Associated bradycardia should distinguish this reaction from shock due to hemorrhage.
   - Fluid should be replaced until systemic arterial pressure responds, but the pulmonary-artery wedge pressure should not be allowed to rise above 18 mm Hg, since patients with spinal cord injuries may sustain pulmonary vascular damage from an injury-associated catecholamine surge, and are thus predisposed to pulmonary edema.

Management in ICU

- Standards: There is insufficient evidence
- Guidelines: There is insufficient evidence
- Options: Management of patients with acute SCI, particularly patients with severe cervical level injuries, in an intensive care unit or similar monitored setting is recommended.
- Cardiovascular Instability period at risk between 1 and 2 weeks.
- Respiratory Insufficiency tends to be more prolonged with ventilation when required not infrequently lasting for weeks.
Blood Pressure Management

- Standards: There is insufficient evidence
- Guidelines: There is insufficient evidence
- Options: Hypotension (systolic blood pressure < 90 mm Hg) should be avoided if possible or corrected as soon as possible following acute SCI. Maintenance of mean arterial blood pressure at 85 - 90 mm Hg for the first seven days following acute SCI to improve spinal cord perfusion is recommended on weak evidence.

Pressure Management

- Based on TBI guidelines where single episode of hypotension associated with 150% increase in mortality.
- Contributes to secondary injury in animal models
- 7 day time point and MAP chosen arbitrarily and have not been subjected to controlled analysis.
- 3 Studies without control groups improvement versus historical results
- There were no recognized untoward effects of MAP Tx
- Systemic Review 2010 Ploumis – “Surprising so little clinical evidence exists” “We do not know what the target MAP should be set at, for how long and with what drugs”

What Pressor to Use?
Danger of Pressors in Blunt Trauma

- 2008 J Trauma - Early Vasopressor use within 12 hours after injury associated with 80% higher risk of mortality if hemorrhagic shock component = transfusion within 12 hrs
- Twofold Higher risk of mortality if used within 24 hours.
- Findings consistent among all vasopressor subtypes - excluded cervical sci and tbi
- Recent (2011) Prelim Randomized Controlled trial MAP of 50 versus 65 significantly decreases postoperative coagulopathy and lowers risk of early postoperative death and coagulopathy - Permissive Hypotension.

Methylprednisolone

- Doses similar to those that inhibit lipid peroxidation and breakdown of neurofilament in animal models. The breakdown of membrane peaks within 8 hrs of injury.
- Methylprednisolone does not produce a significant decrease in neutrophil accumulation but does reduce vascular permeability and tissue edema.
- Protective effects are not neutrophil mediated.
- Dose 1000 times that necessary to activate glucocorticoid receptors

Therapy Acute SCI

- **Corticosteroids: Standards**: There is insufficient evidence
- **Guidelines**: There is insufficient evidence
- **Options**: Treatment with Methylprednisolone for either 24 or 48 hours is recommended as an option in the treatment of patients with acute spinal cord injuries that should be undertaken only with the knowledge that the evidence suggesting harmful side effects is more consistent than any suggestion of clinical benefit.

Early Decompression STASCIS

- 313 patients from 6 Canada and US Centers
- Cervical SCI and imaging evidence of spinal cord compression
- Not Randomized secondary to ethics of decompression in deteriorating patient
- Early Surgery 14.2 +/- 5.4 hour versus Delayed 48.3 +/- 29.3 hours
- 19.8% of early surgery patients had 2 grade or greater improvement compared with 8.8% of delayed surgery patients.
Hypothermia

• AANS Position Statement
• High profile case of football player led to committee to review evidence.
• Not enough evidence to recommend for or against either local or systemic hypothermia.
• Clinicians should be aware that systemic hypothermia has been associated with medical complications in the head injured population

Evoked Potentials

• 46. Consider use of intraoperative spinal cord monitoring including SSEPs and MEPs in any patient with sparing of spinal cord function
• Scientific evidence I/III/IV; Grade of Recommendation A
• 71. If the clinical exam is compromised consider use of electrodiagnostic studies to aid prognosis. Scientific evidence I/III/IV
What is an Evoked Potential
IOM Effectiveness

- Initially SSEPs only in Scoliosis Surgery in place of wake up test.
- SSEP reduced rates of paralysis by 60% with false positive test of approx. 2%.
- Adding MEPs decreases false positives and improves early detection of spinal cord ischemia.
- Maneuvers included correct hypotension to sbp 85, pause surgery (8.5 minutes), steroid administration, removal of spinal instrumentation, and reduction of spinal correction.

Trauma Echo PVA

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- Field Vitals: Bp 80/30 HR 64 GCS 8
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- Hematoma with Lac R orbit, neck no ttp, chest decreased bs left, Abd, non tender with ecchymoses L hip

Trauma Echo PVA 8/7 3AM

- Back Non tender, question decreased rectal tone per trauma.
- Neuro: GCS improved to 10 in ED from 8 in field. Decision made to not intubate. Patient not moving legs bilaterally, but spontaneous bilateral upper extremity movement.
Trauma Echo 86 yo
900 PVA

- Minimal Bilateral frontal and left temporal SAH
- Non Displaced Left C5 lateral mass fx extending into foramen transversarium
- C6 vert. body fx – Bilateral vert artery narrowing C5-C6 Rec. Formal angio and asa when stable
- Facial lacs Right frontal stellate 3x3.
- Facial Fxs: L Max, L Zygoma, L orbital floor, L Coronoid
- Rib Left 5th/6th anterolateral
- T12 vert body acute fx - not moving legs
- Right Elbow open wound
- Non Displaced R iliac wing fx
- Displaced Proximal Right Tibia Fx
- Patient now not moving upper extremities

ICU Management

- Steroids per options protocol
- BP per options: Started with Phenylephrine 70 mcg/min. Attempt to transition to Levophed +/- Vasopressin. All 3 pressors required to obtain MAP
- Sedation for ICP: Propofol 10 mcg/kg/min with Fentanyl 50 ug/hr
- Cause of hypotension – Repeat Het 22 (significant scalp lac) vs hypovolemia vs spinal shock: Phenylephrine will cause compromise of tissue perfusion – suspect hypovolemia but worry of chf

ICU Management

- Attempt to obtain MRI – Patient returned with poor ABG ph 7.1 HCO3 11 Lactate 7.4 thought to be secondary to pressors
- Intubate for declining mental status
- ASIA form – not moving upper extremities now
- Ortho spine – not stable for operative management
- Neurosurg Recs: Order SSEPs and if possible MEPS