Traumatic Spinal Cord Injury

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5:00pm-6:15pm
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Disclosures

• No conflicts of interest to disclose.
Introduction

• Incidence
  – 40 cases per million population in the U.S.
  – 12,500 new cases each year
  – in 2014 estimated 276,000 people in U.S. living with spinal cord injury.

• Males account for 80% of SCI population

• Etiology: Vehicle crash > falls > acts of violence > sports.
Impact

• Hospitalization days average 11 days with 36 days average rehabilitation.

• Impact to health care of spinal cord injury (SCI)

### Lifetime costs

The average yearly health care and living expenses and the estimated lifetime costs that are directly attributable to SCI vary greatly according to severity of injury. These figures do not include any indirect costs—such as losses in wages, fringe benefits, and productivity, which average $71,961 per year in 2014 dollars—but vary substantially based on education, severity of injury, and pre-injury employment history.

<table>
<thead>
<tr>
<th>Severity of Injury</th>
<th>Average Yearly Expenses (in 2014 dollars)</th>
<th>Estimated Lifetime Costs by Age At Injury (discounted at 2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First Year</td>
<td>Each Subsequent Year</td>
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<tr>
<td>High Tetraplegia (C1–C4) AIS ABC</td>
<td>$1,064,716</td>
<td>$184,891</td>
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<tr>
<td>Low Tetraplegia (C5–C8) AIS ABC</td>
<td>$769,351</td>
<td>$113,423</td>
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<tr>
<td>Paraplegia AIS ABC</td>
<td>$518,904</td>
<td>$68,739</td>
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<tr>
<td>Motor Functional at Any Level AIS D</td>
<td>$347,484</td>
<td>$42,206</td>
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</table>

Impact to life expectancy

**Life expectancy** is the average remaining years of life for an individual. Life expectancies for persons with SCI are still significantly below life expectancies for those without SCI and have not improved since the 1980s. Mortality rates are significantly higher during the first year after injury than during subsequent years, particularly for severely injured persons.

<table>
<thead>
<tr>
<th>Age at Injury</th>
<th>No SCI</th>
<th>AIS D—Motor Functional at Any Level</th>
<th>Para</th>
<th>Low Tetra (C5—C8)</th>
<th>High Tetra (C1—C4)</th>
<th>Ventilator Dependent Any Level</th>
<th>No SCI</th>
<th>AIS D—Motor Functional at Any Level</th>
<th>Para</th>
<th>Low Tetra (C5—C8)</th>
<th>High Tetra (C1—C4)</th>
<th>Ventilator Dependent Any Level</th>
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</table>
Tracts

**Ascending tracts**
- Fasciculus gracilis
- Fasciculus cuneatus
- Dorsal white column
- Dorsal spinocerebellar tract
- Ventral spinocerebellar tract
- Lateral spinothalamic tract
- Ventral spinothalamic tract

**Descending tracts**
- Ventral white commissure
- Lateral reticulospinal tract
- Lateral corticospinal tract
- Rubrospinal tract
- Medial reticulospinal tract
- Vestibulospinal tract
- Tectospinal tract
Motor and Sensory

- Motor
- Sensory
Evaluation of Patient

Fig. 1 ENLS traumatic spine injury protocol

- Traumatic Spine Injury
- Immobilize
- Airway
- Disability/Brief Neurological Exam
- Circulation
- Breathing
- Who to Image
- Decision Rules
- Candidate for Clinical Clearance
- Not a Candidate for Clinical Clearance
- Imaging
- Perform Final Clearance Examination
- Unable to Clear
- Leave Immobilized, More Imaging
- Confirmed Injury
- Neurological Exam
- Spinal Cord Injury Treatment
Checklist for the first hour:

- Spine immobilization
- SBP >90
- Supplemental O2
- Early intubation for failure of ventilation
- Rule out other causes of hypotension
Mechanisms of Injury

SPINAL CORD INJURIES

- Flexion Injury
- Penetration Injury
- Distraction Injury
- Compression Injury
- Hyperextension Injury
- Flexion-Rotation Injury
Immobilization of suspected injuries

- Cervical spine immobilization until reliable examination is possible (NEXUS or Canadian C-Spine Rules)
Imaging

- Who to image:
  NEXUS
  Canadian C-spine rules (CCR)
Canadian C-Spine Rules

Canadian High-risk Features
Are there any high-risk factor that mandates radiography?

- Age > 65 yrs. or dangerous mechanism (fall from elevation over 3 ft. or 5 stairs)?
- An axial load to the head (e.g. diving)?
- A motor vehicle collision exceeding 100 km/hr. or with roll-over or ejection, or a collision involving a motorized recreational vehicle, or a bicycle collision?

IF YES to ANY of the above, consider CT criteria for imaging next.

If NO to ALL of the above, move on to Canadian Low Risk features below.

Canadian Low-risk Features
Do any of the following low risk features exist?

- Simple rear-end motor vehicle collision
- Sitting position in the emergency department
- Ambulatory at any time
- Delayed (not immediate) onset of neck pain
- Absence of midline cervical-spine tenderness

If YES to ANY of the above, then proceed to testing of neck rotation.

If NO to ALL of the above, then consider CT criteria for clearance.
The NEXUS rules are:

- No posterior midline cervical-spine tenderness
- No evidence of intoxication
- A normal level of alertness
- No focal neurological deficit
- No painful distracting injuries.
Confirmed Injury

• Initial Management
• Airway
• Breathing
• Circulation
Airway

Intubation: Who?

• Complete injury @ C1-C4: early, elective intubation and mechanical ventilation.
• Parameters for urgent intubation
  – Complaint of "shortness of breath"
  – Vital Capacity < 10 mL/kg or less
  – "Belly breathing" or "quad breathing"
    (abdomen goes out sharply with inspiration)
Airway

Intubation: How?
• Awake, fiberoptic approach by experienced provider
• Urgent or emergent -> rapid sequence intubation
• Cervical in-line stabilization
• TSI patients will already have loss of vasomotor tone; medications that diminish the catecholamine surge may result in hypotension and bradycardia.
Breathing

• Indications for the intubation of the patient with traumatic cervical spine injury:
  – Complete SCI above C5 level
  – Respiratory distress
  – Hypoxemia despite attempts at oxygenation
  – Severe respiratory acidosis
  – Relative indications
  – Complaint of shortness of breath
  – Development of “quad breathing”
  – Vital capacity (VC) of <10 ml/kg or decreasing VC
  – Consideration should be given
  – Need to “travel” remote from ED (MRI, transfer to another facility)
Circulation

• Blood pressure support:
  – Norepinephrine
  – Phenylephrine
  – Dopamine
  – Epinephrine
  – Dobutamine
Disability-Neurological Examination

- Motor and Sensory Exams
- ASIA scale
- Syndromes
  - Anterior Cord Syndrome
  - Central cord syndrome
  - Brown-Sequard Syndrome
ASIA Scale

• (http://www.asiaspinalinjury.org)

ASIA Impairment Scale: Important for prognosis

The American Spinal Injury Association (ASIA) defined a 5-element scale that is prognostic of neurological recovery:

A - Complete: No motor or sensory function in the lowest sacral segment.
B - Incomplete: Sensory but not motor function is preserved in the lowest sacral segment.
C - Incomplete: Less than one-half of the key muscles below the neurological spinal level have grade 3 or better strength.
D - Incomplete: at least one-half of the key muscles below the neurological level have grade 3 or better strength.
E - Sensory and motor function are normal.

Complete injury (no sensory or motor function below a spinal level) has a worse prognosis; however, spinal shock can present this way. Incomplete injuries have better prognosis.
A mixed picture
Anterior Cord Syndrome

- Loss of pain/temperature and motor but NOT light touch; due to contusion of anterior cord or occlusion of anterior spinal artery.
- Associated with burst fractures of spinal column with fragment retropulsion by the axial compression.
Central Cord Syndrome

- Loss of cervical motor function with relative sparing of lower extremity strength.
- Typically due to hyperextension injury in elderly patients with cervical stenosis.
- Often no fracture; rather, buckling of ligamentum flavum contuses cord, causing bleeding with the center of cord.
Brown-Sequard Syndrome

- Hemiplegia, loss of ipsilateral light touch, AND loss of contralateral pain/temperature sensation due to hemisection of the cord.
- Indicates a penetrating cord injury often from missile or knife, or a lateral mass fracture of the spine.
Autonomic Dysreflexia

- Level of SCI = >T6
- Descending inhibitory signals are blocked at the spinal cord
- Baroreceptors in blood vessels detect hypertensive crisis - signal the brain
- Hear rate is slowed
- Hypertension
- Widespread vasoconstriction
- Full bladder or bowel stimulus
- Afferent stimulus
- Massive sympathetic response
Treatment

- Steroids?
- Temperature management
- Stem cells
- Venous thrombus prevention

- Pediatric Consideration
NASCIS 2:

NASCIS 3:

Methylprednisolone for acute spinal cord injury: an inappropriate standard of care*

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University of Calgary Spine Program, Foothills Hospital and Medical Centre, Calgary, Alberta, Canada

Object. Since publication in 1990, results from the National Acute Spinal Cord Injury Study II (NASCIS II) trial have changed the way patients suffering an acute spinal cord injury (SCI) are treated. More recently, recommendations from NASCIS III are being adopted by institutions around the world. The purpose of this paper is to reevaluate carefully the results and conclusions of these studies to determine the role they should play in influencing decisions about care of the acutely spinal cord–injured patient.

Methods. Published results from NASCIS II and III were reviewed in the context of the original study design, including primary outcomes compared with post-hoc comparisons. Data were retroconverted from tabular form back to raw form to allow direct inspection of changes in treatment groups. These findings were further analyzed with respect to justification of practice standards.

Although well-designed and well-executed, both NASCIS II and III failed to demonstrate improvement in primary outcome measures as a result of the administration of methylprednisolone. Post-hoc comparisons, although interesting, did not provide compelling data to establish a new standard of care in the treatment of patients with acute SCI.

Conclusions. The use of methylprednisolone administration in the treatment of acute SCI is not proven as a standard of care, nor can it be considered a recommended treatment. Evidence of the drug’s efficacy and impact is weak and may only represent random events. In the strictest sense, 24-hour administration of methylprednisolone must still be considered experimental for use in clinical SCI. Forty-eight-hour therapy is not recommended. These conclusions are important to consider in the design of future trials and in the medicolegal arena.
Fig. 1. Graphs depicting mean neurological scores for NASCIS II patients receiving treatment within 8 hours of SCI. 

Left: Improved motor function in patients receiving MP compared with those receiving placebo was believed by the investigators to be significant at 6 weeks, 6 months, and 1 year after injury. Center: Pinprick scores were reported to be improved in steroid-treated patients at 6 weeks and 6 months posttreatment, but the effect is lost at 1 year. Right: Light touch data showed an essentially identical trend as that obtained on pinprick sensation. When absolute scores from these three outcomes are compared in their entirety, the difference in recovery between the two treatment groups is not compelling and can easily be explained by random chance. Note that of 487 patients entered into the study, this post-hoc analysis applies to only 127 and represents only half of the available motor data. sem = standard error of the mean.
CONCLUSION: A critical reevaluation of the clinical efficacy of steroid administration in acute SCI demonstrates that, despite a Class I trial and general widespread use, the evidence for 24-hour MP therapy in humans is negligible or weak at best . . . MP therapy should be regarded as potentially harmful and possibly lethal.
Hypothermia

• There are no randomized controlled trials
Stem Cells
Venous thrombus prevention

• Recommendations:
  – Level II, Early administration of VTE prophylaxis (within 72 hours) is recommended.
  – Level III, Vena cava filters are not recommended as a routine prophylactic measure, but are recommended for select patients who fail anticoagulation or who are not candidates for anticoagulation and/or mechanical devices.
Venous thrombus prevention

• Pharmacologic agents (Chest guidelines)
Case study #1

• 41 y.o. male. no significant PMHx, regular Marijuana user, who was brought in as critical code trauma after being pulled out of shallow water with bilateral arm and leg weakness.

• Patient dove into shallow water and was witnessed to be struggling per family who pulled him out. He was weak in arms and legs.
Case #1 physical assessment

GCS: 15

COMPREHENSIVE EXAMINATION: Lungs are rhonchorous, with active secretions. Heart tones are normal. Peripheral circulation w/o cyanosis, good pulses, JVD present. Abdomen is distended, semi-firm, BS assessed. Skin assessed for rash. Volume status assessed.

Neurological examination:
Neurological Exam: Alert, fully oriented, follows commands briskly.

Motor Exam:
Shoulder shrug 5/5 bilat.

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Reflexes Exam:

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Sens:
Diminished to temp, sharp, vibration past upper chest ~T2.
Case #1 admit CT
Case #1 initial management

- CT Cervical Spine show unilateral locked left facet at C3-C4. Patient was placed in halo and 80lb traction for decompression.
- MRI obtained:
Case #1 MRI
Case #1 formal management

- Admit: spinal cord injury, did external reduction with tongs, followed by halo. MRI and CT shows spinal injury. Ortho surgery handling spine.
- Day #1: appears depressed.
- Day #2: Underwent C3-4 decompression and fusion
- Day #3: Hypotension in AM
- Day #4: Robaxin for back pain, pan cultured, ongoing cooling
- Day #5: emesis overnight, Dopamine weaned. Breathing well.
- Day #6: pulmonary edema and infiltrates continue to be an issue.
- Day #7: MAP therapy ends, and no significant change in the motor exam.
- Day #8: Transferred to 6N from ICU
- Day #9: GI consulted: Methylnaltrexone 8mg SQ given
Case #1 post op imaging
Case #1 ICU transfer to floor:

- C3/4 ASIA B spinal cord injury, s/p C3/4 reduction of unilateral facet dislocation and posterior spinal fusion with instrumentation on by orthopedics. He has shown no signs of neurological recovery since his injury and remains quadriplegic with 0/5 in the UEs, 1/5 proximal LEs, 0/5 distal LEs.

- Sodium goal: 135 - 145

- Prosthetics/orthotics: Wear Aspen cervical collar at all times. Duration: at least 6 weeks and until instructed at follow-up appointment.

- Activity: as tolerated
Case #1 hospital discharge exam:

- Motor scores were: 0/5 strength in all extremities at this time. No change since admission. **Internal rotation of hip 1/5 only.**
- **Motor Exam:** Outward movement with pain and withdrawal bilateral lower extremity with painful stimuli. Right leg intermittent spasm.
- **Sensory Exam:**
  Light Touch and pinprick: No sensation below C6.
Case Study #2
Case #2 imaging:
References:

• ENLS reference
• NASCIS
• https://www.nscisc.uab.edu/reports.aspx
Contact

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• Amanda Severson, ACNP-bc: aseverson@mednet.ucla.edu