Contemporary Management of Spinal Cord Injury

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Disclosures

- I have nothing to disclose
Spinal Cord Injury

- Spinal Cord Injury Basics
- What works
- What may work
- What doesn't work
Spinal Cord Injury

- 12,000 new cases in US/year
- 238,000 – 332,000 in US live with SCI
- 80% are male
Spinal Cord Injury

- Two peaks
  - Age 15-29
  - Age > 65

- 40 years – avg age at time of injury

- ↑ in geriatric population with SCI
Spinal Cord Injury

- Incomplete quadriplegia – 41%
- Incomplete paraplegia – 19%
- Complete paraplegia – 18%
- Complete quadriplegia – 12%
Spinal Cord Injury

- Estimated lifetime costs
  - $1.1 million
  - $4.6 million
Mechanism of Injury

- MVC is most common cause
  - Falls – second (common in elderly)
  - GSW
  - Sport related injuries
Mechanism of Injury

- Spinal injuries include:
  - Fractures
  - Ligamentous disruptions
  - Combined

- Direct compression and injury to spinal cord
Pathophysiology
Pathophysicsology

Flexion/extension distraction
Axial compression rotation

Immediate tissue disruption caused by mechanical forces

Normal cord → Mechanical impact → PRIMARY INJURY

Acute pathophysiologic processes

NEUROPROTECTIVE INTERVENTIONS
- In-field stabilization
- Advanced trauma life support resuscitation
- Pharmacologic agents
- Prompt medical/surgical care

SECONDARY INJURY
Pathophysiology

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Normal cord
Mechanical impact
PRIMARY INJURY

Acute pathophysiologic processes

NEUROPROTECTIVE INTERVENTIONS
- In-field stabilization
- Advanced trauma life support resuscitation
- Pharmacologic agents
- Prompt medical/surgical care

SECONDARY INJURY
Secondary Injury
Pathophysiology

- Flexion/extension distraction
- Axial compression rotation

Immediate tissue disruption caused by mechanical forces

- Normal cord
- Mechanical impact
- PRIMARY INJURY

- Acute pathophysiologic processes

NEUROPROTECTIVE INTERVENTIONS

- In-field stabilization
- Advanced trauma life support resuscitation
- Pharmacologic agents
- Prompt medical/surgical care

SECONDARY INJURY
No single pathway has been a successful target of pharmacologic intervention
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Mainstay of treatment

- Attenuate
- Mitigate
- Prevent
Spinal Cord Injury

- Spinal Cord Injury Basics
- What works
- What may work
- What doesn't work
Spinal Cord Injury

- Spinal Cord Injury Basics
- What works
- What doesn’t work
Initial Management
Initial Management

- Airway for high SCI
  - Above C5
  - Up to 65% with cervical SCI have resp dysfunction
- Avoid hypoxia
- Avoid hypotension
Initial Management

- Airway for high SCI
  - Above C5
  - Up to 65% with cervical SCI have resp dysfunction
- Avoid hypoxia
- Avoid hypotension
  - Neurogenic shock
Parasympathetic innervation

Heart (sinus node)
- Reduced heart rate
- Reduced contractility

Baroreceptors in aortic arch and carotid sinus
- Regulates blood pressure

Sympathetic innervation

Heart (T1–T5)
- Increased heart rate
- Increased contractility

Arteries of the upper thorax
- Innervates smooth muscle

Arteries of the lower thorax (T6–L2)
- Innervates smooth muscle

Sympathetic preganglionic neurons located in the intermediolateral cell column in the gray matter of the spinal cord
Sympathectomy and loss of supraspinal control of sympathetic nervous system

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Sympathetic preganglionic neurons located in the intermediolateral cell column in the gray matter of the spinal cord
Sympathectomy and loss of suprascapinal control of sympathetic nervous system

Unopposed parasympathetic activity and stimulation of vagus nerve
Sympathectomy and loss of supraspinal control of sympathetic nervous system

Unopposed parasympathetic activity and stimulation of vagus nerve

Hypotension and profound bradycardia and atrioventricular nodal block
Neurogenic Shock

- Lasts 1-3 weeks

- Fluid resuscitation to maintain euvolemia

- Pressors, inotropes, or combination
  - No established recommendations
## Neurogenic Shock

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Initial Management

- Detailed neurological examination
  - American Spinal Injury Association (ASIA)
### Muscle Function Grading

0 = total paralysis  
1 = palpable or visible contraction  
2 = active movement, full range of motion (ROM) with gravity eliminated  
3 = active movement, full ROM against gravity  
4 = active movement, full ROM against gravity and moderate resistance in a muscle-specific position  
5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person  
NT = not testable (i.e., due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal range of motion)

### Sensory Grading

0 = Absent  
1 = Altered, either decreased/impaired sensation or hypersensitivity  
2 = Normal  
NT = Not testable

### Non Key Muscle Functions (optional)

May be used to assign a motor level to differentiate AIS B vs. C

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<th>Root level</th>
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<td>Shoulder: Flexion, extension, abduction, adduction, internal and external rotation</td>
<td>C6</td>
</tr>
<tr>
<td>Elbow: Supination</td>
<td>C6</td>
</tr>
<tr>
<td>Elbow: Pronation</td>
<td>C6</td>
</tr>
<tr>
<td>Wrist: Flexion</td>
<td>C7</td>
</tr>
<tr>
<td>Finger: Flexion at MCP joint</td>
<td>C8</td>
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<td>Thumb: Opposition, adduction and abduction perpendicular to palm</td>
<td>T1</td>
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<tr>
<td>Hip: Abduction of the index finger</td>
<td>L2</td>
</tr>
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<td>Hip: Extension</td>
<td>L3</td>
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<tr>
<td>Hip: Extension, abduction, internal rotation</td>
<td>L4</td>
</tr>
<tr>
<td>Knee: Flexion</td>
<td>L5</td>
</tr>
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<td>Ankle: Inversion and inversion</td>
<td>L6</td>
</tr>
<tr>
<td>Toe: MP and P extension</td>
<td>L7</td>
</tr>
<tr>
<td>Hallux and Toe: D' and DIP flexion and abduction</td>
<td>L8</td>
</tr>
<tr>
<td>Hallux: Abduction</td>
<td>S1</td>
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### ASIA Impairment Scale (AIS)

#### Steps in Classification

The following order is recommended for determining the classification of individuals with SCI:

1. **Determine sensory levels for right and left sides.**  
The sensory level is the most caudal intact dermatome for both pin prick and light touch sensation.

2. **Determine motor levels for right and left sides.**  
   Defined by the lowest key muscle function that has a grade of at least 3 (or scale level testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as 5).
   Note: In regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level; i.e., if the motor function above that level is also normal.

3. **Determine the neurological level of injury (NLI).**  
   This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strengths, provided that there is normal (intact) sensory and motor function cranially respectively.
   The NLI is the most caudal of the sensory and motor levels determined in steps 1 and 2.

4. **Determine whether the injury is Complete or Incomplete.**
   (i.e., absence or presence of spasticity)
   - If voluntary anal contraction = NO AND all S4-5 sensory scores = 0 AND deep anal pressure = No, then injury is Complete.
   - Otherwise, injury is Incomplete.

5. **Determine ASIA Impairment Scale (AIS) Grade:**
   - **Is injury Complete?**  
     - IF YES, AIS=A and can record  
     - ZSIP (lowest dermatome or myotome on each side with some preservation)  
     - NO  
     - **Is injury Motor Complete?**  
       - IF YES, AIS=B  
       - NO  
       - (No voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

   - **Are at least half (or more) of the key muscles below the neurological level of injury graded 3 or better?**
     - NO  
     - **AIS=C**
     - YES  
     - **AIS=D**

   If sensation and motor function is normal in all segments, AIS=E
   Note: AIS E is used if follow-up testing indicates no individual with a documented SCI has recovered normal function if at initial testing no deficits are found, this individual is neurologically intact; the ASIA Impairment Scale does not apply.
What else Works
Surgical Management

- **Goals**
  - Stabilize the spine
  - Decompress the spinal canal
  - Prevent further injury
Timing??
Timing of Stabilization

- Controversial
- Experimental evidence
- < 1 Hour
Timing of Stabilization

- How early is early?
  - 8, 24, 72 hours? 5 Days?

- What is the endpoint?
  - Improved neurological recovery?
  - Improved morbidity?
Non-Neurological Benefits

- Strong evidence that early (< 72 hours) stabilization:
  - ↓ pneumonia
  - ↓ DVT
  - ↓ LOS
  - ↓ Medical Costs
What about Neurologic Recovery??
Early versus Delayed Decompression for Traumatic Cervical Spinal Cord Injury: Results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS)
Cervical SCI

- Early decompression (<24 hours)
  - 182 patients

- Late decompression (≥ 24 hours)
  - 131 patients

1° Outcome – change in ASIA grade at 6 months
Early decompression (<24 hours)
- 19.8% showed ≥ 2 grade improvement
- 24.2% complications

Late decompression (≥ 24 hours)
- 8.8% showed ≥ 2 grade improvement
- 30.5% complications
- Early decompression (<24 hours)
  - 19.8% showed ≥ 2 grade improvement
  - 24.2% complications

- Late decompression (≥ 24 hours)
  - 8.8% showed ≥ 2 grade improvement
  - 30.5% complications

Early surgery – OR 2.83 (1.10, 7.28)
Decompression within 24 hours is safe and associated with improved neurologic outcomes.
Timing of Decompression in Patients With Acute Spinal Cord Injury: A Systematic Review
Existing evidence supports improved neurological recovery among cervical SCI patients undergoing early surgery.
What Always Works
DVT Prophylaxis
DVT Prophylaxis

- **Incidence of VTE**
  - 12% - 64%

- Accounts for 10% of deaths in first year
Mechanical compression should be implemented asap
DVT Prophylaxis

- Mechanical compression should be implemented asap

- Level I Recommendations:
  - LMWH, rotating beds, or a combination
  - Low dose heparin in combination with pneumatic compression stockings or electrical stimulation
DVT Prophylaxis

- **Level II Recommendations:**
  - Early administration within 72 hours
  - 3-month duration of prophylactic treatment

- **Level II Recommendations:**
  - Vena cava filters not recommended for prophylaxis
What else Works

- Aggressive screening and treatment of infections
- Treatment of hyperglycemia
- Early nutrition
- Protection against pressure ulceration
- Transfer to SCI center
Spinal Cord Injury

- Spinal Cord Injury Basics
- What works
- What may work
- What doesn't work
What May Work
Cardiopulmonary Management

- Maintain MAP 85 - 90 mm Hg
  - For first 7 days
  - Level III recommendations
  - Based on case series and small studies
  - No consensus on choice of agent
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Hypothermia??
Mechanism

- Decreased metabolic rate
  - $1C = -6$ to $10\%$ demand

- Secondary effects
  - Apoptosis pathways
  - Dampened neuro-excitative pathways
  - Regulated free-radical production
  - Anti-inflammatory
Buffalo Bills Football Player Receives New Spinal Treatment

An experimental treatment was used on Buffalo Bills football player Kevin Everett to prevent paralysis from a spinal injury. A spinal cord injury specialist discusses the treatment and its possibilities.
Hypothermia and SCI

- C3 C4 fracture with SCI
- Cooled to 33.3° C immediately and for 48 hrs
- Steroids
- Immediate decompression
Walking again
Therapeutic hypothermia for spinal cord injury

W. Dalton Dietrich, III, PhD
Modest hypothermia: 32-34°C

Robust experimental studies demonstrate benefit

Some clinical evidence demonstrates usefulness
Research

Novel applications of therapeutic hypothermia: report of three cases
Koen J Hartemink¹, Willem Wisselink², Jan A Rauwerda³, Armand RJ Girbes⁴ and Kees H Polderman⁵

August 2004

- 1 patient
- Nontraumatic SCI
- Cooled to 32° C for 24 hours
- Return of neurological function
The Use of Systemic Hypothermia for the Treatment of an Acute Cervical Spinal Cord Injury in a Professional Football Player

Andrew Cappuccino, MD,*† Leslie J. Bisson, MD,†‡§ Bud Carpenter, ATC,*
John Marzo, MD,†‡ W. Dalton Dietrich, III, PhD,¶ and Helen Cappuccino, MD||

- 1 patient
- Complete SCI
- Cooled
- Other interventions utilized
- Conclusions?
Hypothermia and SCI

- Animal studies
- Case reports
- Further studies needed
Spinal Cord Injury

- Spinal Cord Injury Basics
- What works
- What may work
- What doesn't work
What Doesn’t Work

- Pharmacologic Therapy
What Doesn’t Work

- Pharmacologic Therapy
  - Steroids
  - GM1 ganglioside
  - Thyrotropin releasing hormone
  - Nimodipine
  - Gacyclidine (GK-11)
Steroids and Spinal Cord Injury

NASCIS I

- Published in 1984
- Prospective randomized
- Methylprednisolone
- Low dose vs. higher dose

NO DIFFERENCE

4X Wound Infection
Steroids and Spinal Cord Injury
NASCIS II

- 1990 (follow-up 1992)
- Prospective randomized
- Methylprednisolone, naloxone, placebo for 24 hours

NO DIFFERENCE

2X Wound Infection and PE
Steroids and Spinal Cord Injury
NASCIS II

- Post hoc analysis
- Included 38% of study patients
- Improvement in motor and sensory score if given within 8 hours

Not clinically significant
Steroids and Spinal Cord Injury
NASCIS III

- 1997
- Prospective randomized
- 24 hour steroids vs. 48 hour steroids vs. 48 hour tirilazad

**NO DIFFERENCE**

2X pneumonia and 4X severe sepsis
Steroids and Spinal Cord Injury
NASCIS III

- Post hoc analysis
- Included 30% of study patients
- Improvement in motor score if given between 3 and 8 hours for 48 hours

Not clinically significant
There is no convincing evidence to support the use of methylprednisolone in acute SCI
Guidelines for the Management of Acute SCI - 2013

- MP is not recommended

- No Class I or Class II evidence supporting its use

- Class I, II, and III evidence demonstrates harmful side effects of high dose MP
On the horizon?

- Stem Cells

- New Technologies
  - Modern wheelchairs
  - Computer adaptations
  - Electronic aids to daily living
  - Electrical stimulation devices
  - Robotic gait training
Spinal Cord Injury

- What works
  - ATLS, early surgery, DVT proph, supp care

- What may work
  - Hypertension, hypothermia

- What doesn’t work
  - Pharmacologic therapy (steroids)
Spinal Cord Injury

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  - ATLS, early surgery, DVT proph, supp care

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