Quick Facts

1. The average age of the spinal cord injured patient is 40.7 years.1
2. The estimated lifetime expense of spinal cord injury ranges from 1.4 million to 4.4 million dollars.1
3. Over the past decade, an increase in survivorship for spinal cord injured casualties has been observed.1
4. Spinal cord dysfunction is due to two distinct injuries - primary injury and secondary injury. The primary injury is the initial phase as a result of the energy transmitted to the spinal cord. The secondary injury is progressive and evolves over hours following the initial trauma.
5. The most devastating of the spinal cord injuries is tetraplegia. National data demonstrates that patients with tetraplegia have significantly shorter life expectancies than paraplegic patients.
6. COMPLETE injuries are defined as a patient that has any spinal level below which there is no neurological function. Any other presentation would be INCOMPLETE.

Resources

The National Spinal Cord Injury Statistical Center supervises collects and manages the world’s largest database on spinal cord injury with more than 140,000 records. (https://www.nscisc.uab.edu/public_content/annual_stat_report.aspx) The database captures approximately 13% of acute spinal cord injured patients in the United States annually.1 The University of Alabama at Birmingham Department of Rehabilitation Medicine has championed this effort. Patients, families and friend of the spinal cord injured patient frequently seek resources. Several advocacy groups have provided on-line resources which are consistent with standard management. The American Spinal Injury Association (http://www.asia-spinalinjury.org/) makes information available for providers, patients and serves as an advocacy group.2 The Paralyzed Veterans of America (http://www.pva.org/) offers clinical practice guidelines and also serves as a resource for patients and families.3

Pathophysiology and Clinical Presentation

The overwhelming majority of injuries to the spinal cord are associated with injury to the spinal column. Also, most vertebral injuries include both fracture and dislocation.4 The injury to the spine is of great significance to the degree of initial trauma the spinal cord receives as well of risk for further spinal cord injury due to instability. Spinal cord dysfunction is due to two distinct injuries - primary injury and secondary injury. The primary injury is the initial phase as a result of the energy transmitted to the spinal cord. Disruption of axons, blood vessels and cells occur as a result of primary injury. Continued compression of the spinal cord from displacement of the vertebral elements are also considered primary injury.4 The secondary injury is progressive and evolves over hours following the initial trauma. The mechanisms for secondary injury are not completely understood. A cascade of events begins in response to the initial injury.4
Presentations and Patterns
The ability to identify a spinal cord injury is facilitated in the patient who is conscious with no distracting injuries. However, the patient who suffers cord injury has received a significant force, making the rate of traumatic brain injury and other distracting injuries significant. These additional injuries also impact the outcomes of the casualty with a spinal cord injury. The most devastating of the spinal cord injuries is tetraplegia. The National Spinal Cord Center statistical data reveal casualties with tetraplegia have significantly shorter life expectancies than paraplegic patients. For example, a 30 year casualty with paraplegia has a 36.3 year life expectancy, compared to a 30 year old trauma victim with C5-C8 tetraplegia who has a 31.6 year life expectancy.

Traumatic spinal cord injuries are classified as either complete or incomplete. The ASIA Committee classifies “complete” as the presence of any spinal level below which there is no neurological function. This translates into a simple definition of "complete" spinal cord injury in which a person is a "complete" cord injury if they have no motor or sensory function in the anal and perineal region representing the lowest sacral cord (S4-S5). The neurologic deficit due to a spinal cord injury is graded using the American Spinal Injury Association Scale (ASIA Impairment Scale) A complete injury is an ASIA-A. Incomplete injuries are graded as ASIA-B, C or D. AIS E (normal exam) only applies to patients in whom a documented neurologic deficit has resolved. (see table 1.)

Two well-described patterns of incomplete injury are anterior cord syndrome and central cord syndrome. With anterior (ventral) cord injuries, the corticospinal, spinothalamic and descending autonomic tracts to the sacral centers are injured. These patients will have weakness and reflex changes from corticospinal tract involvement. The spinothalamic tract deficit will manifest as loss of pain and temperature sensation. Urinary incontinence is a reflection of descending autonomic tracts. Proprioception, tactile and vibratory sense is maintained.

Central cord syndrome is typically associated with a hyperextension injury in a patient with cervical spondylosis. Motor dysfunction is greater in the upper extremities than the lower extremities. A variable degree of sensory loss may be present caudal to the injury.

Spinal cord injury in the cervical and upper thoracic region can result in loss of sympathetic outflow resulting in neurogenic shock. Preventing secondary injury due to hypotension and hypoxic is a goal during the resuscitation of the spinal cord injured patient, similar to the victim of traumatic brain injury. Clinical practice guidelines recommend achieving a mean arterial pressure of at least 85 mmHg, although no conclusive data supports this target. Fluid resuscitation and pressors may be required.

Neurogenic shock is to be contrasted to spinal shock. Spinal shock is the transient suppression and gradual return of reflex activity caudal to spinal cord injury.

Imaging
The NEXUS study (National Emergency X-Radiography Utilization) identified patients who do not require cervical spine imaging. Specifically, this set of patients are of normal alertness, without midline cervical tenderness, not intoxicated, free of focal neurologic deficit and free of painful, distracting injury. Subsequently, CT of the spine was identified to be more rapid and sensitive for evaluating the spine as compared to plain films. A 2009 study concluded CT should replace cervical spine radiographs as the initial evaluation for blunt cervical spine injury. CT imaging was found to have superior sensitivity for detection of clinically significant injuries in high, medium and low risk groups of patients suffering a blunt mechanism of injury.

Debate continues if CT is adequate to exclude cervical spine injury in the obtunded patient. In a study of 402 patients, Hennessy concluded that CT of the cervical spine was highly sensitive, detecting 99.75% of clinically significant cervical spine injuries. Two studies published in 2010 suggest CT is inadequate to clear the cervical spine. In a meta-analytical cost effectiveness analysis, Halpern concluded neuroimaging studies for cervical spinal clearance in clinically unevaulable patients are not cost-effective as compared to empirical immobilization in a semirigid collar. Complications associates with collar use were usually minor and short-lived. Schoenfeld reviewed eleven studies and concluded that reliance on CT
imaging alone would lead to missed injuries. This meta-analysis supported a role for the addition of MRI in evaluating patients who are unevaluable, despite a negative CT scan. A study published in 2011 suggested clearance of the cervical spine is acceptable in the obtunded blunt trauma patient who has gross movement of all extremities if the CT of the cervical spine is negative for injury.

MRI has demonstrated utility in the patient with a spinal cord injury. MRI scanning provides greater detail of the spinal cord. Cord compression, hemorrhage and edema are all better identified by MRI than CT. These features are all associated with poor prognosis for neurologic recovery.

**Acute Management**

Glucocorticoids have been used for spinal cord injury for approximately twenty years. The laboratory experience dates back to the 1970’s. Glucocorticoids have been found to improve neurologic recovery in animal models. The National Acute Spinal Cord Injury Study (NASCIS) II was published in 1992. The study involved three treatment groups – methylprednisolone, naloxone and placebo. In 427 patients, no significant improvement in neurologic function was noted at one year in the methylprednisolone treatment group. Significant improvement in motor function was observed at six weeks, six months and one year post injury. Complication and mortality rates were similar in all groups. Patients treated eight hours after injury had less improvement in motor function.

Results of NASCIS III were published in 1997 and 1998. Three treatment groups were utilized – methylprednisolone for 24 hours, methylprednisolone for 48 hours and tirilazad mesylate for 48 hours. Tirilazad mesylate is a lipid peroxidation inhibitor. No difference in outcomes at one year was observed in patients receiving treatment within three hours. The patients that received methylprednisolone treatment between three and eight hours had a greater motor, but not functional recovery, when compared to the other groups. Even though mortality was similar in all treatment groups, the group treated with the longer duration of methylprednisolone had more severe sepsis and severe pneumonia than the group treated with the shorter duration of methylprednisolone.

NASCIS II data, a Japanese trial and a French trial were evaluated in a meta-analysis in 2002. The investigator concluded that methylprednisolone resulted in improved motor recovery if administered within eight hours of injury. Several professional organizations have offered guidance on the use of methylprednisolone. The American Association of Neurological Surgeons and Congress of Neurological Surgeons, the Canadian Association of Emergency Physicians and American Academy of Emergency Medicine have all concluded that glucocorticoids are a treatment option, not a treatment standard.

Specific concerns exist about the use of methylprednisolone in multi-system trauma patients. Multi-system trauma patients were not specifically excluded from the NASCIS studies, but they may have been somewhat under-represented. One indication for operative management of spine fractures include significant cord compression with neurologic deficit but not amenable to closed reduction. Another indication for surgical intervention is an unstable fracture or dislocation. The optimal timing of operative management has yet to be elucidated. Animal data suggests early spinal cord decompression is of benefit.

Dimar concluded in a review that early surgical stabilization led to shorter hospital stays, shorter intensive care unit days and fewer ventilator days. These benefits were more noticeable in patients with higher Injury Severity Scores. A meta-analysis of non-randomized cases was conducted by LaRosa. Patients with spinal cord injury that were decompressed within 24 hours had a better outcome than those patients treated non-operatively or with delayed surgery.
Summary
The National Spinal Cord Injury Statistical Center has a robust database on spinal cord injured patients. The American Spinal Injury Association has developed a classification of spinal cord injury. The Paralyzed Veterans of America offer clinical practice guidelines and patient education. While methylprednisolone can be considered in patients with isolated acute blunt spinal cord injury, numerous institutions have abandoned this practice because of poor quality data. Evidence is accumulating early (before 24 hours) spinal cord decompression has improved outcomes over delayed decompression. Research is focusing on repair and regeneration. Preventing secondary injury by optimal resuscitation, early decompression and future pharmacologic measures will lead to improved outcomes.

Table 1.

### American Spinal Injury Association (ASIA) Scale

<table>
<thead>
<tr>
<th>Grade A</th>
<th>Complete</th>
<th>No motor or sensory function is preserved below the neurologic level through the sacral segments S4-S5 (complete cord injury)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade B</td>
<td>Sensory incomplete</td>
<td>Sensory but not motor function is preserved below the neurologic level and extends through the sacral segments S4-S5</td>
</tr>
<tr>
<td>Grade C</td>
<td>Motor incomplete</td>
<td>Motor function is preserved below the neurologic level and the majority of key muscles below the neurologic level have a muscle grade less than 3 (on a scale of 0 to 5)</td>
</tr>
<tr>
<td>Grade D</td>
<td>Motor incomplete</td>
<td>Motor function preserved below the neurologic level and the majority of key muscles below the neurologic level have a muscle grade of at least 3 (on a scale of 0 to 5)</td>
</tr>
<tr>
<td>Grade E</td>
<td>Normal</td>
<td>Motor and sensory function are normal</td>
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</tbody>
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