Spinal Trauma

**Incidence:**

- Spinal injuries are relatively uncommon but can be devastating.
Spinal Trauma

**Occurrence:**
- ~200,000 people living with SCI in the US.
- 15-20 new cases per million population annually.
- ETOH major factor in 25% of SCIs.
Spinal Trauma

Occurrence:

- 80% of SCI patients are male.
- Most new SCIs occur in patients <30 years of age.

Estimated SCI Racial/Ethnic Distribution:

<table>
<thead>
<tr>
<th>Race</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>65%</td>
</tr>
<tr>
<td>African American</td>
<td>25%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>8%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
</tbody>
</table>
Spinal Trauma

- Posterior longitudinal ligament
- Anterior longitudinal ligament
- Intervertebral disc
- Body of vertebra

Anterior view
Spinal Trauma
Spinal Trauma
Spinal Trauma

The diagram illustrates the spinal column, divided into sections:

- **Cervical** (C1-C7)
- **Thoracic** (T1-T12)
- **Lumbar** (L1-L5)
- **Sacral** (S1-S5)

Key anatomical points include:

- **C7**
- **C8**
- **T1**
- **T2**
- **T4**
- **T6**
- **T8**
- **T10**
- **T12**
- **L1**
- **L3**
- **L4**
- **L5**
- **S1**
- **S2**
- **S3**
- **S4**
- **S5**
- **Cauda equina**
- **Sacrum**
- **Coccygeal nerve**
- **Coccyx**

The image also shows a profile view of the spine, indicating the various vertebrae and their corresponding sections in the segmentation of the spine.
Cervical Spine Injuries

SPINAL TRAUMA
Spinal Trauma
Spinal Trauma

- Dens of axis
- Transverse ligament of atlas
- C1 (atlas)
- C2 (axis)
- C3
- Inferior articular process
- Bifid spinous process
- Transverse processes
- C7 (vertebra prominens)
Spinal Trauma

- C2: Atlas
- C3
- C4
- C5
- C6
- C7
- T1

- Spinous processes
- Lateral masses
- Odontoid process (dens)
- Superior articular facet for axis
- Transverse process
- Transverse foramen
- Articulation for skull
- Tubercle
- Process (dens)
- Vertebrae arch
- Body of C2
- Axis
- Vertebral canal
- Lamina
Spinal Trauma
Spinal Trauma

Cervical spine:

Anterior:
- Anterior longitudinal ligament
- Anterior 2/3 of the vertebral body
- Annulus fibrosis
- Intervertebral discs

Middle:
- Posterior longitudinal ligament
- Posterior 1/3 of the vertebral body

Posterior:
- Bony elements
Spinal Trauma
Spinal Trauma
Spinal Trauma

- Cervical Spine Trauma:
  - Most injuries at 2 levels:
    - C2 (~30%)
    - C6, C7 (~50%)
  - Most fatal injuries are high:
    - AO (craniocervical junction)
    - C1, C2
Spinal Trauma

- Cervical Spine Trauma:
  - Flexion Injuries
  - Flexion-rotation injuries
  - Extension injuries
  - Axial (vertical) compression injuries
  - Multiple or complex injuries
<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>Column Affected</th>
<th>Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wedge Fracture</td>
<td>Anterior Only</td>
<td>Stable</td>
</tr>
<tr>
<td>Burst Fractures</td>
<td>Anterior and Middle</td>
<td>Unstable</td>
</tr>
<tr>
<td>Fracture/Dislocation Injuries</td>
<td>Anterior, Middle, Posterior</td>
<td>Unstable</td>
</tr>
<tr>
<td>Seat Belt Fractures (Distraction)</td>
<td>Anterior, Middle, Posterior</td>
<td>Unstable</td>
</tr>
</tbody>
</table>
Spinal Trauma

- **Flexion Injuries:**
  - Simple wedge compression without posterior disruption.
  - Pure flexion injury
  - Stable injury
Spinal Trauma

- Flexion injuries:
  - Teardrop fracture
    - Hyperflexion and compression (e.g., diving into shallow water).
    - Often associated cord injury.
    - Extremely unstable
Spinal Trauma

Flexion injuries:
- Anterior subluxation
  - Posterior ligaments injured.
  - Potentially unstable
Spinal Trauma

Flexion Injuries:
- Bilateral facet dislocation
  - Extreme flexion without compression or rotation.
  - ~75% at C3-C7.
  - Extremely unstable
Spinal Trauma

Flexion Injuries:
- Clay shoveler’s fracture
  - Flexion with upper body muscle contraction
  - Stable fracture
Spinal Trauma

- **Flexion-Rotation**
  - **Unilateral facet dislocation**
    - Flexion with rotation
    - Vertebra are “locked in place”
    - Stable injury
Spinal Trauma

Flexion-Rotation

Rotatory atlantoaxial dislocation

- A type of unilateral facet dislocation.
- More often seen in peds.
- Unstable because of location
Spinal Trauma

- Extension Injuries:
  - **Hangman’s Fracture**
    - Bilateral fractures through the pedicles of C2.
    - MVC most common cause.
    - 30% have other cervical fractures.
    - Seldom have associated neuro injury.
    - Unstable injury
Spinal Trauma

Extension Injuries:

- Extension teardrop fracture
  - Common after diving injuries.
  - Not often associated with cord injury.
  - Tends to occur at C2.
  - Stable
Spinal Trauma

- **Extension Injuries**
  - **Posterior C1 arch fracture**
    - Occurs when head is hyperextended.
    - Stable fracture
Spinal Trauma

Compression

Jefferson fracture

- Burst fracture of C1.
- Compressive downward force.
- Neurologic injury uncommon.
- Unstable

Jefferson fracture
Spinal Trauma

Compression

- Burst fracture of the vertebral body
  - Axial loading injury.
  - Often associated with complete and incomplete cord injury.
  - Retropulsion of bony fragments into the canal determines severity.
  - Unstable
Spinal Trauma

Complex/Multiple

- Odontoid (Dens) fracture
  - Most common upper cervical spine fracture (10-15% of all cervical fractures).
  - Flexion loading (falls).
  - Extension loading (less common).
  - Generally unstable.
Spinal Trauma

- Complex/Multiple
  - Atlanto-occipital dislocation
    - Internal decapitation
    - Hyperflexion or hyperextension
    - Seen in peds
    - Devastating injury (rarely survive)
    - Unstable
Spinal Trauma

- Complex/Multiple
  - Multiple injuries
    - Neuro compromise common.
    - Deficits vary on the site of injury.
    - Usually devastating.
Spinal Trauma

- Complex/Multiple
  - Penetrating trauma
    - Findings depend on level of injury.
    - Rarely or never get better.
    - Stable injuries
Thoracic and Lumbar Injuries

SPINAL TRAUMA
Spinal Trauma

Thoraco/lumbar injuries:

- Neuro deficit encountered 15-25% of all thoracolumbar injuries.
- If complete neuro deficit present, few patients regain any useful motor function.
Spinal Trauma

- Flexion fracture pattern
- Extension fracture pattern
- Rotation fracture pattern
Spinal Trauma

Compression fracture

- Common fracture.
- Falls/MVCs
- Rarely complicated by neuro issues
- Osteoporosis
- Stable fracture
Axial burst fracture

- Usually results from fall from height and landing on feet or buttocks (axial loading).
- Maximal canal incursion occurs at moment of impact.
- Usually stable
Spinal Trauma

- Chance fracture (flexion/distraction)
  - Vertebra literally pulled apart (e.g., pelvis stabilized by lap belt).
  - 50% chance of associated GI injuries.
  - Unstable fracture.
Spinal Trauma

- Transverse process fracture
- Rotation and sideways bending
Spinal Trauma

Fracture/Dislocation

- Most commonly occur at the thoracolumbar junction.
- MVC, sports, falls.
- ~4% of all spinal injuries.
- 50-60% associated with cord injuries.
- Unstable injury
Spinal Trauma

- Penetrating Injuries
  - Findings dependent on location and depth of weapon.
  - Neuro findings generally permanent.
Sacral Injuries

SPINAL TRAUMA
Spinal Trauma

- Sacral Injuries
  - Uncommon.
  - Can occur in 45% of pelvic fractures.
  - Usually high-energy injury.
  - Neurologic injury can occur in up to 25% of cases.
The Spinal Cord

SPINAL TRAUMA
Spinal Trauma

(b) Posterior view of cervical region of spinal cord

- Fourth ventricle
- Glossopharyngeal (IX) and vagus (X) nerves
- Accessory (XI) nerve
- Gracile fasciculus
- Cuneate fasciculus
- Cerebellum of brain (cut)
- Occipital bone (cut)
- Posterior median sulcus
- Vertebral artery
- Denticulate ligament
- Dura mater and arachnoid mater (cut)
- Posterior (dorsal) rootlets of spinal nerve
Spinal Trauma

(d) Superior view
Spinal Cord Syndromes

SPINAL TRAUMA
<table>
<thead>
<tr>
<th>Location of Lesion</th>
<th>Possible Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>At or above C5</td>
<td>• Respiratory paralysis, quadriplegia</td>
</tr>
<tr>
<td>Between C5 and C6</td>
<td>• Paralysis of legs, wrists, and hands</td>
</tr>
<tr>
<td></td>
<td>• Weakness of shoulder abduction and elbow flexion</td>
</tr>
<tr>
<td></td>
<td>• Loss of biceps jerk reflex</td>
</tr>
<tr>
<td></td>
<td>• Loss of brachioradialis deep tendon reflex</td>
</tr>
<tr>
<td>Between C6 and C7</td>
<td>• Paralysis of legs, wrists, and hands, but shoulder movement and elbow flexion usually possible.</td>
</tr>
<tr>
<td>Between C7 and C8</td>
<td>• Loss of triceps jerk reflex</td>
</tr>
<tr>
<td></td>
<td>• Paralysis of legs and hands</td>
</tr>
<tr>
<td>At C8 to T1</td>
<td>• Horner syndrome (constricted pupil, ptosis, facial anhidrosis)</td>
</tr>
<tr>
<td></td>
<td>• Paralysis of legs</td>
</tr>
<tr>
<td>Between T1 and <em>conus medullaris</em></td>
<td>• Paralysis of legs</td>
</tr>
</tbody>
</table>
Spinal Trauma
Spinal Trauma
Spinal Trauma

Complete

Partial
Spinal Trauma

Complete Transection

- Higher lesions associated with spinal shock.
- Priapism implies a complete injury.
- Sacral sparing excludes complete transection:
  - Perianal sensation
  - Rectal tone
Spinal Trauma

Descending (Motor) Tracts

Lateral Corticospinal Tract (Motor)

Ventral Corticospinal Tract (Motor)

Ascending (Sensory) Tracts

Dorsal Columns (Proprioception, Deep touch, Vibration)

Lateral Spinothalamic Tract (Pain, Temperature)

Ventral Spinothalamic Tract (Light touch)
Spinal Trauma

Blood supply to the spinal cord: horizontal distribution

- Posterior spinal artery
- Radicular lumbosacral arteries
- Medial sacral artery
- Right lateral sacral artery

The central area supplied only by the anterior spinal artery is predominantly a motor area.
Spinal Trauma

Anterior Cord

- Etiology:
  - Direct anterior cord compression.
  - Flexion of cervical spine.
  - Thrombosis of anterior spinal artery.

- Symptoms:
  - Complete paralysis below the lesion.
  - Preservation of proprioception, vibration, light touch.
Spinal Trauma

**Central Cord**

- **Etiology:**
  - Hyperextension
  - Loss of spinal cord perfusion.
  - Cervical spinal stenosis.
  - Typically elderly with significant DJD.

- **Symptoms:**
  - Quadriparesis (↑↑↓↓).
  - Some loss of pain and temperature sensation (↑↑↓↓).
Spinal Trauma

Brown-Séquard

- Etiology:
  - Transverse hemisection of spinal cord.
  - Unilateral cord compression.

- Symptoms:
  - Ipsilateral spastic paresis
  - Contralateral loss of pain and temperature sensation.
  - Loss or proprioception/vibratory sensation,
Spinal Trauma

**Cauda Equina Syndrome**

- **Etiology:**
  - Massive disc herniation.
  - Spinal canal hemorrhage.

- **Symptoms:**
  - Urinary retention without overflow incontinence.
  - Rectal incontinence.
  - Bilateral sciatica.
  - Saddle anesthesia.
  - Decreased rectal sphincter tone.
Spinal Trauma

- **Spinal Cord Injury Without Radiographic Abnormality (SCIWORA)**
  - More common in peds.
  - Spinal cord symptoms but negative standard radiography.
  - MRI diagnostic.
  - Outcomes generally favorable.
**Spinal Trauma**

**Spinal shock:**
- Flaccid paralysis below the lesion.
- Loss of DTRs.
- Impaired sympathetic outflow to vascular smooth muscle (vasodilation).
- Absent sphincter reflexes and tone.
- Transient.
<table>
<thead>
<tr>
<th></th>
<th>Spinal Shock</th>
<th>Neurogenic Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Immediate temporary loss of total motor, sensory, and reflexes below the lesion.</td>
<td>Sudden loss of sympathetic nervous system control.</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>Hypotension</td>
<td>Hypotension</td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>Bradycardia</td>
<td>Bradycardia</td>
</tr>
<tr>
<td><strong>Bulbocavernosus reflex</strong></td>
<td>Absent</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td>Flaccid paralysis</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td></td>
<td>48-72 hours after SCI</td>
</tr>
<tr>
<td><strong>Mechanism</strong></td>
<td>Peripheral neurons become temporarily unresponsive to CNS control,</td>
<td>Disruption of autonomic pathways</td>
</tr>
</tbody>
</table>
REVIEW

Central nervous system regeneration does not occur

LS Illis

Study design: Review.
Objectives: To examine the state of research in central nervous system (CNS) regeneration and to suggest an alternative to the sterile research at the lesion site.
Setting: Worldwide.
Methods: A search of publications using ‘PubMed’ and a search of the historical literature relevant to CNS regeneration, biological models, the neurone theory, collateral sprouting, spinal shock and the central pattern generator.
Results: There is no evidence for CNS regeneration.
Conclusion: A century of research focussed on the lesion site has been unproductive. An alternative field of research must be developed and the best candidate is the undamaged CNS.

Spinal Trauma

- Significant changes in prehospital spinal care.
  - Eliminate backboards.
  - Soft cervical collars.
  - Self-extrication when practical.
  - Transport on soft bed in position of comfort.
Spinal Trauma

- **Backboards:**
  - Are an ineffective splint.
  - Cause pain.
  - Impair respirations.
  - Increase diagnostic imaging.
  - Require multiple ambulances.
  - Increased ED nursing ratio
Spinal Trauma

Rigid Cervical Collars:

- Ineffective.
- Can worsen high cervical spinal injuries.
- Can cause pressure sores.
- Impairs mouth opening and airway management.
Spinal Trauma

**Extrication:**

- Spinal movement actually less when patients are allowed to self-extricate (when possible).
Spinal Trauma

Transport:

- If backboard used for extrication, move patient to soft bed ASAP.
- Transport in position of comfort (semi-Fowler’s)
Spinal Trauma

“Simplicity is the ultimate sophistication.”