Spine and Spinal Cord Trauma

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Injuries to the Spine

Quick Facts

- 5% of brain-injured patients have an associated spinal injury
- 25% of spinal injury patients have at least a mild brain injury
- Worsening of symptoms over time
  - Cord edema
  - Inadequate immobilization
- Exclusion of spine injury may be safely deferred
  - C-collar (ASPEN)
  - Spine board
  - Log roll
- Goal = < 2 hours on any hard surface (backboard OR slider)
- Therefore, if awake and alert, exclude based on absence of pain or tenderness along the spine
- ...If comatose / ↓ LOC, Log roll q2h until cleared
Anatomy and Physiology of the Spinal Column

7 cervical
12 thoracic
5 lumbar vertebrae
Sacrum (5)
Coccyx (4)

4 curvatures:
Cervical: convex anteriorly (C1-T2)
Thoracic: concave anteriorly (T2-T12)
Lumbar: convex anteriorly (T12-L5,S1)
Sacroccocygeal: concave anteriorly
• Vertebral bodies separated by vertebral discs and held together with longitudinal ligaments

• Facet joints, interspinous ligaments and paraspinal muscles all contribute to stability
C-Spine

**atlas C1:** articular surface for odontoid process  
no spinous process

**axis (C2):** odontoid process (dens)

*Unique to C-spine:* transverse foramina  
bifurcated spinous process
T-Spine

Unique to T-spine:
- demifacets for articulation with rib head
- articular facets on transverse processes (rib tubercle)
- long delicate spinous processes

vertebral foramen
pedicle
spinous process
lamina
superior articular processes
transverse process
demifacets
vertebral notches which form intervertebral foramina for spinal nerves
L-Spine

broad heavy spinous process,
transverse process lacks facets
Vertebral and Intervertebral Disc Anatomy
Vertebral and Interverteral Disc Anatomy

- anulus fibrosus
- nucleus pulposus
Spinal Tracts

- Gracilus fasciculus
- Cuneatus fasciculus
- Dorsal spinocerebellar tract
- Lateral corticospinal tract
- Lateral reticulospinal tract
- Medial reticulospinal tract
- Lateral tectospinal tract
- Vestibulospinal tract
- Ventral spinocerebellar tract
- Anterolateral system
- Ventral corticospinal tract
- Medial tectospinal tract
3 Tracts can be assessed clinically...

1. Corticospinal Tract
   - posterolateral
   - controls motor power on the same side of the body
   - voluntary muscle contractions / involuntary pain response

2. Spinothalamic Tract
   - anterolateral
   - transmits pain and temperature sensation from the opposite side of the body
   - pin prick and light touch

3. Posterior column (*Gracilis Fasciculus + Cuneanus Fasciculus*)
   - proprioception, vibration and some light-touch sensation from the same side of the body
   - Position sense of joints, and vibration sense (tuning fork)
Corticospinal Tract

- thigh and trunk
- hand and fingers
- leg and foot
- face and tongue
- cerebral peduncles
- motor nucleus of the trigeminal nerve (jaw movement)
- motor nucleus of facial nerve
- pons
- cervical level of spinal cord
- lateral corticospinal tract
- to muscles of fingers and hands
- lumbar level of spinal cord
- to muscles of leg and foot
- ventral corticospinal tract
- direction of motor signal
- sensory ganglion
- motor root
- sensory root
- direction of sensory signal
- lateral corticospinal tract
- white matter
- grey matter
- motor neurons
Spinothalamic Tract
Posterior Columns
Complete Spinal Cord Injury
• No demonstrable sensory or motor function below a certain level
• Dx days after initial injury

Incomplete Spinal Cord Injury
• Any motor or sensory function
• Better prognosis
• Sacral sparing (voluntary or involuntary) as the only residual function

Dermatome: area of skin innervated by the sensory axon within a particular segmental nerve root

Myotomes: muscle groups innervated by a spinal nerve

Reflex: monosynaptic reflex/synapse between the afferent and efferent neurons
## Muscle Strength Grading

<table>
<thead>
<tr>
<th>Score</th>
<th>Results of Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Total paralysis</td>
</tr>
<tr>
<td>1</td>
<td>Palpable or visible contraction</td>
</tr>
<tr>
<td>2</td>
<td>Full range of motion with gravity eliminated</td>
</tr>
<tr>
<td>3</td>
<td>Full range of motion against gravity</td>
</tr>
<tr>
<td>4</td>
<td>Full range of motion, but less than normal strength</td>
</tr>
<tr>
<td>5</td>
<td>Normal strength</td>
</tr>
<tr>
<td>NT</td>
<td>Not testable</td>
</tr>
</tbody>
</table>
Monosynaptic Stretch Reflex

1. Stretching stimulates SENSORY RECEPTOR (muscle spindle)
2. SENSORY NEURON excited
3. Within INTEGRATING CENTER (spinal cord), sensory neuron activates motor neuron
4. MOTOR NEURON excited
5. EFFECTOR (same muscle) contracts and relieves the stretching

Antagonistic muscles relax

Motor neuron to antagonistic muscles is inhibited

To brain

Spinal Nerve

Inhibitory interneuron
Neurogenic Shock vs Spinal Shock

**Neurogenic Shock:** Impairment of the descending sympathetic pathways

1) Loss of vasomotor tone = Vasodilation of visceral and lower extremity blood vessels
   - Pooling of blood
   - Hypotension

2) Loss of sympathetic innervation to the heart =
   - Bradycardia / fail to respond to ↓ BP
   - Massive fluid resuscitation = pulmonary edema

Moderate volume replacement + Vasopressors

Atropine
Spinal Shock

- Flaccidity and loss of reflexes seen after spinal cord injury
- “Shock” = appears functionless, but may not be permanent
- Of varied duration

Cord Edema  Transection

The inability to perceive pain may mask a potentially serious injury elsewhere (ie. Acute abdomen)
Classification of Spinal Cord Injuries

1) Level
2) Severity of Neurologic Deficit
3) Spinal Cord Syndrome
4) Morphology
1) **Level**

- Most caudal segment with *normal* sensory and motor function on both sides of the body
- “motor level” - motor function with grade of at least 3/5
- “Zone of partial preservation”

\[
\begin{align*}
\text{Quadriplegia} & \quad \uparrow \\
T1 & \quad \downarrow \\
\text{Paraplegia} & \quad \downarrow \\
\end{align*}
\]

* Bony level of injury vs neurologic level of injury
2) **Severity of Neurologic Deficit**

In complete
Complete \[\Rightarrow\] Paraplegia

In complete
Complete \[\Rightarrow\] Quadriplegia

Any motor or sensory function below the level of the injury constitutes an incomplete injury, including:

I) Any sensation (position sense) or colutnary movement in the lower extremities
II) Sacral sparing: perianal sensation, voluntary anal sphincter contraction, or voluntary toe flexion
3) **Spinal Cord Syndromes** *Characteristic patterns of neurologic injury*

**Central Cord Syndrome**

- Disproportionately greater loss of motor power in the upper extremities than in the lower extremities, with varying degrees of sensory loss
- Associated with hyperextension injury in a patient with preexisting cervical canal stenosis (+/- fracture or dislocation)
- Vascular compromise of the cord in the distribution of the anterior spinal artery
Blood supply to the spinal cord: horizontal distribution

Anterior spinal artery

The central area supplied only by the anterior spinal artery is predominantly a motor area.
3) **Spinal Cord Syndromes** *Characteristic patterns of neurologic injury*

**Central Cord Syndrome**

- Disproportionately greater loss of motor power in the upper extremities than in the lower extremities, with varying degrees of sensory loss.
- Associated with hyperextension injury in a patient with preexisting cervical canal stenosis (+/- fracture or dislocation).
- Vascular compromise of the cord in the distribution of the anterior spinal artery.
- Mechanism: Hx of fall with facial impact.
- Prognosis: better than other incomplete injuries.
The lesion interrupts fibers crossing to enter the spinothalamic tracts, and fibers mediating the tendon stretch reflex. As it enlarges, it affects the intermediolateral columns (autonomic function), and the lateral corticospinal tracts.
Anterior Cord Syndrome

• Characterized by paraplegia and a dissociated sensory loss with loss of pain and temperature sensation

• Posterior column function is preserved (position, vibration and deep pressure sense)

• Infarction of the cord in the territory supplied by the anterior spinal artery

• Prognosis: poorest of all the incomplete injuries
Brown-Sequard’s Syndrome

- Very rare - results from the hemisection of the cord
- Recovery is varied, but common

Ipsilateral loss of: Position sense (posterior column) + Motor (corticospinal tract)

Contralateral loss of: Pain and Temperature sensation (spinothalamic tract)
4) **Morphology**

I) Fractures

II) Fracture Dislocations

III) Spinal Cord Injury Without Radiographic Abnormalities (SCIWORA)

IV) Penetrating Injuries

*Stable vs Unstable*
Specific Spinal Injuries

Axial Loading

Flexion

Extension

Rotation

Distraction

Lateral bending
C-Spine

Atlanto-occipital dislocation
- severe traumatic flexion and distraction
- 19% of fatal cases of spinal cord injury
- common cause of death from shaken baby syndrome

Atlas Fracture (C1)
- 5% of acute C-spine #
- Burst # = **Jefferson #**, results from axial loading
C1 Rotary Subluxation

C2 Fractures
• 18% of all C-spine fractures, 60% involving the odontoid
C1 Rotary Subluxation

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• Hangman’s fracture - Posterior elements of C2
  20% of C2#, results from extension
C1 Rotary Subluxation

C2 Fractures
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C3 → C7
- Most common C-spine # is C5
- Most common level of subluxation is C5-C6
  (where the greatest flexion/extension of the C-spine occurs)

Subluxation / Dislocation
Unilateral: 80% have neurological injury
  (30% nerve root, 40% incomplete, 30% complete)
Bilateral: 16% incomplete, 84% complete spinal cord injuries
Spinal Cord Injury - Cervical Subluxation (Neck Vertebrae Overlap) and Bilateral Facet Lock

Normal Anatomy

Lateral view of the cervical spine

Spinoius Process
Vertebral body
Facet

Intervertebral disc

Normal Anatomy

Sagittal view of the cervical spine

C5
C6
C7
T1

Post-accident Condition

C4
C5
C6
C7
T1

Subluxation of C6 on C7 causes compression of the spinal cord.

The facets are overlapping on both sides, locking the facets and preventing the spine from returning to proper alignment.
Thoracolumbar Spine

1) Anterior wedge compression injuries
   • Axial load + flexion

2) Burst Fracture
   • Vertical-axial compression

3) Chance Fractures (Flx-distrtraction)
   • Transverse fractures through the vertebral body
   • Flexion about an axis anterior to the vertebral column
   • MVC with lap belt restraint only
   • Associated with retroperitoneal and abdominal injuries

4) Fracture-dislocations
   • Uncommon due to facet Jt orientat
   • Extreme flexion / blunt trauma cause
   • posterior elements of the vertebra
Spinal Stability
General Management

1) Immobilization
2) Intravenous fluids
3) Medications
4) Transfer
anterior-posterior view: lumbar spine

- suture
- vertebrae
- fracture
- rods
The END !!!