Ch 36 - Spinal Injuries

EPISODE CONTENT BASED ON ROSEN'S EMERGENCY MEDICINE (9TH ED.)

Italicized text is quoted directly from Rosen's.

Key Concepts:

1. *The anterior cord syndrome, characterized by paralysis and hyperalgesia below the level of injury, with preservation of position, touch, and vibration, results from hyperflexion injuries causing cord contusion, by the protrusion of a bony fragment or herniated disk into the spinal canal, or by laceration or thrombosis of the anterior spinal artery. Suspicion for an anterior cord syndrome warrants prompt neurosurgical consultation because it is a potentially surgically correctable lesion.*
2. *In the awake, evaluable trauma patient, the NEXUS or CCR decision rules may be used to determine the need for radiographic imaging.*
3. *In the awake, evaluable trauma patient, unless the patient has a very minor trauma mechanism (or CT is not available), CT is preferred over plain radiography, especially if CT is being performed on other body parts.*
4. *Neurogenic hypotension, caused by a loss of vasomotor tone and lack of reflex tachycardia, is a diagnosis of exclusion in the trauma victim. It should not be considered the cause of hypotension unless the patient is flaccid and areflexic, reflex tachycardia and peripheral vasoconstriction are absent and, most importantly, the possibilities of coexisting hemorrhagic shock, cardiac tamponade, or tension pneumothorax have been eliminated.*
5. *Because neurogenic hypotension can lead to hypoperfusion and secondary spinal cord ischemia, prolonged, severe hypotension (systolic blood pressure < 70 mmHg) should be prevented and treated. When there is persistent hypotension despite fluid resuscitation, we recommend vasopressor support with norepinephrine to be started at 0.05 mcg/kg/min and titrated upward to a maximum dose of 1 mcg/kg/min to achieve a MAP of 85 mmHg.*
6. *Methylprednisolone or any other steroid is not beneficial in the treatment of acute spinal cord injury and should not be used.*
7. *Emergency department management of SCI includes care to prevent pressure ulcers, bladder distention, and gastric distention.*

Core Questions

1. Outline the Denis Classification system for determining the stability of spinal injuries
2. List 5 flexion, 2 flexion-rotation, 3 extension, and 2 vertical compression spinal injuries (Table 36.1)
3. Outline the mechanisms and potential complications of the following injuries:

   a. Wedge Fracture
   b. Flexion Teardrop Fracture
   c. Clay Shoveler's Fracture
   d. Spinal Subluxation
   e. Bilateral Facet Dislocation
   f. Altlanto-occipital Dislocation
   g. Anterior Atlanto-axial Dislocation
   h. Unilateral Facet Dislocation
   i. Posterior Neural Arch Fracture
   j. Hangman's Fracture
   k. Extension Tear Drop Fracture
   l. Burst Fracture
   m. Jefferson Fracture
4. How are odontoid fractures classified and what causes them?
5. Organize the spinal motor, sensory, and reflex examinations based on spinal levels. (Tables 36.3, 36.4, 36.5)
6. Detail the following cord syndromes:
   a. Central Cord
   b. Anterior Cord
   c. Brown-Sequard

Wisecracks

1. How do you calculate Power's Ratio and why is it important?
2. What injuries is the open-mouth odontoid radiograph best at visualizing?
3. How are whiplash-associated injuries classified?
4. At what spinal level would you expect an injury to potentially cause Horner's Syndrome?
5. What is spinal shock and what physical exam finding indicates its end?

Rosen's in Perspective

Alright, podcast listeners. We are back at it again with another episode of CRACKCast. Today, we will be reviewing Chapter 36 - Spinal Injuries in Rosen's 9th Edition. This is one of the lengthy chapters in the Bible of EM, so make sure to allot time to crush out the chapter readings.

Anyone who has worked in the ED for any significant period of time will know how debilitating spinal injuries can be. We have all seen our fair share of complex traumas and are relatively comfortable with the initial management strategies for these injuries. However, what many of us fail to recognize is the true significance of these injuries. As is the case with many of the disease processes we manage every day, the effects of spinal cord injuries extend far beyond the resuscitation bay. Often, patients who sustain significant trauma suffer lifelong physical, psychiatric, and socioeconomic issues as a result. It is estimated that the lifetime cost of care for paraplegic SCI victims in the US ranges from $ 1 million in those older than 50 to $4 million for

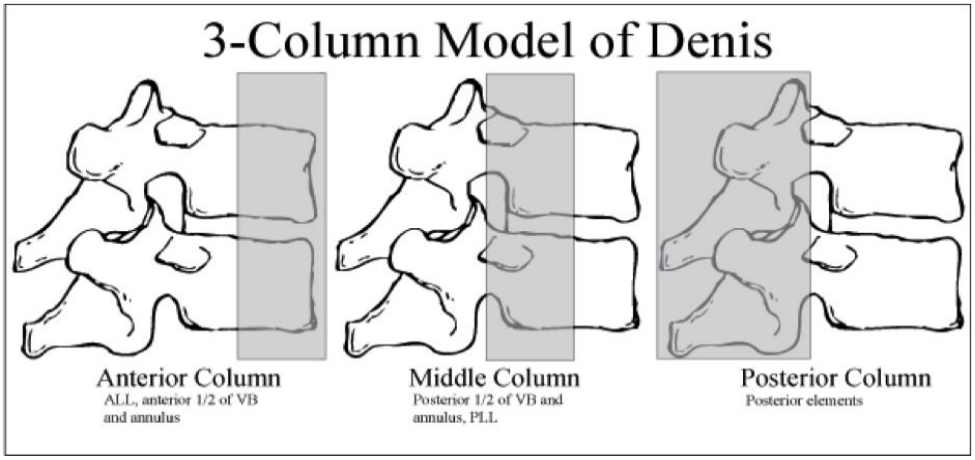
those younger than 25. Moreover, the total societal cost is far more, costing $5 billion in lifelong medical expenses and lost productivity for all ages and types of SCI's. Thus, it is paramount that ED clinicians know how to assess for, treat, and refer these patients appropriately.

If you feel like you could use a refresher on the topic, please listen up. Today, we will review some of the relevant content you will need to know on your next shift in the thunderdome. So, as always, grab a cup of coffee, take a deep breath, and enjoy the show!

Core Questions:

[1] Outline the Denis Classification system for determining the stability of spinal injuries

- The Denis Classification is a model that divides the spine into 3 parallel vertical columns
    - Anterior - formed by the alternating vertebral bodies and intervertebral disks surrounded by the annulus fibrosus (capsule) and anterior longitudinal ligament
    - Middle - formed by the posterior portion of the annulus fibrosis and posterior vertebral wall, posterior longitudinal ligament, spinal cord, paired laminae and pedicles, articulating facets, transverse process, nerve roots, and vertebral arteries and veins
    - Posterior - formed by the spinous processes, nuchal ligament, interspinous ligament, supraspinous ligament, and ligamentum flavum
- Typically, this model allows for a single column to be affected by an injury without causing instability.
- Disruption of two columns results in an injury that is stable in one direction but unstable in another.
- Disruption of all three columns results in a HIGHLY MULTIDIRECTIONAL UNSTABLE INJURY



[2] List 5 flexion, 2 flexion-rotation, 3 extension, and 2 vertical compression spinal injuries (Table 36.1)

The following table is modelled after Table 36.1 - Classification of Spinal Injuries in Rosen's 9th Edition. Please refer to the text for further clarification.

Mechanism of Injury	Stability
FLEXION INJURIES	
Wedge Fracture	Stable
Flexion Teardrop Fracture	Extremely unstable
Clay Shoveler's Fracture	Stable
Spinal Subluxation	Potentially unstable
Bilateral Facet Dislocation	Always unstable
Atlanto-occipital Dislocation	Unstable
Anterior Atlantoaxial Dislocation with or without Fracture	Unstable
Odontoid Fracture with Lateral Displacement Fracture	Unstable
Transverse Process Fracture	Stable
FLEXION-ROTATION INJURIES	
Unilateral Facet Dislocation	Stable
Rotary Atlantoaxial Dislocation	Unstable
EXTENSION INJURIES	
Posterior Neural Arch Fracture (C1)	Unstable
Hangman's Fracture (C2)	Unstable
Extension Teardrop Fracture	Usually stable in flexion, unstable in extension
Posterior Atlantoaxial Dislocation with or without Fracture	Unstable

VERTICAL COMPRESSION INJURIES	
Bursting Fracture of Vertebral Body	Stable
Jefferson's Fracture (C1)	Extremely unstable
Isolated Fractures of Articular Pillars and Vertebral Body	Stable

[3] Outline the mechanisms and potential complications of the following flexion injuries:

- Wedge Fracture
- Flexion Teardrop Fracture
- Clay Shoveler's Fracture
- Spinal Subluxation
- Bilateral Facet Dislocation
- Altlanto-occipital Dislocation
- Anterior Atlanto-axial Dislocation
- Unilateral Facet Dislocation
- Posterior Neural Arch Fracture
- Hangman's Fracture
- Extension Tear Drop Fracture
- Burst Fracture
- Jefferson Fracture

Anatomy and Mechanisms of Spinal Fractures	
Wedge Fracture	- Mechanism: flexion of the spine resulting in a longitudinal pull to be exerted on the nuchal ligament complex. Vast majority of the force or placed on the vertebral body anteriorly, causing a wedge fracture - Generally stable injuries because the posterior column stays intact, but can become unstable if a severe wedge fracture (defined as causing >50% vertebral height loss) or multiple adjacent wedge fractures occur
Flexion Teardrop Fracture	- Mechanism: SEVERE flexion forces cause anterior displacement of the wedge-shaped fragment of the anteroinferior portion of the involved vertebral body, disruption both the anterior and posterior ligaments commonly occurs - Generally considered HIGHLY UNSTABLE - Complications: often associated with neurologic injuries

Clay Shoveler's Fracture	- Mechanism: classically occurred when a clay miner shoveling heavy objects abruptly flexed their neck. This transmitted force through the supraspinous ligament, causing an oblique fracture of the base of the spinous process of one of the lower cervical vertebrae. More modern MOI is direct trauma to the spinous process or sudden deceleration MVC's - Generally stable and requires supportive care only
Spinal Subluxation	- Mechanism: flexion of the spine causing the ligamentous complexes to rupture WITHOUT BONY INJURY in a posterior to anterior fashion - Potentially unstable - Complications: Rarely result in neurologic damage
Bilateral Facet Dislocation	- Mechanism: large flexion force causes soft tissue disruption to continue anteriorly to the annulus fibrosus and the anterior longitudinal ligament, causing the spine to dislocate at the facet joints and move forward. - Generally this is considered to be ALWAYS UNSTABLE - Complications: SCI
Atlanto-occipital Dislocation	- Mechanism: flexion force (in most cases) causes disruption of the stabilizing ligaments of the interface of the occiput and atlas (ie, the tectorial membrane and alar ligaments). Also known as ORTHOPEDIC DECAPITATION - This injury is always unstable - Complications: Death (70%), neurologic deficits
Anterior Atlantoaxial Dislocation with or without Fracture	- Mechanism: flexion force causing disruption of the ligaments between C1/C2 - Generally considered to be unstable - Complications: neurologic deficits
Unilateral Facet Dislocation	- Mechanism: flexion and rotation together centers around one of the facet joint (which acts as a fulcrum), causing the contralateral facet joint to dislocate, causing the superior facet to come to rest in the intervertebral foramen. - This injury "locks" in place, thus making it stable despite the posterior ligament complex being completely disrupted. This can be an unstable injury in the rare event that this occurs in the thoracolumbar or lumbar regions, given the near vertical orientation of the facet joints. - Complications: torticollis
Posterior Neural Arch Fracture	- Mechanism: extension causing fracture of the neural arch of C1 results from the compression of the posterior elements between the occiput and spinous process of C2 - Although the anterior arch and transverse ligament are intact, the fracture is still POTENTIALLY unstable given its location

Hangman's Fracture	- Mechanism: extension causing traumatic spondylolysis and bilateral fractures through the pedicles of the axis (C2); commonly from head on MVC's - Generally unstable - Complications: cord damage is commonly minimal given the wide AP dimensions of the neural canal at this point in the spine and the "field decompression" that occurs with the bilateral pedicle fractures
Extension Tear Drop Fracture	- Mechanism: abrupt extension of the neck causes the anterior longitudinal ligament to pull the anteroinferior corner of a vertebral body off. Commonly seen in the lower cervical vertebrae in driving accidents - The posterior elements remain intact, thus these are considered to be unstable in extension and stable in flexion - Complications: Central cord syndrome
Burst Fracture	- Mechanism: axial loading causes nucleus pulposus of the intervertebral disk to be forced into the vertebral body - Stable fracture because all of the ligaments are intact - Complications: Anterior cord syndrome
Jefferson Fracture	- Mechanism: axial load causes force to be transmitted through the occipital condyles of C1 to the lateral masses of C1. This drives the lateral masses outward, injuring the transverse ligament and causing fractures of the anterior and posterior arches. - - Extremely unstable - Complications: Neurologic deficits, vertebral artery injury

[4] How are odontoid fractures classified and what causes them?

- Odontoid fractures are typically caused by trauma to the head in the anteroposterior direction.
- Odontoid fractures are typically classified into three categories:
    - Type I - fracture to the odontoid ABOVE the transverse ligaments; typically stable as they are only an avulsion fracture to the tip of the odontoid, but becomes unstable if there is damage to the apical and alar ligaments
    - Type II - fracture to the odontoid at the base where it attaches to C2 - unstable, often complicated by non-union
    - Type III - fracture to the odontoid at the base where it attaches to C2 WITH EXTENSION INTO the body of C2 - unstable, can extend laterally into the superior articular facet of the atlas

[5] Organize the spinal motor, sensory, and reflex examinations based on spinal levels. (Tables 36.3, 36.4, 36.5)

This table has been adapted from Table 36.3 in Rosen's 9th Edition - Spinal Motor Examination. Please refer to the text for further clarification.

Level of Lesion	Resulting Loss of Function
C4	Spontaneous breathing
C5	Shrugging shoulders
C6	Flexion of elbows
C7	Extension of elbows
C8-T1	Flexion of fingers
T1-T12	Intercostal and abdominal muscle function
L1-L2	Flexion of hip
L3	Adduction of hip
L4	Abduction of hip
L5	Dorsiflexion of foot
S1-S2	Plantar flexion of foot
S2-S4	Rectal sphincter tone

This table has been adapted from Table 36.4 in Rosen's 9th Edition - Spinal Reflex Examination. Please refer to the text for further clarification.

Level of Lesion (At or above)	Resulting Loss of Function
C6	Biceps
C7	Triceps
L4	Patellar
S1	Achilles

This table has been adapted from Table 36.5 in Rosen's 9th Edition - Spinal Sensory Examination. Please refer to the text for further clarification.

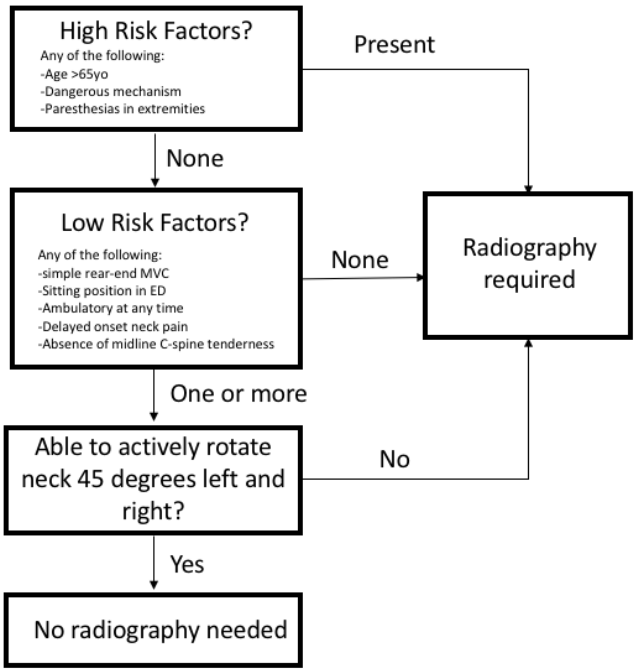
Level of Lesion	Resulting Level of Lost Sensation
C2	Occiput
C3	Thyroid Cartilage
C4	Suprasternal Notch
C5	Below clavicle
C6	Thumb
C7	Index Finger
C8	Small Finger
T4	Nipple line
T10	Umbilicus
L1	Femoral pulse
L2-3	Medial aspect of thigh
L4	Knee
L5	Lateral aspect of calf
S1	Lateral aspect of foot
S2-S4	Perianal region

[6] Detail the following cord syndromes:
-Central Cord
-Anterior Cord
-Brown-Sequard

Cord Syndrome	Clinical Manifestations
Central Cord	- Most common cord syndrome - Often seen in patients with degenerative arthritis with traumatic hyperextension of the neck - Ligamentum flavum buckles, concussing the central gray matter in the pyramidal and spinothalamic tracts - Causes patchy sensory sensory deficits and upper extremity weakness in upper limbs - Remember the mnemonic MUD -E - Motor > sensory - Upper extremity >lower extremity - Distal >proximal - Extension injury
Brown-Sequard	- Caused by hemi-sectioning of the spinal cord, often from penetrating trauma - Patients will have ipsilateral loss of position, vibration sense, and motor function IN ADDITION TO contralateral loss of pain and temperature distal to the site of injury
Anterior Cord	- Results from hyperflexion causing cord contusion by bony fragment or herniated disk into the spinal canal OR laceration or thrombosis of the anterior spinal artery - Patients will have paralysis and hypoalgesia below the level of injury, with preserved position, touch, and vibratory sensations

[7] List the components of the following imaging decision-making tools: Canadian C-Spine Rule, NEXUS C-Spine Rule.

Canadian C-Spine Rule



- Exclusion Criteria include:
  - Age <16Y
  - GCS <15
  - Grossly abnormal vital signs
  - Injury >48 hrs old
  - Penetrating trauma
  - Acute paralysis
  - Known vertebral disease (ankylosing spondylitis, rheumatoid arthritis, spinal stenosis, previous spinal surgery)
  - Return visit for reassessment of same injury
  - Pregnant

NEXUS C-Spine Rule:

1. **No midline tenderness**
2. **No focal neurological deficit**
3. **No abnormal alertness**
4. **No intoxication**
5. **No painful distracting injury**

If all criteria are met, no C-spine imaging is required.

Wisecracks:

[1] How do you calculate Power's Ratio and why is it important?

Answer:

- Power's Ratio is calculated in the following manner:
- First, measure the distance between the basion and the mid vertical portion of the posterior laminar line of the atlas (commonly referred to as BC)
- Then, measure the distance between the opisthion to the mid vertical portion of the posterior surface of the anterior ring of the atlas (commonly referred to as OA)
- After, divide BC by OA to get the ratio
- A value of > 1 indicates subluxation of the atlas and axis
- THESE ARE UNSTABLE INJURIES because of the paucity of muscle and ligamentous support in this area of the spine

[2] What injuries is the open-mouth odontoid radiograph best at visualizing?

Answer:

1. Dens Fracture
2. Jefferson's Fracture
3. Transverse Ligament Injury
4. Basilar Invagination

[3] How are whiplash-associated injuries classified?

Answer:

This table has been adapted from Table 36.2 in Rosen's 9th Edition - Quebec Task Force Classification of Whiplash-Associated Disorders. Please refer to the text for further clarification.

Grade	Description
0	Whiplash injury but no pain, symptoms, or signs
1	Delayed neck pain, minor stiffness, non-focal tenderness only, no physical signs
2	Early onset of neck pain, focal neck tenderness, spasms, stiffness, radiating symptoms
3	Early onset of neck pain, focal neck tenderness, spasm, stiffness, radiating symptoms, and signs of deficit
4	Neck complaint (grade 2 or 3 above) and fracture dislocation

[4] At what spinal level would you expect an injury to potentially cause Horner's Syndrome?

Answer:

- Horner's Syndrome, characterized by unilateral ptosis, miosis, and anhidrosis results from disruption of the cervical sympathetic chain
- Thus, injuries occurring between C7 and T2 could produce Horner's Syndrome

[5] What is spinal shock and what physical exam finding indicates its end?

Answer:

As per Rosen's 9th Edition: "Spinal shock results from a concussive injury to the spinal cord that causes total neurologic dysfunction distal to the site of injury. The end of spinal shock is heralded by the return of the bulbocavernosus reflex."