

TRAUMATIC DISORDERS -- C-SPINE

I. INTRODUCTION

A. Common

1. 50,000 cervical spine (c-spine) injuries per year
2. Almost 15,000 spinal cord injuries per year
3. Median age is 22 years
 - a. 50% motor vehicle crashes
 - b. 20% falls
 - c. 15% assault
 - d. 15% sports related

B. Critical

1. 20% of sudden traumatic death is due to high spinal cord injuries

C. Expensive

1. \$5 billion annually
2. \$1 million to support a spinal cord patient for life
3. Prevention is key

II. INITIAL EVALUATION (ABCs)

A. Airway management

1. Orotracheal intubation
 - a. Rapid sequence induction (RSI)
 - b. Manual in-line stabilization
2. Nasotracheal intubation

3. Primary cricothyroidotomy
4. Transtracheal jet ventilation with fiberoptic intubation
5. All methods cause C-spine movement
6. None confer a significant risk to the unstable C-spine

B. Immobilization of the C-spine

1. Up to 25% of spinal cord injuries occur between the time of the accident and that of definitive care
2. Immobilize everyone with:
 - a. Motor vehicle accidents
 - b. Falls
 - c. Head trauma
 - d. Neck trauma
 - e. Altered mental status
 - f. Neurologic signs or symptoms
3. Adequate immobilization requires:
 - a. Rigid backboard
 - b. Philadelphia collar (or equivalent)
 - c. Sandbags or head blocks
 - d. Tape across both the forehead and collar

C. Clearance of the C-spine

1. Clinical
 - a. No neck pain
 - b. No neck tenderness (midline) *

- c. No neurologic signs or symptoms *
- d. Reliable exam
 - i. Clear sensorium *
 - ii. Sobriety *
 - iii. No distracting injury *
 - iv. Age > than 4 years
- e. Lack of “mechanism”

Note: * Indicates NEXUS criteria

2. Radiologic

III. RADIOGRAPHY

A. Routine trauma series

- 1. Cross-table lateral
 - a. 80% sensitive for fracture
- 2. Cross-table lateral and odontoid
 - a. 90% sensitive for fracture
 - b. Virtually 100% sensitive for unstable fracture
- 3. Cross-table lateral, odontoid, and AP view
 - a. 95% sensitive for fracture
- 4. 3-view series plus obliques
 - a. 97% sensitive for fracture
- 5. Most missed fractures involve:
 - a. C₁₋₂
 - i. True misses
 - b. C₇–T₁
 - i. Inadequate films

- B. Cross-table lateral (ABCDS)
1. A = Alignment
 - a. Anterior vertebral line
 - b. Posterior vertebral line
 - c. Spinolaminar line
 - d. Pediatric pseudosubluxation of C₂ on C₃
 - i. Check spinolaminar line
 2. B = Bones
 - a. Obvious fractures
 - b. Cortical defects
 - c. Changes in bone density
 3. C = Cartilage spacing
 - a. Intervertebral
 - i. 50% wider
 - ii. 50% narrower
 - b. Interspinous
 4. D = Dens
 - a. Predental space > 3 mm is pathologic in adults
 - b. Predental space > 5 mm is pathologic in pediatric patients
 - c. Posteriorly angled dens or V-shaped predental space is pathologic too
 - d. Harris rings

5. S = Soft tissue
 - a. Prevertebral
 - i. 6 mm at C₂
 - ii. 22 mm at C₆ (14mm in a child)
 - b. The rule of "7's"
 - c. C₂ prevertebral soft tissue exaggerated during expiration (especially in pediatric patients)
 - d. Neither sensitive or specific
 6. Must be an adequate film
 - a. Must visualize the top of T₁
 - i. Pull arms down
 - ii. Swimmer's view
 - iii. CT
 - b. Must be a true lateral
 - i. Near and far facets superimposed on each other
- C. Odontoid view
1. Open-mouth
 - a. Lateral aspects of C₁ and C₂ should align
 - b. Medial aspects of C₁ should align with superior C₂ notch
 - c. The dens should be centered between the lateral masses of C₁
 - d. Rotation is assessed by:
 - i. The incisors
 - ii. C₂ spinous process
 - e. Mach effect: posterior arch C₁ may cast a shadow over the dens simulating a fracture

2. Closed-mouth (trauma spike)
 - a. Only good at visualizing the dens
- D. AP view
 1. Adds little
 2. Transverse process fractures
 3. Disc height
 - a. 50% wider
 - b. 50% narrower
 4. Unilateral facet dislocation
 - a. Skewed spinous processes
- E. "Trauma" Obliques
 1. Scotty dog
 2. Adds little considering the current ubiquity of CT
 3. Lamina & pedicle fractures
 4. Facet dislocations
- F. Flexion-extension views
 1. In an unstable cervical spine without fracture is not uncommon
 2. Indicated when **ALL** of the following exists:
 - a. Persistent neck pain or focal tenderness
 - b. Negative plain films
 - c. Alert patient
 - d. Neurologically intact
 3. > 2 mm subluxation is pathologic

4. Contraindicated if previous plain films are suspicious for fracture or dislocation
- G. Computed tomography
1. 2 mm cuts
 2. Superior to plain films in evaluating bony and disc injury
 3. Inferior to plain films in evaluating subluxation and ligamentous injury
 4. Indications
 - a. To further evaluate fractures identified by plain films
 - b. To further evaluate fractures suspected by plain films
 - c. When plain films are inadequate
 - i. C₁₋₂
 - ii. C₇-T₁

IV. MECHANICAL STABILITY

- A. Two column theory
1. Anterior column
 - a. Vertebral bodies
 - b. Intervertebral discs
 - c. Anterior longitudinal ligament
 - d. Posterior longitudinal ligament
 2. Posterior column
 - a. Spinal canal
 - i. Pedicles
 - ii. Transverse processes
 - iii. Facets

- iv. Laminae
 - v. Spinous processes
 - b. Nuchal ligament
 - i. Supraspinous
 - ii. Interspinous
 - iii. Intraspinous
 - iv. Capsular ligament
 - v. Ligamentum flavum
 - 3. Spine is unstable when both columns are disrupted at the same level
- B. Three column theory
 - 1. More accurate
- C. Mechanical vs. neurologic stability
 - 1. Ligamentous injury without fracture
 - 2. Fracture fragments threatening the cord
 - 3. Epidural hematoma

V. SPECIFIC INJURIES

- A. Mechanism of Injury
 - 1. Flexion
 - 2. Flexion-rotation
 - 3. Extension
 - 4. Vertical compression

- B. Simple wedge fracture
 - 1. Compression of vertebral body from forced flexion
 - 2. Loss of height of anterior vertebral body
 - 3. Rarely associated with ligamentous injury
 - 4. Mechanically stable
- C. Flexion teardrop fracture
 - 1. Forced flexion brings the anterior aspects of two adjacent vertebrae together usually resulting in fracture of the more cranial one
 - 2. Oblique fracture through any anterior-inferior vertebral body
 - 3. Commonly associated with ligamentous injury
 - 4. Mechanically unstable
- D. Extension teardrop fracture
 - 1. Forced extension causes anterior longitudinal ligament to avulse a portion of a vertebral body
 - 2. Oblique fracture through anterior-inferior vertebral body (C₅₋₇)
 - 3. Commonly associated with ligamentous injury
 - 4. Mechanically unstable
 - 5. Associated with central cord syndrome
- E. Clay Shoveler's fracture
 - 1. Avulsion fracture of C₇ spinous process due to sudden flexion
 - 2. Can be C₆ or T₁ also
 - 3. Minimal ligamentous injury
 - 4. Mechanically stable

F. Subluxation

1. Disruption of posterior element ligaments from forced flexion which spares the bony structures
2. Subtle findings include:
 - a. Widening of the posterior disc space
 - b. Widening of the interspinous space
3. Anterior longitudinal ligament usually spared
4. Frequently mechanically unstable

G. Unilateral facet dislocation

1. Simultaneous flexion and rotation allows an inferior facet to be drawn cranially and rotated anteriorly above then in front of its corresponding superior facet
2. Identifiable by spinous process malalignment on the AP view or facet malalignment on the lateral view
3. Posterior element ligaments reliably disrupted, but stable as the facet rests, locked in the intervertebral foramen

H. Bilateral facet dislocation

1. Severe flexion resulting in complete disruption of all ligamentous structures at one level
2. Bilateral inferior facets flexed cranially and in front of their corresponding superior facets
3. Usually approximately 50% displacement of affected vertebral bodies
4. Extremely unstable
5. Highly associated with cord injury

I. Hangman's fracture

1. Hyperextension resulting in bilateral pedicle fractures of C₂ with varied degrees of dislocation

2. Can be subtle on lateral view (Harris rings)
3. Prevertebral hematoma is very common
4. Mechanically unstable
5. Usually not associated with significant cord injury
 - a. Cord only occupies 1/3 of canal at C₂
 - b. Bilateral posterior element fractures allow some degree of self-decompression

J. Jefferson fracture

1. Vertical compression shattering C₁ into several parts which displace radially
2. Defining characteristics are involvement of the anterior arch of C₁ and disruption of the transverse ligament which confer extreme mechanical instability to this fracture
3. Readily recognizable by plain films
 - a. Widened predental space
 - b. Prevertebral hematoma
 - c. Malalignment of C₁ lateral masses on odontoid view

K. Odontoid fractures

1. Varied mechanisms
2. Type I
 - a. Avulsion (by the alar ligaments) of the tip of the odontoid above the transverse ligament
 - b. Transverse ligament prevents subluxation of the odontoid
 - c. Mechanically stable

3. Type II
 - a. Fracture of the base of the odontoid at or below the transverse ligament
 - b. C₂ freely subluxes on C₁
 - c. Mechanically unstable
4. Type III
 - a. Fractures involving the dens **AND** the body of C₂
 - b. If not already displaced, should be mechanically stable

VI. SPINAL CORD SYNDROMES

- A. Complete spinal cord lesions
 1. Total loss of all motor and sensory function below the level of the injury
 2. If persistent for 24 hours, chance for functional recovery is remote at best
 3. Complete cord injuries may improve to incomplete, but sub-functional, injuries over the course of several weeks
 4. **ANY** degree of neurologic function below the level of the lesion (no matter how minor) implies an incomplete lesion and bodes an infinitely better prognosis
- B. Spinal shock
 1. Transient, conclusive injury to the spinal cord
 2. Mimics complete cord lesion
 3. Occurs with all types of cord injuries or alone without permanent cord injury at all
 4. Absence of bulbocavernosus reflex implies the existence and/or persistence of spinal shock

5. Generally last less than 24 hours and complete recovery is normal, if not associated with another cord injury
6. When the bulbocavernosus reflex returns, spinal shock is over and what you see is what you get
7. This is why **ALL** cord injuries should get methylprednisolone

C. Incomplete spinal cord lesions

1. Central cord syndrome
 - a. Forced hyperextension with buckling of the ligamentum flavum causing transient cord compression and micro-hemorrhage in the central cord
 - b. Upper extremities affected more than lower extremities
 - i. Pyramidal tract
 - ii. Spinothalamic tract
 - c. A “complete cord lesion with sacral sparing” is nothing more than a large central cord syndrome
 - d. Good prognosis
 - i. > 50% recover bowel/bladder control
 - ii. > 50% become ambulatory
 - iii. The faster the recovery the more complete the recovery
2. Anterior cord syndrome
 - a. Forced flexion resulting in an anterior cord injury from:
 - i. Cord contusion
 - ii. Vertebral body compression fracture with retropulsed fragments
 - b. Spinothalamic tracts affected resulting in loss of pain and temperature sensation

- c. Corticospinal tracts inconsistently affected resulting in a variable degree of paralysis
- d. Posterior columns preserved with intact position, light touch and vibratory sensations
- e. Cord compression is **NOT** transient as in central cord syndrome and emergent imaging in surgery are mandated
- f. Prognosis is not as good as in central cord syndrome, but complete recovery is possible

VII. CONCLUSION

- A. Intubate C-spine injured patients liberally
- B. Ensure adequate immobilization
- C. Beware pediatric pseudosubluxation
- D. Ensure adequate plain films
- E. When in doubt, CT it!
- F. Know the 2-column theory of C-spine mechanical stability for the test . . . then forget it
- G. Beware of normal plain films and lethal ligamentous injuries
- H. Be familiar with:
 - 1. Clay Shoveler's fractures
 - 2. Hangman's fractures
 - 3. Jefferson fractures
 - 4. Odontoid fractures and their classification
- I. Be familiar with:
 - 1. Central cord syndrome
 - 2. Anterior cord syndrome

1. Which of the following areas is a common risk area for a missed fractured radiographically on plain films?
 - A. C₃₋₄
 - B. C₅₋₆
 - C. C₂₋₃
 - D. C₁₋₂
 - E. C₄₋₅

2. What is considered a pathologic predental space in an adult?
 - A. > 3 mm
 - B. .3 - .5 mm
 - C. 1 – 2 mm
 - D. 2 – 3 mm
 - E. .5 – 1 mm

3. Which of the following is an excessive prevertebral soft tissue space on radiograph in a pediatric patient?
 - A. 14 mm at C₆
 - B. 22 mm at C₆
 - C. 2 mm at C₂
 - D. 6 mm at C₂
 - E. 8 mm at C₂

4. Which of the following is true regarding a simple wedge fracture?
 - A. It is associated with central cord syndrome
 - B. It is an oblique fracture
 - C. It is frequently associated with ligamentous injury
 - D. It results from compression from forced flexion
 - E. It is mechanically unstable

5. Which of the following is not true regarding an extension teardrop fracture
 - A. It is an oblique fracture through anterior-inferior vertebral body (C₅₋₇)
 - B. It is commonly associated with ligamentous injury
 - C. It is mechanically unstable
 - D. It is frequently associated with an anterior cord syndrome
 - E. It results from forced extension which causes anterior longitudinal ligament to avulse portion of vertebral body

ANSWERS

1. D—C₁₋₂
2. A—> 3 mm
3. B—22 mm at C₆
4. D—It results from compression from forced flexion
5. D—It is frequently associated with an anterior cord syndrome

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