C-Spine Injuries

Trauma Rounds
OUTLINE

- Introduction: Incidence, Importance
- Normal C-spine Anatomy
- Clinical Criteria for C-Spine X-rays
- Imaging Evaluation & Interpretation
- Fractures: Mechanism, Types, Management
INTRODUCTION

Incidence:
- in USA: 10,000 pts present annually to ER
- 5,000 additional pts die at accident scene
- 50% associated with spinal cord injury (SCI)
- teenagers & young adults -- most common!
- 80% males; 5% children
- most common causes: MVA, falls, sports (football)
INTRODUCTION

- Incidence (cont’d)
  - most common area of spinal injury: 55%, T-spine (15%) thoracolumbar junction (15%), lumbosacral (15%)
INTRODUCTION

Importance:
- consequences: simple neck pain, quadriplegia, or even death
- SCI occurs at time of trauma in 85% pts & as late complication in 15%
- initial post-injury period is critical for neurologic recovery or deterioration
- delayed recognition of injury or improper stabilization --> irreversible SCI
- ~10% of patients with C-spine fracture have a 2nd noncontiguous vertebral column fracture
C-SPINE
ANATOMY

Atlas
(the first
cervical vertebra)

Axis
(the second
cervical vertebra)

Spinous Process

Transverse process

Vertebral body

C1
C2
C3
C4
C5
C6
C7
T1
Sagittal cross-section thru midline
VERTEBRA ANATOMY

Posterior view
C3-C7
ANATOMY
C-SPINE X-RAYS

NEXUS Low-Risk Criteria for C-spine Radiography (neck/head trauma & meets at least ONE):

- No intoxication
- Normal level of alertness
- No midline neck tenderness with palpation
- No neurologic deficit (e.g., paralysis, paresthesia)
- No distracting injury (e.g., broken femur)
C-SPINE X-RAYS

- Canadian C-Spine Rules
  - developed by Dr. Ian Stiell, University of Ottawa
  - for patients with GCS 15, age ≥ 16 yrs old, haemodynamically stable
- Patients awake, alert, neurlogically intact (GCS=15)
  → absence of pain or tenderness along spine virtually excludes a significant spinal injury
PLAIN FILMS:
AP VIEW
PLAIN FILMS: LAT VIEW
PLAIN FILMS:
AP VIEW
PLAIN FILMS: ODONTOID

occiput

lateral
condyles

lateral
mass
of C1

dens

C2 body

spinous
processes

C2

C3

lateral
mass
of C1
dens

C2 vertebral body

lateral
mass
of C1

lateral
mass
of C1
INTERPRETATION

A -- Adequacy (do you see C7-T1 junction?)
A -- Alignment of Column Lines (ant., post., etc.)
B -- Body (vertebral bodies - heights, width)
C -- Cartilage (discs)
D -- Dens
E -- Edema (prevertebral tissue swelling)
SWIMMER’S VIEW
(when can’t see top of T1 in Lat view)
FLEXION & EXTENSION

Question of ligamentous injury???
- focal neck pain
- minimal malalignment on lateral c-spine
  - predental space < 4mm
  - pseudosubluxation < 4mm
  - cord space > 13 mm
- c-spines show NO evidence of unstable fracture

---> obtain Flex/Ex views!!!
FLEXION & EXTENSION

- Should only be performed in awake, cooperative patients
- Halted at point where the patient is in too much pain
- Anterior subluxation injuries are exacerbated in flexion, reduced in extension
FLEXION & EXTENSION
CT C-SPINE

Advantages:

- excellent for characterizing fractures & identifying boney compromise of the vertebral canal
- high contrast resolution --> improved visualization of minimal fractures
- able to reconstruct images in the axial, sagittal, coronal & oblique planes from one patient position
CT C-SPINE

Disadvantages:
- unable to show ligamentous injuries
- relatively high costs cf. plain film x-rays
CT C-SPINE

Screening Helical CT combined with single lateral view in lieu of plain films in high-risk patients

- Mechanism of Injury
  → High speed MVC (≥ 55 kmh)
  → Fall ≥ 10ft
  → Pedestrian struck by car

- Evaluation
  → Significant closed-head injury or ICH
  → altered LOC at time of examination
  → Neuro S+S referred to C-spine
MRI C-SPINE

disc space

vertebral body

spinal cord

base of brain
MRI C-SPINE

- indicated in cervical fractures that have spinal canal involvement, clinical neurologic deficits or ligamentous injuries (e.g., transverse ligament)
- hemodynamically stable patients
- best visualization of soft tissues:
  - ligaments, intervertebral disks, spinal cord &
  - epidural hematomas
MRI C-SPINE

**advantages:**
- excellent soft tissue contrast
- general overview b/c of its ability to show information in different planes
- demonstrates vertebral arteries
- no ionizing radiation

**disadvantages:**
- loss of bony details
- clinical availability in tertiary centres only!
PLAIN FILMS vs. MRI
INJURY MECHANISMS

Hyper-Flexion

Hyper-Extension

Axial-Compression
INJURIES

Atlanto-Occipital Dislocation
  Jefferson
  Odontoid
  Hangman’s
  Flexion Teardrop
  Bilateral Dislocation
  Unilateral Dislocation
  Anterior Subluxation
  Clay Shoveler’s
  Wedge
  Burst
Atlanto-Occipital Dislocation

- aka: craniocervical junction dissociation
- dissociation of occipital condyles from superior articulating facets of Atlas
- ligamentous disruption
- unstable fracture...death d/t anoxia
Best seen on lateral film

- Basion-Axial Interval (should be ≤ 12mm)
- Basion-Dentate Interval (should be ≤ 12mm)
- Increased Power’s ratio > 1
  - basion to posterior arch of atlas / opisthion to anterior arch of atlas
- Cervicocranial prevertebral soft tissue swelling
Jefferson Fracture

- compression fracture of bony ring C1
- Axial load injury (direct blow to top of head)
- moderately unstable
Jefferson Fracture

- lateral displacement of C1 lateral masses
  > 2 mm may be indicative of C1 fracture
- Cumulative displacement of lateral masses > 7mm → transverse ligament disruption likely
- CT required to define extent of fracture & detect spinal canal compromise
Transverse Ligament

- Located anteriorly inside C1 ring, runs along posterior surface of the dens
- Crucial to maintaining C1-C2 stability
- Measure *predental space*
  - $\geq 3\text{mm} \rightarrow$ damaged
  - $\geq 5\text{mm} \rightarrow$ rupture

**Mechanism:** direct blow to occiput e.g. fall
Odontoid Fractures

Type I (rare)
- unstable

Type II
- unstable

Type III
- stable

Mechanism: flexion
Type II Odontoid Fracture
Type II Odontoid Fracture

- Major force trauma
- Usually with multisystem trauma
- Most common odontoid #
- Awake patients c/o immediate and severe high cervical pain, radiates to occiput
- Neurologic injury 18-25% of cases
Type III Odontoid Fracture
Hangman’s Fracture

- **Traumatic spondylolisthesis of the Axis**
- Judicial hangings (usually not suicidal hangings)
- MVC, diving accidents
- Prevertebral soft tissue swelling
- Avulsion of anterior inferior corner of C2 associated with rupture of the anterior longitudinal ligament
- Anterior dislocation of C2 vertebral body
- Bilateral C2 pars interarticularis fractures

**Mechanism:** Hyperextension
Hangman’s Fracture

- May not cause spinal injury due to large diameter of spinal canal
- UNSTABLE
Flexion Teardrop Fracture

- disruption of all ligamentous structures & anterior VB compression fracture
- sudden & forceful flexion
- highly unstable
Flexion Teardrop Fracture

- prevertebral swelling d/t ALL tear
- teardrop fragment from anterior VB avulsion fracture
- posterior VB sublux’n into spinal canal
  - spinal cord compromise from VB displacement (Anterior Cord Syndrome)
- spinous process #
Bilateral Facet Dislocation

- complete anterior dislocation of VB by > half of VB AP diameter
- ALL & PLL disruption "bat wing" appearance of locked facets
- flexion/rotation mech’m
- highly unstable
Unilateral Facet Dislocation

- anterior dislocation of VB by < half AP diameter
- flexion & rotation
- rotation above & below involved level
- widening of the disk space
- "bat wing" appearance of overriding locked facets
Unilateral Facet Dislocation

- AP view → spinous processes will not line up, affected SP deviates to side of vertebra dislocated
- Mechanically stable (unless # of articular masses)
Pillar Fracture

- Extension & rotation mechanism
- Impaction of 1 vertebra on the articular mass of inferior vertebra
- Vertical/oblique fracture of articular mass
- Lateral film “double-outline” sign (articular mass displaced posteriorly causing 2 shadows)
- Stable #
Clay Shoveler’s Fracture

- C7 spinous process #
- hyperflexion & contraction of paraspinous muscles pulling on spinous processes (e.g. shoveling)
- “Ghost sign” on AP view (i.e. double spinous process of C7)
- stable
Anterior Subluxation

- disruption of PLL
- Fanning of spinous processes
- 11 degrees change in angulations at a single interspace
- severe hyperflexion
- subluxation stable initially, but associated with 35% delayed instability
- flexion & extension views are helpful in further evaluation
Wedge Fracture

- compression fracture
- severe flexion

**Radiographic features:**
- buckled anterior cortex
- lost height of anterior VB
- anterosuperior fracture of vertebral body
- unstable (usually PLL disruption)
Burst Fracture
Burst Fracture

(note: soft tissue swelling at C6)
Burst Fracture

- fracture of C3-C7 d/t axial compression/loading -- failure of ant. & mid. columns
- SCI secondary to displacement of posterior fragments in to spinal canal
- CT required to evaluate canal compromise
- unstable fracture
Extension Teardrop

- Hyperextension mechanism
- Most common at C2
- ALL tear + avulsion anteroinferior vertebral body
- Central Cord Syndrome
- Unstable in extension
Hyperextension Dislocation

- Complete tear of ALL, PLL, disc
- Associated with facial trauma, central cord syndrome
- Diffuse prevertebral STS
- Disc space wide, anteroinferior vertebral #
SCIWORA

- Adults & kids
- 1 large study showed up to 3% with SCI had SCIWORA
- MRI → disc herniation, spinal stenosis, intramedullary hematoma, cord contusion/edema
Paediatric C-Spine

- NEXUS criteria have been applied but with difficulty (due to fear and agitation in injured kids)
- X-rays indicated for
  - moderate or high risk head injury
  - multiple trauma
  - S+S spine injury
  - mechanism
  - Altered LOC or focal findings
  - distracting injury (e.g. # forearm)
Paediatric C-Spine

- Look for Pseudosubluxation
  - common until age 12
  - Swischuk’s Line
Paediatric C-Spine

- Up to 66% SCIWORA
- Prevertebral STS at C2 ≥ 8mm or > 50% width of adjacent vertebral body
- If any suspicious findings on plain film, or any neuro deficits, parasthesiae, weakness → CT C-spine
- If considering Dx SCIWORA → MRI
- Do not do Flex/ext views if Neuro S+S
Paediatric C-Spine

Management
- immobilization
- steroids if Neuro deficits
- refer early!
Clinical Management

- Prognosis for spine trauma depends upon action taken by the paramedic/emergency team in the first 12 hours post-injury.

- **Main objective:**
  - To prevent primary cord injury.
  - To minimize secondary injuries to spinal cord tissue due to inadequate immobilization, & persistent spinal cord compression (ischemia).
Clinical Management

EMS
- rigid C-spine collar &/or sandbags/rolls with immobilization to a “hard” board for transport
Clinical Management

- **Goal**: to optimize the environment for the spinal cord to recover as much as possible
- 3 indications for surgical intervention:
  - Neurologic deficit
  - Spine instability
  - Intractable pain
Clinical Management

- **Jefferson fracture**: halo immobilization 12 weeks; results in primary union of C1 ring & stability with respect to C2

- **Odontoid fracture**:
  - **Type I** usually does NOT have neurologic symptoms; treat with Philadelphia collar
  - **Type II** difficult to treat in halo vest; nonunion rate as high as 45%; if nonunion persists, surgical fusion indicated
Clinical Management

**Type III** treat with halo immobilization; high rate of union

- **Hangman's fracture:** heals with halo immobilization for 12 weeks; surgical fusion rarely indicated

- **Vertical compression fractures:** treated initially with traction to reduce fragmentation & subsequently with halo vest; tend to heal well
Clinical Management

- **Unilateral facet dislocations**: halo immobilization provides good outcome
- **Bilateral facet dislocations**: treated conservatively; facet joints are reduced and immobilized; posterior ligament usually heals poorly
- **Clay Shoveler's fracture**: treated with soft collar for comfort; excellent prognosis
EAST Guidelines

Eastern Association for the Surgery of Trauma (EAST) Practice Management Guidelines Committee for C-Spine Clearance in Obtunded Patients (2000):

- unremarkable 3 views on plain films
- unremarkable occiput-C2 on thin-slice CT
- ---> C-spine cleared!!!
<table>
<thead>
<tr>
<th>Description</th>
<th>Imaging</th>
<th>Findings</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>- awake collar</td>
<td>no radiographic</td>
<td>C-spines cleared</td>
<td>remove</td>
</tr>
<tr>
<td>- not intoxicated</td>
<td>studies necessary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- neurologically intact</td>
<td>studies necessary</td>
<td></td>
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<tr>
<td>- no neck tenderness with palpation; able to rotate neck 45° to right and to left</td>
<td>no radiographic</td>
<td></td>
<td></td>
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<tr>
<td>- no thoracic / lumbar pain or midline tenderness palpation of spine</td>
<td>no radiographic</td>
<td>T / L spines cleared</td>
<td></td>
</tr>
<tr>
<td>- thoracic / lumbar pain, but no midline tenderness on palpation of spine</td>
<td>studies necessary</td>
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### Description

- - awake, alert
- - neck pain or midline tenderness; unable to rotate neck 45° to right or to left
- - age > 65
- - dangerous mechanism injury
- - paresthesia

### Imaging

- - AP & lateral C-spine
- - open mouth odontiod
- - swimmer’s view
- - neutral erect view
- - CT with reconstruction
- - voluntary flex/ext of lateral C-spines
- - AP & lateral T / L spine

### Findings

- areas of suspicion
- no abnormal findings
- no abnormal findings
- no abnormal findings

### Action

- consult spine service
- remove collar
- remove activity
- restrictions
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<tr>
<td>- Altered mental status and return of normal status not anticipated within 2 days</td>
<td>- AP &amp; lat C-spine (with shoulder pull)</td>
<td>areas of suspicion in C / T / L spine</td>
<td>consult spine service</td>
</tr>
<tr>
<td></td>
<td>- open mouth odontiod</td>
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<td></td>
<td>- swimmers’ view prn</td>
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<tr>
<td></td>
<td>- CT occiput to T1 (with reconstruction)</td>
<td>no abnormal findings</td>
<td>remove collar</td>
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<td>C-spine cleared</td>
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<td>- AP &amp; lateral of T / L spine</td>
<td>no abnormal findings</td>
<td>remove activity</td>
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<td></td>
<td></td>
<td>T / L spine cleared</td>
<td>restrictions</td>
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