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“The role of radiography in the initial evaluation of C-Spine Trauma”

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OBJECTIVES

- Better understand normal radiographic anatomy
- Standardized approach to reading c-spine radiographs
- Review of common cervical spine injuries seen in the blunt trauma patient and their significance
- Discuss using NEXUS as a framework; who to x-ray, which studies needed to adequately screen for CSI and appropriate use of advanced imaging
Normal Radiographic Anatomy
Normal Lower Cervical Vertebra

1) Vertebral end-plate
2) Pedicle
3) Laminae
4) Spinous process
5) Superior facet
6) Inferior facet
7) Spinolaminar line
8) Uncinate process
ABCs of the C-Spine

- Alignment, Adequacy
- Bony Element
- Cartilage Space, Connective Tissue
- Soft Tissue
Cross Table Lateral View
Alignment/Adequacy

- C7 –T1 thru post. F. Magnum
- ALL & PLL
- Spinolaminar Line
- Tips of Spinous Processes
- Predental Space <=3mm
- Basion Dental interval (BDI)
- Basion Axial Interval (BAI)
CTLV – Alignment
BDI, BAI <= 12mm

Source Undetermined
Pseudosubluxation C2
CTLV – Bony elements
Density & Symmetry

- Ant. & post. Cortices body
- Sup. & Inf. Endplates
- Ring of C2
- Transverse processes
- Pedicles
- Articular Masses
- Sup. & Inf. Facets
- Laminae
- Spinous processes
- C1-2 and C5-7
Cartilage space and connective tissue

- Intervertebral disc
- Interfacetal joints
- Interlaminal space
- Interspinous space
Soft Tissue

- Retropharyngeal space
  \(\leq 6\text{mm}\)
- Retrotracheal space
  \(\leq 22\text{mm}\)
- Cervical esophagus at
  C4-5
- Absolute measurement not reliable, sensitivity \(~5\%\)
  lower C-spine

Source Undetermined
Is This An Adequate CTLV?
Anatomy of the cervicocranium
Odontoid view (open mouth) **Alignment**

- Odontoid process located between lat. masses of axis
- Lateral margins of atlanto-axial facet joints
- Bifid spinous process midline
- w/o tilt or rotation
Odontoid view w/ rotation
Odontoid view

Bony elements

- Odontoid and artifacts
- C1 lateral masses
- C2 vertebral body
Odontoid view

Cartilage space

- Interfacetal joints
A-P View
Alignment

- Spinous processes midline
- Tracheal air shadow
A-P View

Bony elements

- Vertebral bodies
- Sup. & Inf. Endplates
- Uncinate processes
- Articular masses
  - Lateral columns
A-P view

Cartilage space and connective tissue

- Intervertebral disc space
- Interspinous space
- Joints of Luschka
Swimmer’s View

- For evaluation of C7-T1 interface when CTLV is inadequate
- Posterior C7 not well visualized
- Use only when suspicion of injury is low
CSI by Mechanism

Hyperflexion
Hyperflexion Strain

- Hyperkyphosis at level of injury
- Ant. displacement Vertebral Body > 2mm
- Disruption post. Ligamentous complex
- Interspinous & Interlaminal fanning
- Disc space widened post. And narrowed ant.
Hyperflexion Strain (cont)
Hyperflexion Strain (cont)

- Soft Tissue Swelling may be only evidence CSI.
- Loss of cervical esophagus highly suspicious of CSI.
- Flexion film shows anterolisthesis C4 on C5 with upward and forward movement of inferior facet.
- 30% to 50% incidence delayed instability.
Hyperflexion Strain MRI

- Sagittal STIR image
- Ruptured ALL
- Ruptured PLL
- Abnormal signal throughout interspinous and supraspinous ligaments
Bilateral Facet Dislocation

- Dislocation of bilat. facet joints
- All ligamentous structures disrupted
- Ant. Displacement => 50% A-P diameter subjacent vertebral body
- Purely soft tissue injury w/ pre-vertebral STS
- Unstable
Bilateral Facet Dislocation (cont)
Bilateral Facet Dislocation

CT
Flexion Teardrop Fracture

Marked prevertebral STS

Retropulsion of fragments into spinal canal

Anterior Cord Syndrome
Quadriplegia
loss pain, pinprick, temp
preserve post. column
(vib., pressure, proprio)
Hyperflexion with rotation

Unilateral Facet Dislocation
Unilateral Facet Dislocation

- Ant. Subluxation of vertebral body <= 25% AP diameter
- Ant. Dislocation of one articular mass inferior facet
- Rarely assoc. w/ neuro deficit of nerve root distribution
- Mechanically stable
Unilateral Facet Dislocation (cont)

- Dislocated Articular mass stuck in subjacent intervertebral Foramina (locked)
- Obliques to confirm site of dislocation
Unilateral Facet Dislocation (cont)

- A-P view – spinous process at level of dislocation displaced towards
Vertical Compression
Jefferson Fracture of C1

- At least one Fracture through the ant. & post. Arch
- Lateral expulsion of the lateral masses of C1
- TAL avulsion or rupture with increased AADI
- Retropharyngeal swelling
Jefferson Fracture C2 (cont)

- Lat. displacement of C1 articular masses on odontoid view
- Coronal CT reformations – disruption of occiputal-C1 articulation, displacement C1 lat. mass
Jefferson Fracture (textbook)
Odontoid view and axial CT
Burst Fracture

Intrusion of NP into vertebral body

Retropulsion fracture fragments
Hyperextension
Hangman’s Fracture
Traumatic Spondylolisthesis

- Bilateral Pars Interarticularis Fx
- Type I – III
- Ant. Displacement C2 vertebral body
- Disruption intervertebral disc
- Dislocation C2-3 Facet Joints
- Displaced & angulated posterior arch
- STS
- Mechanically unstable

Source Undetermined
Hangman’s Fracture
Myelopathy and the Cervicocranium

A-P diameter > at this level of the C-spine
Auto decompression
Diverse Mechanisms
Odontoid Fracture

- Hi (type II) Fracture
- Soft Tissue Swelling
- +/- Odontoid Displacement
- Fracture at base of Odontoid
- Most common type
- Unstable, 26-36% nonunion
Odontoid Fracture

- Low (Type III)
- Disruption “Ring of C2” on CTLV
- Fracture upper C2 vertebral body
- +/- prevertebral soft tissue swelling
- Unstable, better prognosis than Type II

Source Undetermined
NEXUS

National Emergency X-Radiography Utilization Study
Validity Of A Set Of Clinical Criteria To Rule Out Injury To The Cervical Spine In Patients With Blunt Trauma

- Prospective, Observational Multicenter Study
- 34,069 patients w/ Blunt Trauma who underwent C-spine imaging
- Examined the performance of a set of 5 clinical criteria to identify patients who have a low probability of cervical spine injury
Patients considered Low Prob. Injury if:
Stable and met 5 Criteria

- No Midline Cervical Tenderness
- No Focal Neurological Deficit
- Normal Alertness
- No Intoxication
- No Painful Distracting Injury
Performance of Clinical Criteria

- 818 patients (2.4%) x-ray documented injury: missed 8
- 576 patients w/ clinically significant* injury: missed 2
- Sensitivity 99.0, NPV 99.8; Specificity 12.9
  PPV 2.7
- Rate of missed CSI: 1 in 4000 patients
Conclusions

- Confirms validity of a decision instrument based on 5 clinical criteria for identifying blunt trauma patients who have extremely low probability of having CSI.
- Sensitivity ~ 100% for clinically significant injury
- Decrease in ordering of radiographs by 12.6%
Sons of Nexus

- Reliability of Standard 3-view series
- Value of F/E views in acute blunt trauma
- Distribution and Patterns of CSI
Use of Plain Radiography to Screen for Cervical Spine Injuries

- 34,069 patients; 818 had total of 1,496 CSI (2.4%)
- Plain radiographs; 932 CSI in 498 patients (1.4%) missed 564 CSI in 320 patients (.94%)
- Majority missed CSI; x-rays interpreted as abnormal but not dx or inadequate (.80%)
- 23 patients (.07%) had 35 CSI (3 ? Unstable) not visualized on adequate plain films
- 2.81% of all injured patients, 4.13% of 557 w/ adequate 3-view
Use of Plain Radiography (cont.)

35 missed CSI

- 3 (2 patients) dx on MRI
- 8 (6 patients) dx on Flex/Ext
- 29 (18 patients) dx on CT
- 1 detected on risk management review
- Sensitivity adequate 3-view 89%, NPV 99%
- Lamina & Post. arch most common site
- C 6-7 (48%) most common level followed by C 2 (20%)
Use of Plain Radiography (cont.)

Conclusions

- Standard 3-view reliable screen in most blunt trauma patients.
- On rare occasions will fail to detect unstable injuries. (.20% of injuries, .008% all patients)
- Difficult to obtain adequate plain radiographic imaging in a substantial # patients. (30%)
Use of Flexion-Extension Radiographs of the Cervical Spine in Blunt Trauma

- 818 patients w/ CSI, F/E ordered in 86
- 6 patients w/ CSI not seen on 3-view, none clinically significant
- 3 dislocations detected, all seen on 3-view
- 15 of 16 subluxations detected, 4 missed on 3-view*
Use of Flex/Ext (cont.)

Conclusions

- Largest prospective study; adds very little to 3-view supplemented when appropriate w/ CT, MRI.
- MRI preferable evaluate Lig. Instability
- CT better to evaluate for occult Fx.
Distribution and Patterns of Blunt Traumatic Cervical Spine Injury

- 34,069 patients, 818 (2.4%) radiographic CSI
- 1,195 Fractures & 231 Subluxations or dislocations
Distributions and patterns (cont)

RESULTS

- C2 most common site of fracture (23.9%)
- C3 least likely to be injured
- C5-6 & C6-7 most common level of dislocation
- 240 patients (29.3%) clinical insign. CSI
- 32.3% patients > 50 years, had 45.3% of all atlantoaxial injuries
Advanced Imaging

CT Scan

- CT detects 97-100% of Fractures but accuracy in detecting purely ligamentous injury not documented
- Limited in patients with severe degenerative disc disease
- Inability to detect axially oriented fractures, lig.injury and facet subluxation largely overcome on current scanners if thin cuts and multiplanar reformations (MPR).
Advanced Imaging
MRI

- MRI highly sensitive in detection of ligamentous injury but may be too sensitive
- Much less sensitive than CT in detection of fractures to the posterior arch and injuries to the craniocervical junction.
- In patients with neurologic deficits, MRI is the study of choice to define cord injury or impingement