

PAEDIATRIC SPINAL INJURIES

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EPIDEMIOLOGY — C-SPINE TRAUMA

- 1% of all Paediatric fractures
- 2 % of all Spinal Injuries are involving Paediatric patients
- Neurological deficit rare
 - Incomplete recover better vs incomplete in Adults
- Age
 - <8 – Upper C-Spine Injuries – Lax ligaments, Horizontal facets, larger Head vs Body
 - >8 – Upper / Lower
- Mechanism
 - Infants-Abuse
 - <9 yo – RTA > Falls
 - >9 yo – Sport > RTA
- Higher injury = risk of head injury = increase mortality = 9/10 pre-hospital

FLEXIBILITY OF PAEDIATRIC SPINE

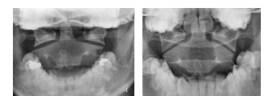
- "Injuries follow differential flexibility between cord and spine"
 - Spinal Column (Vertebrae AND DISC space) more flexible Than Cord
 - Elongate 2 inches before failure
 - Cord takes ¼ elongation before neurological deficit
- C1-C2 50% more flexible in Flexion and Extension Vs Adults
- "Most flexible segment descends with Age"
 - Age 3-8 – C3/C4
 - 9-11 – C4/C5
 - 11-15 – C5/C6
 - Follows age related pattern of injuries

PAEDIATRIC SPINE TRAUMA

- Cervical spine trauma
 - More common than T-L spine
 - More severe and often fatal
- Thoraco-lumbar spine trauma
 - Less common but more potential for neurological injury

HOW IS PAEDIATRIC C-SPINE DIFFERENT TO ADULTS?

- Flexibility
- Facets
- Physcal considerations
- Ossification
- Head neck ratio
- Variants



FACETS

- Translational injury contributes to the bending injuries due to flexibility
- C1/C2
 - 50-55 degrees at birth to 70 degrees at maturity
- Subaxial Spine
 - 30 degrees at birth
 - 70 degrees at Maturity
- Younger the child the more horizontal orientation of the facet
 - Think of the mechanism and the potential translation of the facet at point of injury

PHYSEAL CONSIDERATIONS

Junction between Vertebral body and End plate

- Body – Metaphysis
- End plate – Physis
- Junction weaker than body/disc

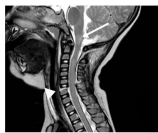
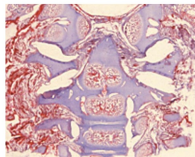
End plates are firmly bound to the adjacent disc

Fracture through zone of proliferation – Salter Harris 1

Inferior end plate > superior

- Superior protected by Undulating uncinat process

Disc space widening on x-rays may indicate SH-1 injury to the inferior end plate



OSSIFICATION

Immature skeleton – challenge to decide what is abnormal

Atlas

- 3 centres – Body, 2 neural arches
- Ring reaches adult size by 4 years of age
- (Fusion after doesn't lead to stenosis)

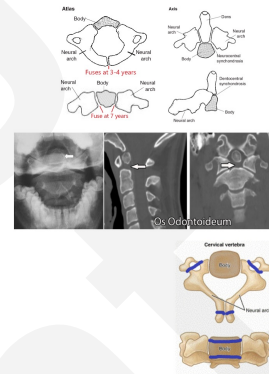
Axis

- 4 centres – Dens, Body, 2 neural arches, (Bifid dens/Os terminale)
- Vestigial disc between Dens and Body
 - Below the level of Superior Articular Facet, Cup shaped - Normal
- No Synchrondroses should be seen after age of 7
- Os odontoideum – unrecognised trauma leading to

Sub axial spine

- Centres for Body and 2 neural arches

5 secondary centres till age 25



HEAD NECK (BODY) RATIO

Head larger compared to body

Flat spinal board leads to inadvertent flexion of the C-Spine

May aggravate pre-existing c-spine injury

Maintain alignment by

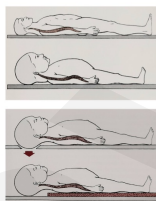
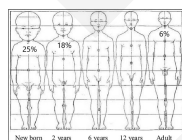
- Head recessed spine boards
- Split mattress spine board

Larger head = higher tendency to roll

- Higher centre of rotation to the floor

Hard collar – allows 17 deg flexion, 19 extension, 4 deg rotation

Collar + tape = 3 degrees in all planes



VARIANTS

Atlas

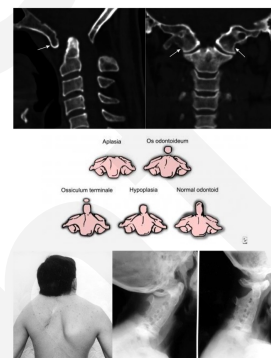
- Occipitalisation – failure to separate from occiput
 - Foramen Magnum narrowing – neurological deficit
 - Increased stresses on Atlanto Axial joint – instability
- Failure of fusion of posterior arch

Axis

- Aplasia – complete absence of
- Hypoplasia – stubby dens
- Os Odontoideum

Klippel feil

- Severely restricted ROM
- Increased stresses on mobile segments – injury prone



PAEDIATRIC TRAUMA EVALUATION - HISTORY

New born

- Obstetric injury, Lack of head control – minor trauma

Infants

- Mostly SCIWORA – Child abuse

Toddlers/young children

- RTA, LOW energy falls

Adolescents

- Sport – Rugby stingers

Presentation

- Pain – localised to cervical spine

Obtunded/Uncooperative patient

- Consider SCIWORA – complete evaluation

Head/neck Trauma, Distracting injury

- Complete evaluation before C-spine clearance

Infants

- Unexplained respiratory distress
- Weakness/Hypotonia

Symptoms

- Headache, reduced ROM/deformity (torticollis)
- Keeps head in hands – feeling of instability

PAEDIATRIC TRAUMA EVALUATION - EXAMINATION

Paediatric ATLS protocol – A(C)B(O)₂CDE

High index of suspicion

- Head and neck trauma has a high incidence of C-spine injuries

Look

- Soft tissue abrasions, Seat belt marks, Anterior Soft tissues

Feel the C-Spine

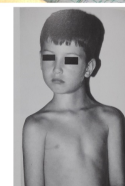
- Tenderness, muscle spasm, alignment
- 1/5th have concomitant spinal injury – examine the whole spine

Move

- Not in uncooperative or obtunded patient – repeat exam

Document Neurology

- Gross if not specific
- PR exam, Bulbocavernosus reflex



PAEDIATRIC SPINE TRAUMA EVALUATION - IMAGING

Plain radiographs – Standard of 1x

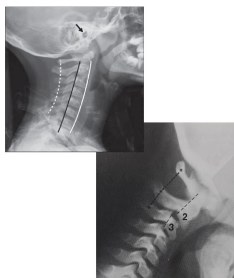
- If possible AP, Open mouth, Lateral C-Spine
- At least cross table lateral if unstable
- Include C-spine in CT head to reduce radiation
- 23-26% false negative rate: repeat films in department

System to read plain radiographs

- Alignment
 - Anterior, Posterior vertebral body lines, Spino-laminar line, Posterior Spinous process line
- Interspinous distance – Less than 1.5 times adjacent
- Vertebral contour, know the variants and physal lines
- Soft tissues – up to the width of the vertebra at C6 is normal
 - Is the child crying?

Flexion extension views

- Alert and cooperative patient only
- Midline c-spine pain and tenderness with normal plain radiographs



PAEDIATRIC SPINE TRAUMA EVALUATION - IMAGING

CT

- Careful patient positioning – recessed head board
- High Radiation dose – careful patient selection
- Paediatric CT Protocols

MRI

- R/o Ligamentous injury in uncooperative patient
- Early mobilisation/ Early treatment
- Assessment of Disc pathology in facet subluxations
- Assessment of patients with SCIWORA

SCIWORA PANG AND WILBERGER 1982

Spinal Cord Injury WithOut Radiographic Abnormality (Normal Radiographs or CT)

- Common before 8 years of age
 - Hypermobility, laxity, immature vascular supply

Complete or incomplete lesion

- Incomplete lesion improves better than adults
- Paediatric SCI before puberty leads to spinal deformities in almost all patients
 - Scoliosis > kyphosis > lordosis
- BEWARE: Delayed onset paralysis
 - Look for subtle neurological deficit
 - Immobilise

Severe flexion and/or distraction of the Cervical Spinal Cord

- Cervical spine flexibility > Spinal Cord flexibility
- Ligament disruption

Ischaemic injury to the Cord

SH-1 fracture of the Paediatric vertebral end plate

MRI can pick up the injury (1/4 to 2/3 abnormal) – Often away from injury zone

- Extra-neural/neural pathology
- Correlates with recovery potential – no abnormality recover best

MANAGEMENT - IMMOBILISATION

Before c-spine clearance, post-op, definitive management

Hard Cervical collar

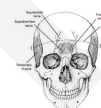
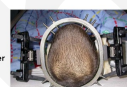
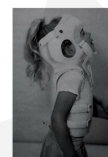
- Still allow a degree of mobility
- Can be further restricted by tape and blocks

Custom orthosis/ Minerva Cast

- Difficult patient anatomy for standard collar sizes
- Correction of deformity, usually inadequate extension in Collars

Paediatric Halo

- Ring alone for traction or with vest for immobilization
- Pre-fabricated or custom made sizes available
- Pin sites, number, insertion torques
 - Pre-op CT to evaluate Cranial cortex/Fontanelles/Sutures
 - Anterolateral, Posterolateral PAIRS 180 degrees opposite to each other
 - 8-12 pins at lower torque (2Nm) or finger tight



BOA STANDARD

Cervical spine clearance in the trauma patient



British Society of
Skeletal Radiologists

May 2021

Spinal clearance protocol must be in place for all hospitals

Spinal protections must be in place till injury is excluded

Assess the **WHOLE** spine

If clinical signs positive, Complete neurological assessment should be done (ASIA)

If abnormal neurological Signs – immediate discussion with Spine Surgery centre

Significant Spinal injury is excluded if

- Normal neurological examination in an awake and alert patient
- Imaging protocols rule out a Spinal injury



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Imaging Protocols

CT

- Head CT should include C-spine
- Polytrauma CT should include C-spine
- Thoracic and Lumbar CT according to Local MTC protocol
- Suspected C-spine Injury – Thin slice CT from Occiput to T4
- Initial report of C-spine clearance before Pt leaves A&E and definitive report in 18 hours

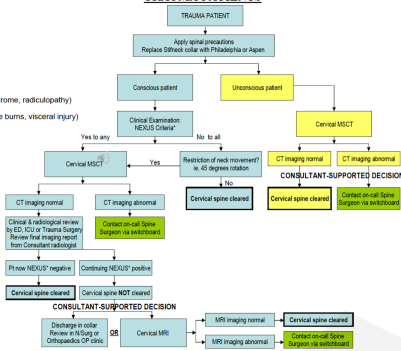
MRI

- In all suspected cord injuries
- When CT is indeterminate

***NEXUS Criteria**
Midline cervical tenderness
Focal neurological deficits
Intoxication (ie, alcohol or drugs)
Painful distracting injuries
Altered mental status

***NEXUS Criteria**
Midline cervical tenderness on palpation
Focal neurological deficit (ie. paraesthesia, central cord syndrome, radiculopathy)
Intoxication (ie. alcohol, narcotic analgesic, other drugs)
Painful distracting injury (eg. long bone fracture, considerable burns, visceral injury)
Altered mental status (ie. GCS<15)

CERVICAL SPINE CLEARANCE PROTOCOL:
TRAUMA PATIENTS



UHW PROTOCOL

Paediatric Trauma Cervical Spine Guidelines UHW

Traumatic injuries of the cervical spine (C-spine) are uncommon in children. However, it is safer assume there is a cervical spine injury until examination and/or radiological investigation demonstrate otherwise. It is often challenging to assess and immobilize children when a C-spine injury is suspected.

- Frequent reassurance is required to help keep the child still and reduce their anxiety levels.
- If the child is anxious or uncooperative and a thorough examination is not possible, try and maintain in line C-spine immobilisation.
- Early provision of simple analgesia (paracetamol / ibuprofen) and early review by a senior clinician who is experienced in the management of paediatric C-spine assessment may avoid prolonged periods in C-spine collars.

Indications for cervical spine immobilisation: -

- 1. All patients with altered level of consciousness post trauma
- 2. Patients in whom the mechanism of the injury could have resulted in injury to the spine:
 - Severe force (e.g., motor vehicle crash or fall)
 - Diving-related injuries
 - Acceleration-Deceleration injuries
 - Sports injuries (particularly hockey, football and horseback riding)
- 3. All patients with signs and symptoms consistent with spinal cord injury:
 - History of transient paraesthesia, **dysaesthesia**, shooting pains or subjective extremity paralysis
 - Complaints of neck pain or discomfort, or presence of muscle spasm
 - Limited range of motion or tenderness over the spine

Note: Cervical spine in an unconscious patient can only be confidently cleared after the patient regains consciousness. In doubtful situations it is mandatory to continue with cervical spine immobilisation, expert consultation is available preferably after negative radiology and normal clinical examination. If a child has had a negative MRI, then there is no injury.

SUMMARY

Age related injury patterns and mechanisms

Differences in Paediatric Vs Adult C-spine

Appropriate and serial evaluations

Immobilisation techniques

Local protocols

PAEDIATRIC THORACOLUMBAR SPINE TRAUMA

Uncommon vs adults

Less common vs paediatric C-spine trauma

Treatment considerations

- Mechanism of injury
- Neurological status
- Associated injuries

APPLIED ANATOMY

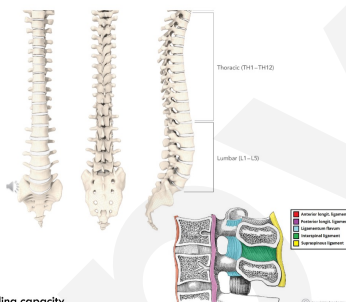
Bony anatomy

- 12 thoracic, 5 lumbar
- Thoracic-Smaller, Shingled SPs, facets Sagittal
- Lumbar- Larger, wider spaced SPs, facets Coronal
- Heal better Vs Soft Tissues

Soft tissues

- Discs
 - Thoracic smaller – less ROM
 - Lumbar Thicker – More ROM
- ALL, PLL, Capsule, LF, IS SS ligaments – limited healing capacity

Junction prone to injury due to transition of the rigidity between T and L segments



MECHANISMS OF PAEDIATRIC T-L SPINE INJURY

Critical in treating Thoracolumbar spine injuries

Point of loading : Flexion/ Flexion-Distracton

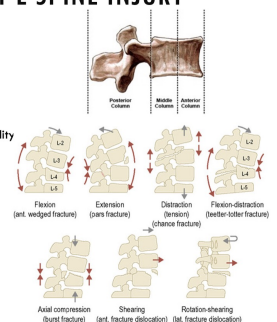
- Flexion distraction injuries – fulcrum anterior to the spine
- Anterior column compression, posterior column distraction
- RTC: Lap seat belt vs shoulder strap or full frontal harness
- Potential for posterior tension band incompetence and instability

Point of loading - Axial loading

- Point of loading - Axial loading
- In extension – anterior and middle columns loaded
- Leads to burst with retropulsion
- RTC, Sports – rugby scrum,
- Potential for neurological injury

ALWAYS correlate with the MAGNITUDE of injury

- Consider pathologic if any discrepancy
- Steroids, Langerhans, Eosinophilic granuloma



EVALUATION

ATLS

Symptoms

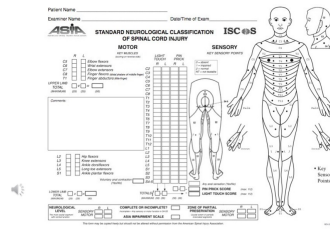
- Pain – dull, mechanical, sharp, burning
- Pins & needles, Numbness
- Inability to Move

Examination

- Look: Lumps, Ecchymosis, Deformity
- Feel: Tenderness, Bony landmarks – SPs Widening/Step, Gibbus

Neurology

- If any deficit, perform a detailed assessment
- Incomplete injury - Good prognosis in paediatric population
- Progression – serial evaluations absolutely necessary
 - Explore Surgical Indications if getting worse



ASSOCIATED INJURIES

Concomitant Spine injuries

- Spine fracture is a risk factor for another spine fracture
- Cervical injury with head injury & vice versa
- Scan whole spine

Concomitant Extra spinal injuries

- Related to the force and mechanism – **HIGH index of suspicion**
- Flexion distraction injuries - aorta, viscera (solid and hollow) abdominal wall
- Indicators: lap belt mark, abdominal wall ecchymosis

Neurological

- 85% no neurological deficit, 10 % COMPLETE SCI, 5% Incomplete SCI
- Spinal instability can be the cause of neurological deficit
 - Direct trauma to cord by bony fragments
- Neurological deficit should prompt assessment of complete spine integrity



TREATMENT CONSIDERATIONS

Goals

- Maximise potential for Cord recovery with SCI
- Provide stability to skeletal column
 - To prevent further/ future SCI

SCIs

- Remarkable potential for recovery
- Complete – 1/3 fatal, 1/3 no improvement, 1/3 become ambulant to some degree
- Incomplete – good prognosis
- To 'operate early' or to allow cord to 'rest'

Functional stability

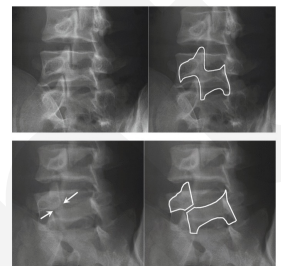
- 'Is the Spine stable enough to continue to protect the cord'
- Bony – Radiographs (flex-extn), CT
- MRI
 - Oedema open to overinterpretation
 - Good Intra-op correlation with PLC injury

PARS DEFECT

Repetitive extension

Lumbar pars interarticularis fracture

- Gymnasts, cricketers, divers, trampolines
- Pars fracture / defect
- Commonest traumatic cause of back pain in children
- X-rays and CT / MRI
- Rest and activity modification
- Diagnostic / therapeutic injection or surgery



SUMMARY — PAEDIATRIC SPINAL INJURIES

ATLS

Perform thorough assessment of neurology and SCI

Know the Imaging protocols

Know the age specific variations/ considerations

Perform an accurate early assessment of stability

Suspect and treat other injuries

Know the prognosis

Communicate effectively with family, involve them in assessment and care

THANK YOU