Pediatric Spinal Cord Injury

Trauma Management for Rural EMS and Community Hospitals
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Disclosures

- Nothing to disclose

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Learning Objectives

- Identify differences in the pediatric population with spinal cord injury
- Learn how to best fit a rigid c-collar on a pediatric patient
- Recognize SCIWORA and describe why this occurs

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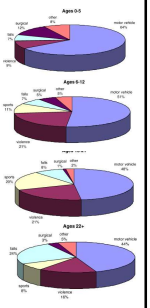
Epidemiology

- Pediatric Spinal cord injury (SCI) after trauma is relatively uncommon
  - Contributes 1-10% of all SCI
- Majority: Age 15-18 year old, M>F
- Mechanism:
  - Most common: MVC
  - Others: birth-related injury, sport-related, falls, NAT, GSW
- Most common location:
  - Cervical spine: 60-80%
  - Thoracolumbar spine: 5-30%



Hachiya, DJ et al. "Spinal Cord Injury in the Pediatric Patient". Clin Ped Em Med (2009) 9:2, 106-123

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Anatomy

- Maturation of the pediatric spine results in changes over time
  - Significant anatomical and biomechanical differences
  - Infants:
    - Increased mobility / elasticity, underdeveloped neck muscles, incompletely calcified bones, large head size

    → more likely to have **high cervical injury**
  - Older children:
    - Maturation starts at upper c-spine and progresses down, usually completed by ~14 yo

    → more likely to have **lower cervical injury**
- Multiple imaging modalities may be needed to evaluate
  - X-ray, CT, MRI

Brockmeyer D "Pediatric Spine Trauma" Handbook of Pediatric Neurosurgery (2018) Thieme, New York, p390-396

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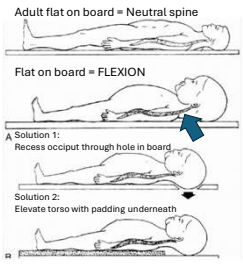
Initial Management

- Initial evaluation:
  - All patients should be assumed to have a SCI until proven otherwise
  - Immobilization in a hard collar and back board
  - Strict logroll precautions, minimize spine manipulation
- Trauma ABCs and Neuro exam
  - Palpation of entire spine to detect any bony "step off" or point tenderness



Herzenberg J et al "Emergency transport and positioning of young children who have an injury of the cervical spine: the standard backboard may be hazardous" J Bone Joint Surg (1983) 71A, 15-22

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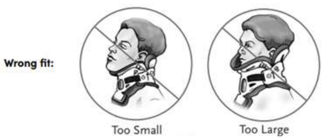
Fitting a child in a cervical collar

- Is the chin supported?
- Are the ears free?
- Do the front and back parts overlap?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Different injuries that occur

- SCI patterns that occur in the pediatric population:
  - SCIWORA
  - Atlanto-Occipital dislocation
  - Atlanto-axial Rotatory subluxation

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SCIWORA

- Spinal Cord Injury Without Radiographic Abnormality
  - Wide range of incidence due to differences in reporting: 5-70% (~20%)
- The pediatric spine is hypermobile compared to the adult
  - Able to move without sustaining damage
  - Movement is at the expense of protective function to the spinal cord
    - Movement results in stretch / compression on spinal cord resulting in symptoms
- Proportionally large head mismatched against neck musculature
  - Predisposed to wider swings when subjected to similar external forces

Brockmeyer D "Pediatric Spine Trauma" Handbook of Pediatric Neurosurgery (2018) Thieme, New York, p390-396
Pang D and Eibach S "Spinal Cord Injury Without Radiographic Abnormality (SCIWORA) in Children" Textbook of Pediatric Neurosurgery. (2020) Springer Nature Switzerland. Vol 3, Ch 131, p 2853-2882

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SCIWORA

- Radiographic evaluation:
  - Patients will likely need CT and MRI scans of the spine as soon as feasible
    - Need to rule out any potentially causative injury
  - However, SCIWORA will have normal imaging across all modalities
- Treatment:
  - Immobilization, activity restriction → prevent another SCI

Pang D and Eibach S "Spinal Cord Injury Without Radiographic Abnormality (SCIWORA) in Children" Textbook of Pediatric Neurosurgery, (2020) Springer Nature Switzerland, Vol 3, Ch 131, p 2853-2882

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Atlanto-Occipital Dislocation

- Traumatic disruption of the structures responsible for stability between the skull and C1
- Most common etiology: high energy impact
  - MVC, bicyclist / pedestrian vs. car, sports related (football, horseback riding), boat accidents, hanging
- Overall uncommon cause of SCI
- Due to high SCI location, patient have high risk of mortality
  - Overall incidence probably underreported

Wong ST and Pang D "Traumatic Atlanto-Occipital Dislocation in Children" Textbook of Pediatric Neurosurgery, (2020) Springer Nature Switzerland, Vol 3, Ch 132, p 2883-2902

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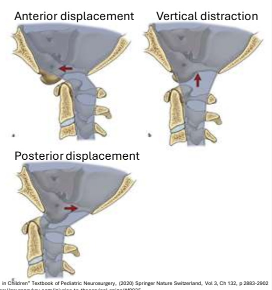
Atlanto-Occipital Dislocation

- Initial management similar: spinal precautions, thorough imaging
  - Avoid any traction on the head
- Imaging findings:
  - CT: widening of the joint space between occiput and C1
  - MRI: ligamentous injury or hematomas between occiput and C1
- Treatment:
  - Occiput-cervical fusion (at least O-C1-C2)



Wong ST and Pang D "Traumatic Atlanto-Occipital Dislocation in Children" Textbook of Pediatric Neurosurgery, (2020) Springer Nature Switzerland, Vol 3, Ch 132, p 2883-2902
Figure: Yashar M et al "Injuries to the Cervical spine (2016) https://neuropsykey.com/injuries-to-thecervical-spine/#f0035

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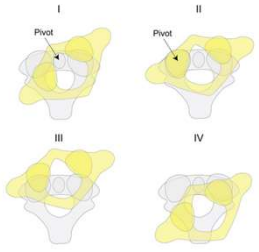
Atlantoaxial Rotatory Subluxation

- Rotational injury at C1-C2
  - C1/2 allow ~ 45 deg rotation, "center of mobility" = high risk for instability
- Symptoms:
  - Neck pain, often neurologically intact
  - Torticollis / head tilt → difficult to correct to midline
- Treatment:
  - Depending on the type
  - Reduction → immobilization +/- fusion



Goel A "Torticollis and rotatory atlantoaxial dislocation: A Clinical Review" J Craniovertebr Junction Spine (2016) 10(2): 77-87.
Figure: Arino B "Fielding and Hawkins classification of atlantoaxial rotatory subluxation. Case study" Radiopaedia.org (2014) https://radiopaedia.org/cases/fielding-and-hawkins-classification-of-atlantoaxial-rotatory-subluxation

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Conclusions

- Assume trauma patients have a SCI until proven otherwise
- Pediatric patients require different positioning on a backboard because of their larger head size
- It's important to have the appropriate fit of a rigid cervical collar in a pediatric patient
- There are anatomic differences in the anatomy of the cervical spine in the pediatric population that predisposes these patients to a different pattern of injury compared to adults

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Thank you!

- Any Questions?

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References

- Mathison DJ et al "Spinal Cord Injury in the Pediatric Patient" Clin Ped Em Med (2008) 9:2, 106-123
- Herzenberg J et al "Emergency transport and positioning of young children who have an injury of the cervical spine: the standard backboard may be hazardous" J Bone Joint Surg (1989) 71A; 15-21
- Brockmeyer D "Pediatric Spine Trauma" Handbook of Pediatric Neurosurgery (2018) Thieme, New York, p390-396
- Pang D and Eibach S "Spinal Cord Injury Without Radiographic Abnormality (SCIWORA) in Children" Textbook of Pediatric Neurosurgery, (2020) Springer Nature Switzerland, Vol 3, Ch 131, p 2853-2882
- Wong ST and Pang D "Traumatic Atlanto-Occipital Dislocation in Children" Textbook of Pediatric Neurosurgery, (2020) Springer Nature Switzerland, Vol 3, Ch 132, p 2883-2902
- Figure: Yashar M et al "Injuries to the Cervical spine (2016) https://neuropsykey.com/injuries-to-thecervical-spine/#f0035
- Goel A "Torticollis and rotatory atlantoaxial dislocation: A Clinical Review" J Craniovertebr Junction Spine (2019) 10(2): 77-87.
- Figure: Amini B "Fielding and Hawkins classification of atlantoaxial rotatory subluxation. Case study" Radiopaedia.org (2016) https://radiopaedia.org/cases/fielding-and-hawkins-classification-of-atlantoaxial-rotatory-subluxation

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