Pediatric Spine Trauma

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J. Mason DePasse, Craig P. Eberson, and Alan H. Daniels

Spine Trauma Evaluation

- Suspect spine trauma in high-energy injuries, head injuries, or multiple abdominal injuries.
- Use a pediatric backboard – the high head/neck ratio in children may result in cervical hyperflexion when on a standard backboard.
- Perform a thorough neurologic exam.
  - If deficits are present, check for spinal shock by checking the bulbocavernosus reflex.

Imaging

- Begins with plain films of the affected area of the spine.
- Any detected fracture mandates imaging of the entire spine and advanced imaging.
- Low-dose CT or MRI should also be performed in the setting of high clinical suspicion, head injuries, altered mental status, or inability to cooperate with exam.

J.M. DePasse, MD (✉) • C.P. Eberson, MD
Department of Orthopedic Surgery, Division of Pediatric Surgery, Warren Alpert Medical School of Brown University, Providence, RI, USA
e-mail: jmdepasse@gmail.com

A.H. Daniels, MD
Department of Orthopedic Surgery, Division of Spine Surgery, Warren Alpert Medical School of Brown University, Providence, RI, USA

- May perform flexion and extension plain films to check for occult ligamentous injury.

Upper Cervical Spine Trauma

Occipitocervical Dissociation or Atlanto-occipital Dissociation

- Very high mortality.
- Young children at highest risk due to a larger head/neck ratio, smaller occipital condyles, and ligamentous laxity.
- Common measurements used to make the diagnosis, such as Power's ratio or Harris' rule of 12, may be ineffective.
- Treated with surgical stabilization and immobilization in a halo.

Occipital Condyle Fractures

- Rare in children, though CT should be performed in patients with basilar skull fractures or head injuries with neck pain
- Three types:
  - Type 1 – comminuted impaction fracture
  - Type 2 – condyle fracture with associated basilar skull fracture
  - Type 3 – alar ligament avulsions
- Most treated with cervical orthosis

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  - Occipitocervical fusion or halo immobilization for unstable type 3 fractures

Atlas or C1 Ring Injuries

- May fail through the bone or synchondrosis:
  - Posterior synchondrosis closes at 3 years of age, while neurocentral synchondrosis closes at 7 years.
  - Fractures through the synchondrosis are difficult to appreciate.
- Type:
  - Anterior or posterior arch fracture
  - Burst or "Jefferson" fracture, bilateral anterior, and posterior arch fractures from axial load
  - Lateral mass fracture
- Stability determined by the transverse atlantal ligament (TAL):
  - May evaluate TAL on open-mouth odontoid view or CT scan.
  - Rule of Spence – if lateral masses displaced more than 6.9 mm (8 mm with radiographic magnification), then TAL is disrupted, and fractures are unstable.
  - Displacement of the lateral masses >2 mm relatively to the superior articular facet of the axis is concerning in adults, but in children younger than 4, a "pseudo-spread" is commonly seen.
- Treated with a cervical orthosis, Minerva cast, or halo vest if stable or halo traction if unstable:
  - Fusion required if instability persists

Atlantoaxial Rotatory Subluxation (AARS)

- Fixed rotational deformity of C1 on C2 with loss of motion and pain:
  - Patients present with head tilted to one side and rotated toward the other.
- May follow minor trauma, an upper respiratory infection (Grisel syndrome) or an ENT procedure.
- Differentiate from congenital torticollis:
  - No pain in congenital torticollis.
  - Torticollis is passively correctable.
  - In torticollis, sternocleidomastoid tight on side contralateral to chin deviation, while in AARS, sternocleidomastoid tight on ipsilateral side as an attempt to correct deviation.
- Types:
  - Unilateral rotation of C1 without displacement
  - Anterior displacement of one lateral mass by 3–5 mm and deficiency of TAL
  - Anterior displacement of both lateral masses by 5 mm and deficiency of the TAL and secondary ligaments
  - Posterior displacement due to an injury to the dens
- May evaluate with lateral skull radiograph, open-mouth odontoid, or dynamic CT.
- Treatment depends on duration of symptoms:
  - Less than 1 week – soft collar, anti-inflammatories, and physical therapy
  - Greater than 1 week – halter traction and muscle relaxants
  - Greater than 1 month – halo traction and bracing
  - Greater than 3 months or irreducible – posterior fusion

Odontoid or Dens Fractures

- Most commonly through the synchondrosis at the base of the odontoid, Salter-Harris I fractures
  - Synchondrosis fuses at 6 years of age, so fractures usually before 6
- Likely from sudden deceleration and forced head flexion
- Spinal cord injury more common than in adults
- Treated with closed reduction in extension followed by a halo or Minerva cast

Os Odontoideum

- Hypoplastic dens separate from the C2 vertebral body with smooth cortical margins.
- Unclear if developmental abnormality or nonunion after trauma.

- May be asymptomatic, cause pain, cause myelopathic symptoms, or cause intracranial symptoms from vertebrobasilar ischemia.
- Instability can be seen on flexion and extension radiographs.
- Surgical fusion followed by halo immobilization required for neurologic symptoms or instability.

Traumatic Spondylolisthesis, also Called "Hangman's Fracture"

- Bilateral pars fracture caused by hyperextension and axial load
- Neurologic injury rare, as this widens the canal
- Often associated with child abuse
- Anterolisthesis of C2 on C3 seen on radiographs, but must be differentiated from persistent synchondrosis or congenital arch defect
- Treated with closed reduction with neck extension and placement of a halo or Minerva cast

Lower Cervical Spine Trauma

- More common in adolescents as their spine approaches maturity

Ligamentous Injuries

- Usually in children younger than 8
- Caused by flexion and distraction
- Diagnosed with radiography or MRI
- Treated with immobilization in a hard collar or halo
- Fusion required for persistent instability

Compression Fractures Are Failure of the Anterior Column or Anterior Vertebral Body

- Caused by flexion and axial loading.
- Must be differentiated from incomplete ossification of anterior vertebral body
- Treated with hard collar if stable, surgical fusion required if unstable from injury to the posterior ligamentous complex.
- Burst fractures include failure of the anterior and middle columns, often with retropulsion of fracture into the spinal canal.
- Treated with a hard collar or halo in patients without neurologic symptoms or decompression and fusion if symptoms are present.

Facet Dislocations

- Bilateral or unilateral
  - Unilateral facet dislocations missed frequently on plain radiographs.
- May cause radiculopathy (more common with unilateral) or significant spinal cord injury (more common with bilateral).
- Prereduction MRI performed if the patient is obtunded or unable to cooperate.
- Reduction with Gardner-Wells tongs or a halo and hanging weights.
- Surgical fixation should be considered following reduction.

Thoracolumbar Spine Trauma

Commonly Caused by Inappropriate Seat Belt Use

- Tends to lie over the abdomen in small children, causing hyperflexion of the spine in deceleration.
- Lap belts should always lie over the pelvis.

Denis Three-Column Classification

- Anterior column consists of the anterior longitudinal ligament and anterior two thirds of the vertebral body.
- Middle column consists of the posterior one third of the vertebral body, intervertebral disc, and posterior longitudinal ligament.
- Posterior column consists of posterior elements of the osseous spine.

Compression Fractures

- Most common thoracolumbar injury in pediatric spine trauma
- Caused by flexion and axial compression
- Failure of the anterior column only
- Treated with 6–8 weeks of bracing in a thoracolumbosacral orthosis (TLSO)

Burst Fractures

- Caused by axial load
- Thoracic fractures more likely to cause neurologic injury due to tighter canal
- Stability assessed by kyphotic deformity, lamina fracture, and posterior ligamentous injury
- Treated with 6–8 weeks of bracing in a TLSO or hyperextension cast if stable and instrumentation with or without decompression and fusion if unstable

Flexion-Distraction Injuries (Chance Injuries)

- May be purely boney, purely ligamentous, or a mix
- Treated with 8 weeks of TLSO immobilization if the injury is boney and the fracture is reduced or surgical stabilization with instrumentation if purely ligamentous

Apophyseal Fractures

- Unique to children with open physes, typically under 10
- Separation of the vertebral apophysis from the spongiosa of the vertebral body
- Analogous to adult disc herniation, as the apophysis herniates into the canal
- Treated with 8 weeks of TLSO immobilization and anti-inflammatories if no neurologic symptoms but may require decompression if symptoms are present

Spinous and Transverse Process Fractures

- Isolated fractures may be treated with pain control.
- Lower lumbar transverse process fractures may be associated with unstable pelvic fractures.

Cauda Equina Syndrome

- The spinal cord ends at L3 in newborns and then migrates to L1 in adults.
- Injury to the neural elements caudal to the cord may cause cauda equina syndrome.
- Bilateral lower extremity weakness, perianal and perigenital numbness, loss of bowel control, and urinary retention
- Treated with emergent decompression

Spinal Cord Injury

- Relatively rare in the pediatric population.
  - Most occur in the cervical spine
- Neurologic prognosis is better than in adults, but development of scoliosis secondary to neurologic injury is common, especially in younger children.
- Spinal cord injury without radiographic abnormality (SCIWORA):
  - Defined as traumatic myelopathy without evidence of vertebral column disruption on radiography or CT scans.
  - More common in children younger than 8 years.
  - Believed to be caused by ligamentous laxity allowing displacement of the cord without boney injury.
  - May present with complete or incomplete spinal cord injury.
  - MRI should be obtained to determine degree of soft tissue and neural injury.
  - Treated with bracing for 7–10 days if symptoms resolve within 24 h or 3 months for persistent symptoms.
    - May require surgical stabilization if ligamentous injury is present.