Angela Rabbitt, DO, FAAP
Assistant Professor Pediatrics
Medical College of Wisconsin
Child Advocacy and Protection Services
Children's Hospital of Wisconsin

Spine Injury in Suspected Abusive Head Trauma

Objectives

- Describe barriers to child safety in AHT: the neck injury controversy.
- Review literature related to abusive neck injury, including types of injuries we are seeing.
- Discuss limitations in our knowledge of spine injury in physical abuse cases

CHW Physical Abuse Guidelines

- Recommend extending cuts through the whole spine when obtaining an MRI of the head in suspected abusive head trauma.

Case 1

1 month old presents to ED with respiratory arrest

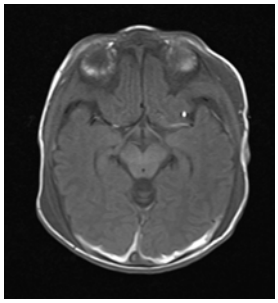
Case

- CC: 1mo old presents to ED with respiratory arrest.
- HPI:
  - History #1- slipped out of father's hands and fell onto bed.
  - History #2- father stated he gave pt a "bear hug" then pt turned blue while changing a diaper. He may have fallen on the baby onto the bed.
  - History #3- prior history of fall 2ft onto carpet while strapped into car seat.

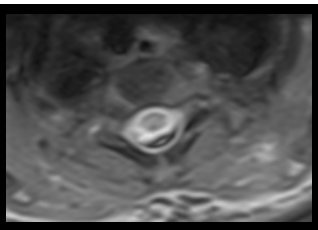
Hospital Course

- Hospital Course:
  - Initial CT with multi-focal extra-axial hemorrhage bilaterally, CT neck normal.
  - Skeletal survey with a CML of right proximal tibia.
- Physical exam:
  - Intubated, sedated, being hand ventilated, moving upper and lower extremities.
  - Multiple bruises including linear bruising over bilateral chest and abdomen.
  - Retinal hemorrhages

MRI Head



- MRI head 4 days later
  - small subdural hemorrhages over bilateral parietal lobes, occipital lobes and cerebellar hemispheres.



Thin lobulated T2 and T2 shortening in the posterior subdural space, most prominent from C5 through T1. GRE susceptibility artifact is seen within this collection, compatible with blood products. Edema of nuchal ligament.

Case

- Confession:
  - Per police: Father was playing video games when mother brought the child to him to watch. He "lost his cool" because of the crying and squeezed patient until he heard a "pop" then shook him. Then he fell with patient onto the bed, landing on top of him.

Case 1

- Intubated x1wk. After extubation moves all extremities normally, but increased tone L>R, started on baclofen.
- Follow-up one year later- Increased tone in legs with ataxia due to spasticity. Otherwise normal motor development.

Shaking Does Not Injure Infants

DISCOVER
Science, Technology, and The Future

2008- Does Shaken Baby Syndrome Really Exist?
Mainstream medicine supports the diagnosis, but some doctors claim the evidence behind it is questionable.

The New York Times

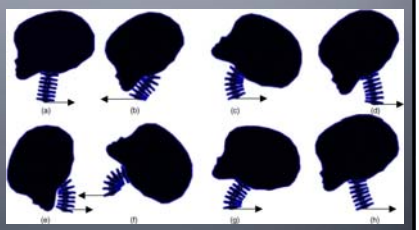
2010- Anatomy of a Misdiagnosis
"Some scientists point to studies using dummies modeled on the anatomy of infants as evidence that shaking cannot possibly generate sufficient force to cause the triad of symptoms- or that it could not do so without also causing injury to the infant's neck or spinal cord."

The New York Times

2011- Shaken-Baby Syndrome Faces New Questions in Court.
"Many doctors who testify for the defense agree that shaking could in theory cause the triad of symptoms but only if there is an injury to the neck or spinal cord. . . It's the absence of signs of this kind of an injury that makes some shaken-baby cases particularly fraught."

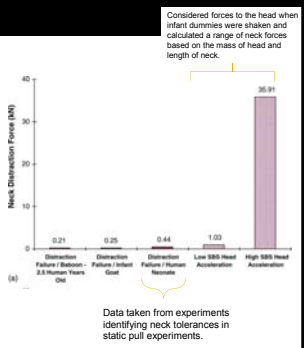
What about the neck?

Abusive Head Trauma can not be from shaking because we would see evidence of neck injury before significant brain injury.



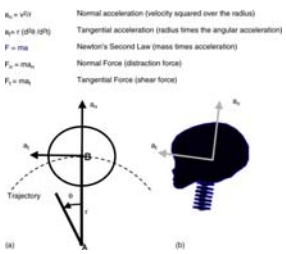
Neck Injury

- Bandak 2005- Calculations of SBS head acceleration compared to acceleration force causing major structural failure of the cervical spine in animal models and neonate cadavers.



Neck Injury

"Head acceleration and velocity levels commonly reported for SBS generate forces that are far too great for the infant neck to withstand without injury."



Response to Bandak

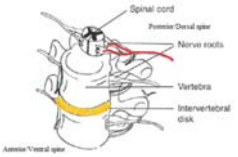
- Margulies 2006; Prange 2003; Rangaran 2006- forces to neck in shaking are 10 times lower than calculated by Bandak.
- Rangaran- experimentally obtained values on dummy models reveal lower forces (200N)
- Neck injury is possible with AHT but is not the rule in both living and deceased infants.

Case 1

- Defense argues the subdural hemorrhage, retinal hemorrhages and brain injury are from hypoxia from choking or a medical condition. Bruises are from accidentally falling on him.

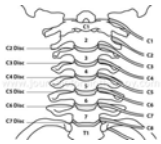
Biomechanics of Infant Neck

- Increased mobility:
  - Increased ligamentous laxity
  - Low muscle tone
  - Horizontal facet joints
  - No lateral hook to vertebral body (uncinate process)

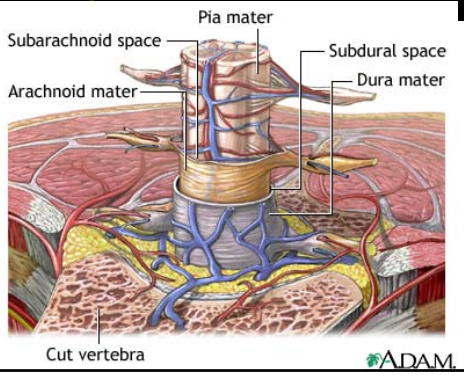


Biomechanics of Infant Neck

- Higher incidence of SCIWORA in children <8
  - Spinal column is more flexible than the cord, protects bony structures
    - 2004 Songai
    - 1922 Crothers



Anatomy



Questions?

Spine Injury at Autopsy

- Neck injury is documented frequently in autopsy studies of children with AHT.
  - Geddes 2001- (21%) 11/53 cases of fatal AHT with localized axonal injury to cervical SC.
  - Judkins 2004-Cervical injury can be more apparent if the brain stem and spinal cord are removed in continuity.
  - Brennen 2009- (71%) 29/41 children with AHT had primary cervical cord injuries-
    - 21 parenchymal, 24 meningeal hemorrhages, 16 nerve root avulsion or hemorrhage. No spinal fractures. Ligamentous and muscular injury was present in some but not universal.
  - Matshes 2011- (100%) 12/12 who died of confirmed or suspected hyperflexion and extension had bilateral intraneural and/or perineural hemorrhage involving the cervical nerve roots.

Spine Injury in Living Children

- **Feldman 1997-**
  - 23 infants with AHT, 12 studied with MRI of the neck.
  - 0/12 with SC injury on MRI (T1 and T2 images only).
  - Five of these died. On autopsy 1/5 had SDH, 3/5 had SAH in cervical SC which were not seen on MRI .

Spine Injury- literature

- Kemp- systematic review (19 studies, 25 children between 1950 - 2009)
  - Symptoms were masked by altered mental status and not suspected due to unclear history
  - Incidence of spinal injury in AHT is unknown, but there has been an association between spinal injury and AHT.
  - The mechanism of the spinal extra-axial hemorrhage is unknown (artifact vs injury).

Spine Injury- literature

- Koumellis 2009-
  - 2000 – 2005= MRI spine only when indicated
    - 2/7 with spinal hemorrhage
  - 2005 – 2008= routine MRI whole spine in suspected AHT cases
    - 6/11 with spinal hemorrhage
  - Conclusions:
    - There is a high incidence of occult spinal SDH in children with AHT. (55% when MRI of **whole** spine is done routinely)
    - Further research is needed to evaluate the clinical implications.

Spinal subdural haematomas in children with non-accidental head injury. Koumellis P. McConachie NS. Jaspan T. Archives of Disease in Childhood. 94(3):216-9, 2009 Mar.

Spine Injury- literature

- AAP 2009: "Increasing attention has been directed toward a possible association of cervical spinal cord injury and extra-axial hemorrhage with inflicted head injury, and some centers include the cervical region in their cranial MRI trauma protocols."

Spine Injury- literature

- Kemp- Literature Review 2010-2014
  - 8 further studies identified
    - Clear evidence of spinal involvement in AHT,
    - Evidence supports flexion-hyperextension injury, possibly inducing apnea
    - MRI spine is recommended in AHT to exclude occult spinal injury

Spine Injury- literature

- Choudhary 2012
  - 67 AHT children- 46% overall with spinal hemorrhage, (24% of c-spine only, 63% with whole spine imaging)
  - 70 Accidental cases- 1% with spinal hemorrhage (thought related to occipital fracture)

Spine Injury- literature

- Chaudhary 2014
  - Purpose- to compare the relative incidence of spinal ligamentous and soft tissue abnormalities on spinal MRI among children with AHT, accidental trauma, and nontraumatic conditions
  - 183 children <48mos of age

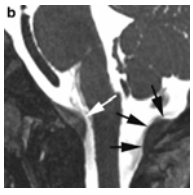
Spine Injury- literature

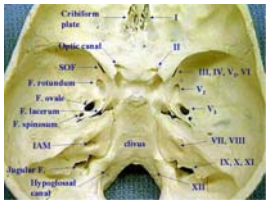
	AHT (n=67) C-spine only (36) Whole spine (31)	Accidental Trauma (n=46) C-spine only	Non-traumatic (n=70)
Ligamentous Injury	78% (52)[1]	46% (21)	1% (1)[2]
Spinal Subdural Hemorrhage	48% (32) total -67% (21) when whole spine done	2% (1)	0
Bony Injury	6% (4)	2% (1)	0
Prevertebral ST Edema	13% (9)	2% (1)	0

[1]Correlated with ischemic injury; predominantly nuchal, atlanto-occipital and atlanto-axial ligaments
[2]Child with 20min tonic-clonic seizure

Spine Injury- literature

- Silvera 2014
  - 65 children with AHT
    - Retroclival collections in 32%





Spine Injury- literature

- Jacob 2016
  - 89 children <5yrs with abusive injuries (92% had AHT), 67% with cervical injury
    - 67% with ligamentous injury
    - 18% with spinal subdural hemorrhage, 10% with epidural hemorrhage, 32% with abnormal fluid collections at skull base
    - Children with evidence of parenchymal injury on MR were 6.22 times more likely to have cervical spine injury

Spine Injury- literature

- Kadom 2014
  - 74 children with abusive, accidental, or undefined head trauma
    - 36% with ligamentous injuries
    - 1 child with spinal blood, 2 with spinal edema
    - Spine injury was not predictive of abuse or accidental classification

Spine Injury

- Conclusions:
  - Spinal injuries may be under-reported in early literature- current research shows injury in 36-78% depending on what findings study is looking at.
  - There is a higher % of ligamentous injury and spinal hemorrhage in AHT compared to accidental
  - The absence of spine injury does not exclude AHT
  - We may miss a significant number of spinal injuries if we only image the c-spine

Trauma Protocol

- T_1
- T_2
- T_2*
- DWI
- STIR

Why is this important?

- May identify clinically significant neck injury in abused infants.
- May provide evidence of further injury that supports a diagnosis of trauma.
- Improves child safety by halting court conversations about neck injury.

Unanswered Questions

- What is the mechanism of spinal SDH?
- Are the outcomes for these infants different?
- How do the clinical characteristics of these infants differ from those without neck injury, with accidental neck injury?
- What is the role of even more sensitive MRI techniques (DTI) in the evaluation of abusive head trauma?