Child Physical Abuse

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Child Physical Abuse

- Current controversies in AHT
- Forensic evaluation of injury mechanism

explore this difficult diagnosis
discuss why missed dx
examine literature on falls
review lucid interval
list explanations for mixed density subdural fluid on CT
Case Study A

- 5 mos girl
- Fall off bed 3 ft
- Thin carpet, overlying concrete
- Unwitnessed
- Heard screaming, found face down
- Picked up by mom
- Stopped screaming/breathing, arms extended
- Mom gave rescue breaths, compressions x 2 to 3
- Baby started crying again
- Not yet known to roll, reaching, babbling
Case Study A

• Vomited and sleepy at OSH
• Appropriate, interacting in CMH ED
• Skull atraumatic
• No bruises
• Normal exam
Imaging
Imaging
Case Study B

- 11 mos girl
- Fall from crib – side partially down, mattress propped at head, 3 to 4 ft
- Carpet
- Witnessed by mom, her friend both on couch 10 ft away
- Cried, picked up by mom
- Eyes rolled up, shaking all over x 5 mins
- Post ictal x 20 to 30 mins
- 2 episodes “not breathing”, mom gently rubbed chest
- Vomited all day prior to fall
Case B

- Pulls to stand and walks alone
- Hx of knocked backwards by door 2 d prior, hitting occiput on concrete
- Cried, no LOC, no V, acted okay after
- Appropriate, interacting in CMH ED
- Skull atraumatic
- No bruises, faint 1.5x1.5cm abrasion occiput
- Normal exam
Imaging
Imaging
Which case is inflicted TBI?

Both, neither, A or B?
Short Distance Falls

• Falls - most common cause of injury for pediatric ED visits
• Literature: short falls rarely result in serious, life-threatening head injuries
• Many credible studies support conclusion that severe head injury purported to be accidental, not related to MVC or fall from significant height, very likely to be abuse
• Unwitnessed, short heights, at home
AHT – A Debated Diagnosis

- Mechanisms, resultant injuries overlap for AHT and accidental injuries
- AHT rarely witnessed
- Lack of accurate history of event by caregiver
- No single test to determine accuracy of diagnosis
- Significant legal consequences
AHT – A Difficult Diagnosis

- AHT diagnosis sometimes obvious
- Commonly, subtle and non specific signs/symptoms
- Wide differential diagnosis
- Unrecognized by unsuspecting physicians
- Physicians do not always report suspicions
- Children at risk
AHT – A Missed Diagnosis

- Jenny, C et al. JAMA. 1999
- Retrospective chart review
- Academic children’s hospital
- N = 173 < 3 yo, with AHT
- 54 “missed” cases

- prior to dx AHT s/b physician ≥ 1 for non specific clinical signs c/w head trauma
- medical eval did not result in dx AHT
- child later found to have injuries, admission by caregiver
Missed Diagnosis

- Of the 54 cases “missed” (31.2%)
- Mean number visits before AHT dx = 2.8
- Mean number of days before AHT dx = 7
- Who was more likely to be missed?
  - younger
  - white
  - lives with both parents
  - present with vomiting or irritability (not as ill)
### Table 3. Frequent Erroneous Diagnoses Made in Cases of Missed Abusive Head Trauma

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral gastroenteritis or influenza</td>
<td>14</td>
</tr>
<tr>
<td>Accidental head injury</td>
<td>10</td>
</tr>
<tr>
<td>Rule out sepsis</td>
<td>9</td>
</tr>
<tr>
<td>Increasing head size</td>
<td>6</td>
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<tr>
<td>Nonaccidental trauma (not head injury)</td>
<td>4</td>
</tr>
<tr>
<td>Otitis media</td>
<td>5</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>5</td>
</tr>
<tr>
<td>Reflux</td>
<td>3</td>
</tr>
<tr>
<td>Apnea</td>
<td>3</td>
</tr>
<tr>
<td>URTI</td>
<td>2</td>
</tr>
<tr>
<td>UTI or pyelonephritis</td>
<td>2</td>
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<tr>
<td>Bruising of unknown origin</td>
<td>2</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>2</td>
</tr>
<tr>
<td>Meningitis</td>
<td>2</td>
</tr>
<tr>
<td>Other dx’s made only once</td>
<td></td>
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</tbody>
</table>
Missed Diagnosis

• 5/54 missed AHT died, 20/119 recognized AHT died
• Estimated 4/5 missed AHT deaths preventable
• 15/54 missed AHT re-injured
• 7 missed AHT attributed to radiological errors missing trauma (6 CT, 1 SS, 1 XR)
Missed Diagnosis

• Logistic regression probability of AHT recognition 1 in 5 -> no sz, normal respirations, no facial/scalp injury, intact family
• How to facilitate dx?
  - Look for head, neck bruising
  - In evaluation of vomiting, fussiness, fever, consider ddx includes AHT
  - CSF xanthochromia
  - Pediatric Radiologists
  - Dilated eye exam
Support from Case Histories

- Feldman, 2001 – blunt impact or impact with shaking can result in infant head injury
- Starling, 2004 – commonality of shaking in perpetrator admissions supports mechanism
- Bayir, 2006; Christian, 2007 – mechanisms of secondary brain injury (hypoxia, ischemia, metabolic) contribute to poor outcomes
- Brennan, 2009 – in severe or fatal cases, C-spine injury can also be found
- Shaken Baby Syndrome (SBS) is a subset of AHT
- Shaking and/or impact can/does cause death, permanent neurological disability
Study on Confessions

- **Starling 2004:**
- 171 children with AHT
- 81 confessions
- 68% admitted to shaking
- 54% admitted shaking without impact
- Some with shaking only confessed had evidence of impact
- Not all infants with impact had visible signs
Models

• Biomechanical, biofidelic and computer based modeling used to support, refute contributions of shaking, impact to AHT
• All have limitations
• Can’t study humans
• Clinicians, researchers acknowledge precise mechanisms for all abusive head injuries incompletely understood
Efforts to Gain Better Understanding

• Improved gathering of objective clinical data – meticulous hx taking, exams, workups
• Recognition of, screening for medical conditions with presentations that can mimic AHT
• Expansion of medical, biochemical research
• Improvement of modeling
• Clinical, pathological experience
• Advancement of radiology
• Education of child welfare agencies
Responsibility of Healthcare Providers Treating Children

- Be cognizant of possibility of AHT
- Consider alternative explanations
- Diagnose after consideration all clinical data
- Consult Child Abuse Pediatricians, other subspecialists
- Make working diagnosis
- Take legally mandated steps
- Interpret information to non medical professionals
- For family: identify, treat, offer honest information
Forces

- *Impact, contact forces*
- Head struck by or impacts object, surface
- Can occur without head moving
- Damage at site of contact

- Scalp hematoma, laceration
- Skull fracture
- EDH
- Brain surface contusion
Forces

- *Inertial forces*
- Structures inside skull set in motion or stopping
- Occur with, without contact of head
- Acceleration, deceleration
- Tissue deformation, over time strain
- Injury if exceeds tolerance to stretch,
- If deformed at particular rate

- Concussion
- Bridging vein rupture, SDH
- Traumatic axonal injury (shear)
Reality

• Most injury is combination of types
• Absence signs of contact does not rule it out
• Force distributed over wide area of deformable surface
• No surface injury visible
• Considerable deceleration to skull contents
Jaspan - 3 phases of injury from AHT

1) acute – immediately post injury
2) Extra- or intra-axial hemorrhage
3) Anatomical disruptions of brain, cranium – contusions, shearing tears
4) Cardiorespiratory depression – brainstem dysfunction
Jaspan - 3 phases of injury from AHT

• 2) early subacute – cascade mechanisms after primary injury
• Disruption of cerebral autoregulation
• Perfusion, chemically mediated damage
• Evolves over time
• SDH can increase in size
• Brain swelling, infarction possible
Jaspan - 3 phases of injury from AHT

• 3) late subacute or chronic
• Hydrocephalus, impaired CSF resorption
• Chronic SDH
• Scarring, atrophy
• Leptomeningeal cysts
• Impaired head growth – large, small
• Developmental delay
AHT Causing Serious Head Injury in Infants

- **Duhaime**: N=100, < 2 y o, admitted with head injury
- 73 initial hx of household fall
- 24 found to have AHT
- Another 32 with injuries suggestive of abuse
- Only 3 with EDH who fell < 4ft
- Fall > 4 ft resulted in 2 with focal SAH, 4 with focal parenchymal contusion
- AHT disproportionate ICH = 13/24, 3 deaths
AHT Causing Serious Head Injury in Infants

- **Greenes, Schutzman**: young infants with intracranial injury after accidental trauma
- Asymptomatic at presentation
- Retrospective, < 2 y o, admitted with ICH, cerebral contusion, cerebral edema
- 19/101 asymptomatic IC injury
- 14/19 due to short falls or fall downstairs
- 1/19 AHT
- 19/19 neurologically normal at discharge
Problem Lies in Less Severe Head Injuries

- How to distinguish AHT from accidental?
- Studies difficult to compare, differ in who and what studied
- Collectively 4600 children
- Best divided into short falls (1732), falls >1 storey (1902), stairway falls (1037)
Short Falls

- **Helfer**: 3 -5 ft out of bed, off sofa, at home or hospital
- N = 246, < 6 y o
- 2 had linear skull fracture
- None with CNS damage
- **Nimityongskul, Anderson**: fall in hospital
- N = 76
- 1 skull fracture
- Scrutinized surface: carpet, thick rug cushions
Short Falls

- **Williams**: $N = 44$, < 10 ft; $N = 62$ $\geq 10$ ft
- < 10 ft group, serious, not life threatening injuries
- Include small, depressed skull fracture from contact against sharp edges
- 2/53 uncorroborated falls < 5 ft died
- In $\geq 10$ ft group, 1 died from 70 ft fall
Short Falls

- **Lyons, Oates**: < 6 y o
- N = 124 from crib, up to 54 in
- N = 83 from bed, 25 to 41 in
- no serious, multiple, visceral, life threatening injuries
- 21 m o climbed over railing – clavicle fracture
- 10 m o fell from crib - simple linear skull fracture
Short Falls

- **Selbst**: falls from top bunk bed
- 6/68 admitted, 4 concussion, 1 skull fracture with SDH, 1 laceration near eye
- **Chadwick, Salerno**: serious head injury while at child care centre
- N = 338
- 2.5 y o, 5 ft fall from tree to concrete walk
- Temporary LOC, normal CT
Short Falls

• **Tarantino**: < 10 mos to ED after vertical fall \(\leq 4\) ft
• 12/167 skull fracture
• 7/167 long bone fracture
• No ICH
• 2 with ICH, false history fall only short distance
Short Falls

- **Mayr**: \( N = 103, \ 7 - 30 \text{ mos}, \) fall from highchair
- ~ \( \frac{1}{2} \) not restrained
- 14\% tipped highchair over in fall
- No ICH

- **Summary**: simple linear skull fractures can occur from short falls < 3 ft
Stairway Falls

- **Joffe, Ludwig**: < 11 yo to ED, stairway fall
- Head, neck injury common
- Most superficial, no ICU admits
- Injuries in fall > 4 steps not more severe or numerous than fall < 4 steps
- 4/10 infants with skull fracture fell while caretaker carried
- 24/40 injuries involved 6 to 12 mo old in walkers
Stairway Falls

• **Chiavello**: most serious injuries from falls carried by caretaker
• Fell on child against stairs
• $N = 3$, 2/3 skull fracture, 1 of 2 SDH, cerebral contusion, C2 fracture
• Overall – stairway injuries less than free falls same vertical height
• **Mayr**: $N = 143$, stairway falls in walkers
• No intracranial injuries
Stairway Falls

- **Chiavello**: N = 46, stairway falls in walkers
  - Most only minor injuries
  - 1 fatality, skull fracture, SDH, C spine fracture
  - 4 ICH
- **Smith**: N = 260 stairway falls in walkers
  - Intracranial injury rare
  - 10 skull fractures, admitted
  - 3/10 depressed, 3/10 with ICH
Playground Falls

- **Plunkett**: retrospective review US CPSC National Injury Clearinghouse data
- 75,000 playground falls
- Distances “felt” to range 2 to 10 ft
- 18 deaths
- 5 children 12 to 24 mos, 5 aged 25 to 60 mos, 8 aged 6 to 13 yrs
- 23 m child, fall 28 in, captured on video, lucid interval, b/l RH
Playground Falls

- Autopsies: 1 EDH, 2 cerebral infarction, 10 SDH, 12 cerebral edema
- Concluded short distance falls can cause death, have associated lucid interval and RH
- Incidence death 18/75 000, extreme rarity of fatal outcome
- Death rate 1.3/100,000 falls presenting to ED
Playground Falls

- Spivack: Limitations to Plunkett Study
- 2 medical cases (TAR, A-V malformation)
- 7 not witnessed by non-caregiver (uncorroborated)
- 6/18 no autopsy
- 6/18 children >1y, < 3y (no infants)
- “Bilateral, multi-layer” RH in 3/6 with RH, no ophthalmologist exam
- 8/18 the height of fall was estimated by witnesses
- Many accelerated impacts (swingsets) so not typical vertical short distance
Playground Falls

- Other methodological problems
- Data rely on acceptance of hx at face value by hospital personnel
- Variety of reporting practices over 10 y of data submission
Falls from Extreme Heights

- Expected to cause serious head injury
- Combined data, N = 1902, < 18 yrs
- Mortality low, 23 deaths
- 19/23 fall > 3 storeys
- Most long fall studies lack morbidity details
- Correlations of ht of fall to severity of intracranial injury not possible
Falls from Extreme Heights

- **Saudi Arabian study**
- $N = 104$, $< 13$ yo
- No brain injuries in falls $< 23$ ft
- Fatalities/morbidities related to $2^{nd} - 3^{rd}$ floor balconies
- $3/44$ died: 2 from $2^{nd}$ fl, 1 $3^{rd}$ fl balcony
- 5 falls 23 to 39 ft, multiple skull fractures, hemorrhagic cerebral contusions, moderate CNS sequelae
Other Household Accidents

- **Bernard**: N=73, CPSC reports TV falling
  - 28 deaths in 7y
  - 72% head injury
  - 13/14 deaths due to crush head injury

- **Duhaime**: N=7, crush head injury
  - 4 run over, 3 pulled heavy objects onto head
  - All basilar skull fracture
  - Calvarial fractures – multiple, complex, with SAH or intraparenchymal hemorrhage
Bottom Line for Falls

- Severe intracranial injury attributed to short falls
- Falls in arms of caregiver can result in skull fracture (depressed, complex, with focal EDH or SDH or SAH or small parenchymal contusion)
- Falls down stairs in walkers infrequent cause of severe injury, rarely fatal
- High velocity impact, fall from significant height, falls onto extremely hard surface present opportunity for more severe injury
AHT

- Most cited explanation is accidental injury
- Consider biomechanics
- Factor in epidemiology of childhood injury
- Contact injuries can’t be applied to injuries from inertial forces (shaking)
- Injuries look different and are clinically different
- Perform search for other occult injury
- Thorough investigation into cause for each child
AHT Clues

- Young < 1 y o
- Hx lack significant trauma
- Changing hx
- Symptomatic, apnea, seizures at presentation
- Head, neck bruising
- Poor outcome
- Caregiver believe that resuscitation at home injured child
Lucid Interval?

- **Arbogast 2005:**
  - 314 fatally injured children <4 yo
  - Compared mechanisms of injury (121 inflicted, 40 falls, 153 MVC) with initial GCS and age
  - <24 mos with AHT 10x as likely to have GCS >7
  - 6 children lucid (GCS >12) at admission - unclear injury findings
  - 5 of the 6 age <24 mos
  - Only included trauma centre cases – no death scene cases
  - Retrospective design with injury mechanism based on ICD9 codes
  - Relied on GCS for determination of lucidity
Lucid Interval?

- **Starling 2004:**
  - 52/57 confession stated immediate onset of symptoms
  - 5/57 stated onset within 24 hours
  - None described as normal after the injurious event
- **Willman 1997:**
  - 95 pediatric MVC victims
  - 1/95 with lucid interval – EDH

- Common causes for lucid interval: EDH, rapidly expanding SDH, post-traumatic seizure, post-traumatic hyponatremia
Mixed Density Fluid on CT
Meninges and Superficial Cerebral Veins

FOR DEEP VEINS OF BRAIN SEE PLATE 138
Mixed Densities on CT

- Acute SDH and acute hygroma (blood, CSF)
- Hyperacute SDH
- Evolving SDH involving clot formation
- Rebleed into an already existing SDH
- Neomembrane formation in an SDH that bleeds
- More than 1 SDH – repeated trauma
- Enlargened SA space with SDH (BEAF)
Chronic SDH and Rebleeding

- Septations, membranes within chronic SDHs
- Predispose to repeated episodes of bleeding with little or no trauma
- Up to 33% of SDH may progress to CSDH [Hymel 2002, Lee 2000, Lee 2004]
- Well described in adult literature.
- Re-bleeding does not occur in remote locations
- Not in subarachnoid space
- No acute deterioration but may cause localized compression
- Jaspan 2008:
  - Longitudinal study
  - Re-bleeding does not occur in infants with a birth related SDH
Questions?
Textbook References


