Abusive Head Trauma: The Evidence and the Arguments

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Handouts

• The handouts are NOT a complete representation of my presentation. Specific case studies have been omitted.

Virginia Jaspers: “The Boys Jeered Her”

• Pediatric nurse
• 15 children became ill in her care
• Admitted to maltreating 5 children, shaking at least one

“The brutal and tragic career of nurse Virginia Jaspers is tied to her massive physical traits. Now 33, she is an ungainly 6 feet, weighs 220 pounds, and has a 52 inch waist. Police concluded that she probably had no idea of the strength in her cruelly big arms and hands.”

Abusive Head Trauma Objectives

• Anatomy and definitions
• Epidemiology
• Medical findings
• Medical evaluation
• Mechanisms of brain injury
• Outcomes
• Arguments
• Case Examples

Basic Anatomy

• Scalp
• Skull
• Meninges
  • Dura mater
  • Arachnoid
  • Pia mater
• Brain
  • Gray matter
  • White matter

Triad of:
• Subdural hematomas
• Retinal hemorrhages
• Metaphyseal fractures
Normal Brain

Epidural Hematoma (EDH):
Blood between the skull and dura mater
Subdural Hematoma (SDH): Blood between the dura mater and the brain

Subarachnoid Hematoma (SAH): Blood between Arachnoid membrane and brain

Parenchymal contusion: Bruise to the brain tissue

Infarction: Area of tissue death due to lack of blood flow

Ischemia: A decrease in the blood supply to the brain

Epidemiology of AHT
Abusive Head Trauma

- Most common cause of mortality and morbidity in physical child abuse
- Most occurs in children < 2 years
- Approximately 80% of deaths from head trauma in infants and children < 2 years were inflicted injuries
- Mortality rate 15-38%
- Incidence 17-30 per 100,000 infants

Risk Factors

- Young, unmarried mothers
- Maternal education < high school
- Unstable family situation
- Low socioeconomic status
- Multiple birth pregnancies
- Disability / prematurity
- Parent in the military

Clinical Presentation of AHT

- Variable, depending on duration and number of shakes, presence of impact, severity of injury
- Continuum from:
  - Decreased responsiveness, irritability, lethargy, limpness
  - Seizures, tachypnea, bradycardia, hypothermia
  - Coma, death

Epidemiology of AHT

- 64% of head injury in infants (<1 year) are abusive
- 95% of infant serious intracranial injuries are abusive
- 33-40% cases have evidence of previous trauma
- Male victims predominate
- 35% have no obvious external trauma

Perpetrators of AHT

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father of child</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td>Boyfriend of mother</td>
<td>26</td>
<td>20.5</td>
</tr>
<tr>
<td>Female baby-sitter</td>
<td>22</td>
<td>17.3</td>
</tr>
<tr>
<td>Mother</td>
<td>16</td>
<td>12.6</td>
</tr>
<tr>
<td>Male baby-sitter</td>
<td>5</td>
<td>3.9</td>
</tr>
<tr>
<td>Step-father</td>
<td>4</td>
<td>3.1</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td>100</td>
</tr>
</tbody>
</table>

Signs and Symptoms

- Variable, depending on duration and number of shakes, presence of impact, severity of injury
- Continuum from:
  - Decreased responsiveness, irritability, lethargy, limpness
  - Seizures, tachypnea, bradycardia, hypothermia
  - Coma, death
Reasons for Seeking Care

<table>
<thead>
<tr>
<th></th>
<th>Inflicted TBI (n = 49)</th>
<th>Noninflicted TBI (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea</td>
<td>14 (17.5%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>12 (15.0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Found Lifless*</td>
<td>11 (13.9%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>10 (12.5%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Unexplained facial bruising/limb deformity</td>
<td>6 (7.5%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (1.2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Lethargy</td>
<td>8 (10.0%)</td>
<td>6 (29.0%)</td>
</tr>
<tr>
<td>Intubability</td>
<td>5 (6.6%)</td>
<td>2 (10.0%)</td>
</tr>
<tr>
<td>Unresponsive</td>
<td>7 (8.8%)</td>
<td>4 (20.0%)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>3 (3.8%)</td>
<td>4 (20.0%)</td>
</tr>
<tr>
<td>Asymptomatic/parental concern</td>
<td>0 (0%)</td>
<td>6 (29.0%)</td>
</tr>
<tr>
<td>Facial/head swelling/poynody</td>
<td>0 (0%)</td>
<td>7 (35.0%)</td>
</tr>
</tbody>
</table>

Table 2. Reason for Care Seeking in Children With Inflicted TBI (n = 49) Versus Noninflicted TBI (Excluding MTCs) (n = 20) as Represented by the Categories

Diagnostic Utility of History

- 163 children with acute traumatic intracranial injury
- 49 (30%) definitely abused
- Examined clinical history of trauma
- NO history of trauma specific for abuse
- Hx of no or low impact fall with persistent neurologic sequelae diagnostic of abuse
- Home resuscitation excuse suggests abuse

Medical and Event History

- What time did event happen?
- What exactly happened?
- Who was present?
- What did child look like after the event?
- How did symptoms begin and change?
- If a fall, what were the specifics? Height, flooring, how did child land?
- Previous injuries or physical symptoms?
- Detailed medical, family, social, and ROS

“Can the initial history predict whether a child with a head injury has been abused?”

<table>
<thead>
<tr>
<th></th>
<th>Definite Abuse (n = 49)</th>
<th>Not Definite Abuse (n = 114)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury &gt;24 h ago</td>
<td>3 (6.1%)</td>
<td>12 (8.3%)</td>
</tr>
<tr>
<td>Sibling blamed</td>
<td>21 (42.9%)</td>
<td>5 (4.5%)*</td>
</tr>
<tr>
<td>Additional history of trauma</td>
<td>9 (18.4%)</td>
<td>10 (8.8%)</td>
</tr>
<tr>
<td>Home CPR blamed</td>
<td>6 (12.2%)</td>
<td>0*</td>
</tr>
<tr>
<td>History changed</td>
<td>9 (18.4%)</td>
<td>0*</td>
</tr>
</tbody>
</table>

Table 3. Reported Mechanisms of Injury

Missed Abusive Head Injury

- 173 head injured patients
- 54/173 with missed diagnosis
- 15 children were re-injured after missed diagnosis
- 4 deaths might have been prevented if abuse recognized
- Factors associated with missed diagnosis:
  - Both parents living in home
  - White children
  - Lack of significant respiratory symptoms or seizures
Medical Evaluation of AHT

**CT**

- Rapidly performed
- Acute Hemorrhage:
  - SDH, SAH
  - Epidural
  - Intraparenchymal
- Acute edema
- Skull/Facial Fx with bone windows
- May miss small bleeds
- Not as sensitive for older bleeds

**MRI**

- Longer test
- Expensive
- Highest sensitivity and specificity for chronic injury
- Fully assessing intracranial injury
- May miss acute SDH/SAH
- Should be delayed 5-7 days (at least 3 days)

**The Skeletal Survey**

- Plain x-ray studies
- Mandatory in all cases of suspected abuse in kids <2 years
- Patients age 2-5 years based on clinical indicators
Laboratory Studies

- CBC, serial hematocrits
- Coagulation studies (PT, PTT)
- Electrolytes, BUN, Creatinine, Osmolality
- Urinalysis
- Liver Enzymes, amylase, CPK
- Consider:
  - Urine organic acids
  - Acylcarnitine profile
  - Factor XIII level

RH in Inflicted Neurotrauma

- Incidence between 50-100%
- Dilated retinal examination
- Performed by Ophthalmologist
- Detailed description or photographic documentation IMPORTANT
- Location topographically, layer, number or severity

TABLE 4. Primary Outcomes: Ophthalmoscopic Findings

<table>
<thead>
<tr>
<th></th>
<th>Abuse (N = 15)</th>
<th>Accident (N = 67)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH</td>
<td>60% (9/15)</td>
<td>10% (7/67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Unilateral RH</td>
<td>20% (3/15)</td>
<td>9% (6/67)</td>
<td>.36</td>
</tr>
<tr>
<td>Bilateral RH</td>
<td>40% (6/15)</td>
<td>1% (1/67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pre-RH</td>
<td>30% (5/15)</td>
<td>0% (0/67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Single RH</td>
<td>0% (0/15)</td>
<td>4% (3/67)</td>
<td>1.0</td>
</tr>
<tr>
<td>With RH extending to periphery</td>
<td>27% (4/15)</td>
<td>0% (0/67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>With premacular RH</td>
<td>20% (3/15)</td>
<td>0% (0/67)</td>
<td>.005</td>
</tr>
<tr>
<td>Vitreous hemorrhage</td>
<td>13% (2/15)</td>
<td>0% (0/67)</td>
<td>.03</td>
</tr>
</tbody>
</table>

Location of RHs

- **Subretinal**
  - Blood vessels seen over the hemorrhage
- **Intraretinal**- most common
  - Blood vessels usually obscured
    - Dot, Blot- round
    - Flame- very superficial
- **Pre-retinal**
  - Subhyaloid (between retina and vitreous)
  - Vitreous

Differential Diagnosis of RH

- Vaginal delivery- intraretinal
- Child abuse
- Severe accidental injury
- Coagulopathy, Vasculitis, Leukemia
- Severe hypertension
- AV malformations
- Papilledema (flame shaped, around optic nerve)
- Meningitis
- Metabolic diseases
Mechanisms of Injury

**Mechanisms of TBI**

**TRANSLATIONAL**
- Scalp contusion
- Skull fracture
- Epidural hematoma
- Superficial brain contusions
- Brain lacerations
- Subdural hematoma

**ROTATIONAL**
- Concussion
- Traumatic axonal injury
- Deep brain contusions
- Deep brain hematomas
- Gliding contusions
- Subdural hematomas

**CONTACT**

**NON-CONTACT**

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Translational (Impact) Forces

- Linear type event (fall)
- Rectilinear movement with essentially no complex movements or twisting about the axis of the head or body
- Impact events
- Focal injury

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Rotational, Non-contact forces

- Forces that result in a rotation of the brain about its center of gravity cause diffuse brain injury
- Sudden angular deceleration experienced by the brain and cerebral vessels results in intracranial injury

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Biomechanics of AHT

- Genarelli, Thibault, Ommaya, et al 1960s
  - Adult monkeys subjected to 5-30 msec accelerations on sleds
    - Head immobilized (linear accelerations)
    - Head NOT immobilized (angular accelerations)
  - Three primate species with different brain sizes used
  - Thresholds for concussion, SDH, and axonal injury established for each species

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Shaking vs. Impact

**Duhaime 1987 study**

- 48 cases of SBS – 2/3 showed impact
- All fatal cases (n=13) – evidence of impact
- 3 doll models used to show shaking alone could not generate sufficient forces to produce injuries
- “Shaking alone in an otherwise normal baby is unlikely to cause SBS”

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Perpetrator Confessions

- Retrospective study comparing 81 cases with perpetrator confessions with 90 cases with no confession
- 32/69 cases shaking only
  - 29 with SDH, 27 with RH
- 20/69 impact only
  - 17 with SDH, 14 with RH, 8 with skull fx
- 17/69 shaking and impact

Primary Brain Injury

- Brain injury that is the direct result of the initial traumatic force
- Examples:
  - Shear injury, cortical contusions, gliding contusions
- Potential clinical signs:
  - Cardiorespiratory depression, loss of consciousness, apnea, seizures, vomiting, lethargy, irritability

Secondary Brain Injury

- Brain tissue becomes damaged as a consequence of primary injury
- Common secondary injuries:
  - Hypoxic-ischemic changes, brain swelling, herniation
- Potential clinical signs:
  - Decreased mental status, irritability, seizures, changes in pupils, focal neurologic findings

Brain contusion

<table>
<thead>
<tr>
<th>Table 2. Comparison of Injuries by History Among the 69 Children Whose Perpetrators Admitted to Inflicting Traumatic Brain Injury*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Injury</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Subdural hematoma</td>
</tr>
<tr>
<td>Retinal hemorrhage</td>
</tr>
<tr>
<td>Skull fracture</td>
</tr>
<tr>
<td>Scalp swelling</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage) of each group.

<table>
<thead>
<tr>
<th>Table 3. Trauma associated with shaken baby syndrome in 48 cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated Trauma</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>no evidence of blunt impact to head</td>
</tr>
<tr>
<td>no extracranial trauma</td>
</tr>
<tr>
<td>additional extracranial trauma</td>
</tr>
<tr>
<td>acute</td>
</tr>
<tr>
<td>old trauma only</td>
</tr>
<tr>
<td>evidence of blunt impact to head</td>
</tr>
<tr>
<td>skull fractures</td>
</tr>
<tr>
<td>cranial soft-tissue contusions</td>
</tr>
<tr>
<td>additional extracranial trauma</td>
</tr>
<tr>
<td>acute</td>
</tr>
<tr>
<td>old trauma only</td>
</tr>
</tbody>
</table>

Ischemic (dead) brain tissue (aka stroke)
Terminology

- Whiplash shaken-baby syndrome
- Shaken baby syndrome
- Shaking impact syndrome
- Shaken – slam syndrome
- Non-accidental head injury
- Inflicted head injury
- Inflicted Traumatic Brain Injury
- Inflicted childhood neurotrauma
- Abusive head trauma

Outcomes

- 20% mortality
- 80% of survivors with neurologic impairment

The Arguments

- "The American Academy of Pediatrics recommends that pediatricians... embrace a less mechanistic term, abusive head trauma, when describing an inflicted injury to the head and its contents."

Late Complications

- Cognitive, neuromotor, and behavioral problems
- Seizure disorders
- Visual impairment
- Hydrocephalus
- Cerebral atrophy

Common Defense Arguments

- Short Distance Falls
- Stairway falls
- Another child caused injuries
- Medical disease arguments
  - Meningitis
  - Bleeding disorders
  - Vaccinations
  - Rebleeding
Controversies in AHT

1. Shaking vs. Impact
2. Neck Injuries
3. Serious head injuries from short falls
4. “Lucid Interval” and timing of injuries
5. Forces required to cause injury

Shaking vs. Impact

• No one has been able to produce a model that approximates the properties of the infant head.
• Properties of the infant head are so variable and forces needed to injure so poorly understood, that answers to how much force is required are not known.

Neck Injuries

• Cervical spine injuries reported in 1% – 2%
• Hadley found subdural and epidural bleeding in 6 fatal cases.
• Feldman found that MRI failed to identify autopsy-positive SDH/SAH in 4/12 fatally injured abused children.

Cervical Injury

• Uncommon to identify significant ligamentous or spinal cord injury
• MRI evaluation
• Significance of soft tissue swelling on MRI not known – consistent with whiplash type event?
• Clinical symptoms: apnea, priapism, weakness, decreased movement of extremities

Short Falls

• Plunkett reported 18 fatal short fall deaths from head trauma in children
• Reviewed > 75,000 public records
• 5 occurred at home; 13 at school or playground
• Ages 12 months-13 years
• Describes injuries, “lucid” intervals

Short Falls

• Concludes that every fall is a complex event
• Retinal hemorrhage may occur whenever ICP exceeds venous pressure or there is venous obstruction
• A fall from < 3 meters (10 feet) in an INFANT or child may cause fatal head injury and may not cause immediate symptoms
Short Falls

• SHORTcomings
  • No infants included in the study
  • Lucid intervals (consciousness):
    • < 5 years old: 0 - 10 minutes
    • > 5 years old: 0 minutes - 48 hrs

Lucid Interval

• 95 fatal pediatric injuries (MVC)
• Two lucid intervals:
  • EDH
  • Abdominal bleeding
• Average age 8.5 years
• Only 2 infants included in study

Conclusions

• AHT is commonly misdiagnosed
• Typically associated with other injuries (fractures, head injury)
• No history of trauma or minimal trauma history most common
• Onset of symptoms immediate
• Mechanism of trauma typically not exactly known
• Severe and violent traumatic forces

Short Falls, in reality...

• Serious or fatal injuries RARELY result from a short distance fall
• Children falling from 2nd, 3rd, or 4th story height with mortality rate <1%
• Simple falls \(\rightarrow\) simple injuries