Abusive Head Trauma
Differentiating Myths from Reality

Suzanne P. Starling, MD
Clinical Professor of Pediatrics
University of California San Diego
Medical Director, Chadwick Center for Children & Families
Rady Children’s Hospital San Diego

Objectives
- Define and outline sentinel components of abusive head trauma
- Discuss the literature and support regarding shaken baby syndrome
- Discuss the well-publicized articles in both the lay press and in the medical literature questioning the existence of shaken baby syndrome
- Learn key components to recognize and diagnose AHT and discuss the “controversy” with colleagues

Abusive Head Trauma
- Radiologic evidence of intracranial injury - intracranial bleed with or without brain swelling
- Retinal hemorrhages in approx 80%
- 50% show associated non-cranial injuries
- Age range 2 weeks to several years - average age 6.6 months
- Slight predominance of male victims
- Death rates equal for males and females

With thanks to
Christopher Spencer Greeley, MD
Associate Professor of Pediatrics
Center for Clinical Research and Evidence-Based Medicine
University of Texas Health Science Center at Houston

and his lecture
Deconstructing Donohoe: The evidence behind the “lack of evidence”

Relationship of Perpetrators to Victims

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father</td>
<td>47</td>
<td>37</td>
</tr>
<tr>
<td>Boyfriend</td>
<td>26</td>
<td>20.5</td>
</tr>
<tr>
<td>Female Babysitter</td>
<td>22</td>
<td>17.3</td>
</tr>
<tr>
<td>Mother</td>
<td>16</td>
<td>12.6</td>
</tr>
<tr>
<td>Male Babysitter</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>

- Starling SP and Holden JR, Southern Medical Journal. 2000
### Most Common Histories for AHT

<table>
<thead>
<tr>
<th></th>
<th>Abusive HT</th>
<th>Accidental HT</th>
</tr>
</thead>
<tbody>
<tr>
<td>No explanation</td>
<td>51 (64%)</td>
<td>0</td>
</tr>
<tr>
<td>Shake to revive</td>
<td>3 (4%)</td>
<td>0</td>
</tr>
<tr>
<td>Shake intentional</td>
<td>2 (2.5%)</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (1.3%)</td>
<td>0</td>
</tr>
<tr>
<td>Fall</td>
<td>12 (15%)</td>
<td>15 (21%)</td>
</tr>
<tr>
<td>Dropped</td>
<td>6 (7.5%)</td>
<td>8 (11%)</td>
</tr>
<tr>
<td>MVC/peds</td>
<td>0</td>
<td>38 (53%)</td>
</tr>
<tr>
<td>Fall with parent</td>
<td>0</td>
<td>2 (3%)</td>
</tr>
<tr>
<td>Other</td>
<td>5 (6%)</td>
<td>4 (6%)</td>
</tr>
</tbody>
</table>


### Spectrum of Axonal Injury and Clinical Presentation

**Mild, Reversible**
- Concussive symptoms
  - Sleepiness
  - Lethargy
  - Irritability
  - Poor feeding
  - Vomiting
  - Loss or alteration of consciousness
  - Seizures
  - Apnea
  - Coma
  - Death

**Severe, Irreversible**
- Diffuse axonal injury dispersed throughout brain and at deepest levels

### Head Injury Concepts

- **Focal vs. Diffuse Injury (Contact vs Noncontact)**
  - Concentrated area of injury vs. widespread injury
- **Primary vs. Secondary Injury**
  - What happens initially vs. what comes afterwards

### Contact (Focal) Head Injuries

- Skin/scalp/subgaleal contusion
- Skull fracture
- Epidural hematoma
- Focal subdural hematoma
- Cortical contusion

Injuries at deeper tissue layers were caused by greater force


### Normal CT vs. Epidural Hematoma

- Normal CT image
- Epidural Hematoma image
Diffuse Brain Injury
Results from rotational acceleration forces with or without impact

- Concussion
- Diffuse axonal injury
- Deep brain hematoma
- Deep brain contusion
- Gliding contusion
- Diffuse subdural hemorrhage
- Subarachnoid hemorrhage

Subdural Hematoma

Primary Brain Injury

- Cortical Injury
  - Contusions
  - Lacerations
- Axonal injury
- Hemorrhage
Secondary Brain Injury

- Hypoxic-Ischemic Encephalopathy
  - Metabolic alterations in ion homeostasis and membrane function
  - Pathologic changes in microvasculature
- Cerebral Edema
  - Leads to increased intracranial pressure, ischemia, herniation
- Altered Neurochemistry
  - Increased release of excitatory amino acids leading to edema

Children are not little adults

- Large head relative to the body
- Weaker neck muscles
- Shallow flat skull
- Immature unmyelinated brain
- Most models saying shaking is not harmful only consider a single shake rather than repetitive events (effects of tissue fatigue)

Comparison of Animal Models to Humans

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>Weight</th>
<th>Brain Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult human</td>
<td>170 cm</td>
<td>64 kg</td>
<td>1250 gm</td>
</tr>
<tr>
<td>Chimpanzee</td>
<td>91 cm</td>
<td>48 kg</td>
<td>425 gm</td>
</tr>
<tr>
<td>Rhesus monkey</td>
<td>71 cm</td>
<td>9 kg</td>
<td>85 gm</td>
</tr>
<tr>
<td>Squirrel monkey</td>
<td>29 cm</td>
<td>1.25 kg</td>
<td>23 gm</td>
</tr>
<tr>
<td>Infant human</td>
<td>50 cm</td>
<td>3.5 kg</td>
<td>375 gm</td>
</tr>
</tbody>
</table>

Ratio of body weight to brain weight

<table>
<thead>
<tr>
<th></th>
<th>Brain weight/Body weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult human</td>
<td>1:51</td>
</tr>
<tr>
<td>Chimpanzee</td>
<td>1:112</td>
</tr>
<tr>
<td>Rhesus monkey</td>
<td>1:105</td>
</tr>
<tr>
<td>Squirrel monkey</td>
<td>1:54</td>
</tr>
<tr>
<td>Infant human</td>
<td>1:9</td>
</tr>
</tbody>
</table>

Other Differences

- No other primate infant has as large a brain as the human infant
- No other primate is as helpless as a human infant
- No other primate has the extraordinarily weak neck of a human infant
Retinal Hemorrhages

- Diffuse hemorrhages generally not caused by accidental injuries, can rarely be seen when significant forces involved (i.e. MVC)
- Hemorrhages can be seen in coagulopathies, meningitis, vasculitis, sepsis, and birth
- Not caused by CPR

Shaking produces traction on the tightly adherent vitreous causing retinal injury
Site and Extent of RH of AHT

• Posterior pole of retina most common
• Typically in all layers- but may be just one
• They must be characterized in detail
• The more extensive RH, the more likely AHT
• But it cannot be said that less extensive RH is less likely to be AHT

So what can cause symptoms that might look like abusive head trauma?

Differential Diagnosis of AHT

• Accidents- falls, other household injury
• Bleeding disorders- factor disorders, liver disease, Vit K deficiency
• Metabolic diseases such as GA1
• Infection- meningitis, encephalitis, sepsis
• Birth trauma
• Intracranial pathology-SA cysts, sinus thrombosis, ruptured AVM, intracranial tumors

The So-Called Controversy

Commonwealth v Louise Woodward
October 6-30, 1997

The Au Pair Trial

Background

• Increasing lack of confidence in
  – medical profession
  – experts
  – abuse diagnosis
• Media coverage doubting existence of SBS
Why is there so much controversy?

- People simply cannot believe that anyone would shake a child and cause injury
- Early studies suggested shaking could not cause injury without impact - later studies have refuted this
- Articles with confessions are dismissed as flawed
- Defense authors have published some seriously flawed works to support their opinions
- The lay press largely prints the defense theories

Reasons Given by Defense Experts for the “Controversy”

- Pediatricians believe it is possible to shake a child into injury
- Pediatricians disregard all other diagnoses when they see a head bleed and retinal hemorrhages
- Pediatricians believe the onset of AHT is immediate
- Pediatricians believe the last person to be with the child must have harmed him
- AHT is diagnosed by “The Triad”

“But closer scrutiny of the body of research that is said to support the diagnosis of shaken baby syndrome has revealed methodological shortcomings.”

Reference: Lantz et al, Perimacular retinal folds from childhood head trauma (BMJ 328 : 75)

- Single case report of crush head injury
“Doctors have learned that in many cases in which infants have triad symptoms, there can be a lag of hours or even days between the time of the injury and the point when the baby loses consciousness.”

Reference: Plunkett, Fatal Pediatric Head Injuries Caused by Short-Distance Falls (AJFMP, 2001)
- Contains no infants
- Youngest child with duration >15 minutes is 4 yrs

The secret to creativity is knowing how to hide your sources.

Albert Einstein

Still a man hears what he wants to hear and disregards the rest.
Simon and Garfunkel

Denialism

February 2, 2011

Shaken-Baby Syndrome Faces New Questions in Court

By EMILY BAZELON

Last September, the fight among the doctors broke out in public on the Web, after Deborah Tuerkheimer, a former prosecutor and a law professor at DePaul, wrote a New York Times Op-Ed warning of wrongful convictions and calling on the National Academy of Sciences to reframe the shaken-baby-syndrome dispute. On the Web site CommonHealth, about 20 doctors commented, mostly to express outrage. One of them was Binds. He wrote that Tuerkheimer had “been beguiled by a group of physicians who are using the courtroom to distort science, facts and reality.” And he denounced her for “furthering the cause of the so-called innocence project.”
Denialism

- Manufacture of doubt
- Identification of conspiracies
- Creation of impossible expectations of research
- Use of fake experts
- Misrepresentation and logical fallacies
- Selectivity of citation
  - Any paper, no matter how methodologically flawed, that challenges the dominant consensus is promoted extensively
  - Any minor weaknesses in papers that support the dominant consensus are highlighted and used to discredit their messages

Denialism Themes

- Conspiracy to suppress “The Truth”
  - Governments, Societies, Industry
- Compelling narrative of good vs. evil
  - Saving people from a harm
  - Self view of being a “hero”
- Usually involve complex, esoteric science
- All supporting data is “flawed”
  - There is a difference of interpretation of the data

Denialism

- Conventional approaches to scientific progress—such as hypothesis generation and testing, and argument and counterargument— that seek to elicit the underlying truth no longer apply

- Is not simply a disagreement of the experts, it’s a histrionic ideology unswayed by the data

Denialism Arenas

- Immunizations cause autism
- HIV does not cause AIDS
- Climate change is not occurring
- Shaken Baby Syndrome does not exist

SLEAZE Tactics

- Scientific conspiracies alleged
- Logical flaws in argument
- Evidence is creatively selected
- Absolute perfection demanded of others
- Zany arguments used to mislead
- Experts are bought to undermine good science

Capewell and Capewell, BMJ 342:188, 2011
Child Abuse and the Courts

We have a criminal justice system which is superior to any in the world and its efficiency is marred only by the problem of finding 12 men who don’t know anything and can’t read.

Mark Twain

Current Defense Testimony in AHT

- Biomechanics of inflicted brain injury- shaking does not cause injury
- Unique theories of causation
  - Minor unrecognized injury leads to subsequent re-bleed
  - Lucid interval
  - Undiagnosed illness/birth trauma/metabolic disease in child
  - Delayed birth trauma
  - Copper/Vit C/Vit D deficiencies
  - DTP and other vaccinations
- Falls and other accidental means of injury
  - Minor falls cause major injury

How Often Do Kids Fall?

- Based on two studies, kids experience approximately 25 short falls per year in the first five years of life
- Based on population data, from 1994 to 1998, children under five fell over 2 billion times

Did you ever stop to think, and forget to start again?

Winnie the Pooh

Falls
Evaluating the Potential Effects of a Fall

<table>
<thead>
<tr>
<th>Decreased Risk</th>
<th>Increased Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower mass</td>
<td>greater mass</td>
</tr>
<tr>
<td>high pt. elasticity</td>
<td>low pt. elasticity</td>
</tr>
<tr>
<td>lower height</td>
<td>greater height</td>
</tr>
<tr>
<td>initial velocity 0</td>
<td>+ initial velocity</td>
</tr>
<tr>
<td>soft surface</td>
<td>hard surface</td>
</tr>
<tr>
<td>large impact area</td>
<td>small impact area</td>
</tr>
</tbody>
</table>

Characteristics of falling object or person

As the mass of the falling object or person increases, impact forces will increase if all other determinants remain the same (F=ma)

The bigger you are, the harder you fall

---

Short Falls Common Defense


- Looked at consumer product safety commission databases and medical records from 1988 to 1999
- 75,000 children
- Ages 12 months old to 13 years old
- Falls from 2 to 10 feet
- Results:
  - 18 head injury related deaths (out of ~ 1.3 million falls in that 11.5 years)
  - Concluded that falls <3 ft can cause fatal head injuries

Analysis

- 6/18 cases unwitnessed
- Exact height of falls known in 10 cases
- Falls described were complicated and often severe falls- fall from porch swing onto rocks, fall with flip over object
- Inclusion of deaths from swings- angular acceleration and velocity associated with DAI
- History from caretakers taken at face value

---

Characteristics of falling object or person

As the mass of the falling object or person increases, impact forces will increase if all other determinants remain the same (F=ma)

The bigger you are, the harder you fall

Analysis

- 4 cases had RH, but no ophthalmologists used
- Autopsy not completed in many cases
- Included children with bleeding disorders and AV malformations
- Of the 5 cases under 2, only 1 witnessed
- Type of injury in most not same as injury in abusive head injury
  - SDH present associated with impact, except for one case
  - Crush injuries included
  - Several subgaleal and epidural hematomas
- Real conclusion: This is a very rare event
Evidence that Children Don’t Die from Short Falls

- Seiben, et al. 1971
  - 55 falls > 10 feet
  - 5 deaths, 9%
- Smith, et al. 1975
  - 37 falls from heights less than one story - 0 deaths
  - 37 falls from one to three stories - 0 deaths
- Musemeche, et al. 1991
  - 70 falls from windows 1 to 17 stories
  - 0 deaths

Evidence that Children Don’t Die from Short Falls

- Barlow, et al. 1983
  - 61 falls from windows, bridges, fire escapes, etc.
  - 14/61 died (23%)
  - All deaths occurred in kids falling more than 3 stories
- Williams 1991
  - 59 falls 10 to 22 feet - 0 deaths
  - 3 falls 22 to 40 feet - 0 deaths
  - 1 fall 70 feet resulted in death

**Factors that increase likelihood of death from short accidental falls**

- Type of falls
  - Walkers, bunk beds, swings, fall from caretaker resulting in crush injury
- Epidurals or large contact subduralcs can cause death
- Characteristics of the child
  - Bleeding disorders, genetic conditions, intracranial pathology such as AVM

**Short Falls Data**


Annual Risk of Death Resulting From Short Falls Among Young Children:
Less than 1 in a Million

- Reviewed 188 articles on falls
- 2.5 million children
- 13 deaths from short falls
  - arms of adults and crush injuries included
- < 1 per million

**Childhood Falls**

<table>
<thead>
<tr>
<th>Year</th>
<th>Chadwick</th>
<th>Meta-analysis of literature on short falls</th>
<th>National Electronic Injury Surveillance System (NEISS) (mean 3 short fall deaths among 400,000 children; calculated rate 0.625 cases per million young children per year; California Epidemiology and Prevention of Injury Control Branch (EPIC) database found 6 short fall deaths per 2.9 million children in five years, or 0.44 cases per 1 million children per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Chadwick</td>
<td>122 children who fell before age 2</td>
<td>209 short fall (bed, couch, changing table; all falls 4 ft or less), 28% of falls with injuries (bruises, bumps, scars), no serious injuries</td>
</tr>
<tr>
<td>2010</td>
<td>Study</td>
<td>122 children aged 3 years or less</td>
<td>Falls from varying heights, including from a staircase, into a pit, from furniture, and 3 without fall information, 2 without injuries, 4 with minor injuries (head injury, puncturing tissues), no deaths</td>
</tr>
<tr>
<td>2011</td>
<td>Study</td>
<td>122 children aged 3 years or less</td>
<td>Falls from varying heights, including from a staircase, into a pit, from furniture, and 3 without fall information, 2 without injuries, 4 with minor injuries (head injury, puncturing tissues), no deaths</td>
</tr>
</tbody>
</table>

Biomechanical Modeling

Case

- 2½ yo girl, home with mom’s boyfriend, had unobserved fall from a bed
- Suffered a fatal head injury
- Mom’s boyfriend charged with murder

A biomechanics expert modeled the fall from bed in the room where the child was found down using HYBRID-3 yo dummy

Results: Hybrid III 3 Year Old

Injury Reference Value (570 HIC, 175 G)

Expert’s conclusion

- In 8 of 9 tests, fall of dummy to floor exceeded head injury thresholds
- Conclusion: A fall from a bed from a standing position could have easily killed this child

What are the fallacies in the expert’s opinion?

- HIC of 570 is correlated with a 50% chance of linear skull fracture, not complex basilar fracture, subdural hemorrhage, and death
- HIC for child/infant dummy are not derived from experimental data, but are scaled from adult data
- Engineer demonstrated child falling onto the back of her head, ignoring multiple head impact sites
- If the model is accurate, we would expect 8 out of 9 toddlers to die who fell from the height of a bed (not consistent with actual experience)
The right to be heard does not automatically include the right to be taken seriously.

Hubert Humphrey, 38th U.S. vice president

Rebleed

- A SDH occurs days to weeks before acute symptoms develop
- This SDH produces insufficient symptoms at the time to provoke medical attention
- Trivial injury triggers rebleeding in this organizing SDH
- Rebleeding leads to sudden rise in intracranial pressure (ICP)
- This ICP produces collapse and death

Many children re-bleed into old subdurals

- Re-bleeds are low-pressure oozes into old clots
- Rarely are children symptomatic with re-bleeds, unless (theoretically) a large amount of blood accumulates over time
- Low pressure, re-bleeds into existing subdurals from minor trauma do not present as serious brain injury
- Subdural bleeding is only a marker of injury
- Critical lesion in AHT is neuronal destruction

SDH and RH are caused by hypoxia

Corollary that SDH are due to dural leak because of hypoxia

Geddes

- Geddes I, 2001
  - Supported Duhaime’s study due to paucity of DAI
  - Cervical cord damage may play a significant role
- Geddes II, 2001
  - Theorized stretch injuries to spinal cord
  - “Seen from this point of view, the debate over shaken or shaken-impact becomes irrelevant, and because there is no DAI, it is possible that the severe acceleration-deceleration injury that is so often cited does not occur in shaken-baby syndrome.”
Dural haemorrhage in non-traumatic infant deaths: Does it explain the bleeding in “shaken baby syndrome”?


Dural haemorrhage

- 50 non-traumatic cases:
  - 17 intrauterine deaths
  - 3 spontaneous abortions
  - 16 perinatal deaths < 7 days of age
  - 9 infants none older than 5 months, seriously ill ex-premies
- Eyes not examined in any
- Only 1 case had grossly evident SDH: 25 week-old with sepsis and DIC

Dural haemorrhage

- Trauma cases:
  - 8 month-old
  - 7 weeks-old
  - 5 weeks-old
- All had BSDH radiographically & post-mortem
- All had RHs

Dural haemorrhage

- Authors conclude the findings in the 50 non-traumatic cases “identical” to those seen in SBS
- They implicate “hypoxia-induced alterations in the permeability of immature vessels” as the cause of leakage of blood between the dural leaflets – intradural haemorrhage

Dural haemorrhage

- Authors suggest hypoxia as mechanism that “activates the pathophysiological cascade which culminates in altered vascular permeability and extravasation of blood within and under the dura
- This is followed by “severe brain swelling with venous congestion (to) produce widespread oozing from leaky, hypoxic dural veins, possibly with contribution by similarly leaky bridging veins”

Dural haemorrhage

- Authors state that RHs “occur for essentially the same physiological reasons as subdural bleeding”
- They contend that SBS victims “show very little if any traumatic pathology in the brain” believing that all of the pathology is due to hypoxia
Critical Analysis

- 20 of 50 study group subjects were intrauterine deaths or stillbirths
- Congested dura in macerated brains would support the authors’ hypothesis
- The authors showed no statistically significant relationship between hypoxia and intradural bleeding or gross SDH
- Why is hypoxia-induced alteration in vascular permeability of immature vessels isolated to the dural vessels?
- Why are widespread serosal hemorrhages not typically observed in head-injured infants?

Other papers addressing hypoxia

  - 91 infants dying with HIE from drowning, asphyxia, complications of anesthesia, etc.
  - None had SDH
  - 156 children who had head CT within 1 day of admission for drowning; 18 < 1 yo
  - None had SDH

Favorite Court Diseases

- Vaccines
- Vitamin C deficiency
- Copper deficiency
- Birth trauma
  - Can have SDH and RH
  - SDH gone by 4 to 6 weeks
  - If symptomatic, will present in newborn period

Can DTaP vaccine cause permanent brain damage?

- Multiple studies have shown it does not

- National Vaccine Compensation Board compensates children if encephalopathy occurs within 72-hours of administration, but does not include SDH or RH as compensatable.

If babies are shaken hard enough to cause brain injury won't they have a neck injury?

- Head and neck mechanical model postulating structural failure of spine
- Concluded that there must be neck injury in all cases
- Included serious mathematical miscalculations
Spinal Cord and Brainstem Injury
Brennan et al, 2009
- Largest study to date
- 41 AHT victims < 2 yo
  - 6 with no sign of trauma, 35 with signs of impact
  - Soft issue of neck and cervical vertebrae/spinal cord
- 71% (29/41) had cervical spinal cord injury
- All 6 without signs of impact had spinal cord injury
- Conclusion: Spinal cord injuries were common, but not universal

Brainstem and Spinal Injuries
Upper two cervical vertebrae are more mobile in infants and young children
- Ligaments not fully formed
- Facets are more horizontal; free to slide
- Neck can be hyperextended
- Hemorrhagic lesions and axonal damage can be noted

Confessions
- 7 year retrospective study, 2002-2009, of patients diagnosed with AHT in 39 different French courts
- Objective: correlate legal statements made by perpetrators with medical documentation to offer insights into injury mechanism

Methods
- 112 cases referred to the court were reviewed
- Compared 29 cases of confessions to 83 cases with no confessions
- AHT based on subdural hemorrhage, with or without skin findings, fractures, or retinal hemorrhages
- All confessions gave detailed accounts in writing during judicial proceedings
- 2 groups were compared for demographics, symptoms, and injuries
Results

- 85 boys and 27 girls, mean age 5.6 months
- Among all cases: 99% had SDH at multiple sites, 88% RH, 62% seizures, 27% fractures
- Of the 83 non-confessed presenting histories
  - 19 shake to revive
  - 28 minor accident
  - 36 no history
- No difference in the 2 groups for age, sex, deaths, symptoms, fractures, bruises, RH or subdural pattern

Confession group

- 7 girls, 22 boys, mean age 8 months
- 9 deaths
- 79% presented with seizures, 83% had RH, 100% with multifocal SDH
- Perpetrator
  - Father or stepfather 45%
  - Mother 27%
  - Both mother and stepfather 1 case
  - Teenage brother 1 case

Confession group

- All children were taken under the arms and shaken violently
- In 5 cases there was a final impact on a bed
- Single shaking episode in 13 cases (45%)
  - Immediate symptoms- 4 cases
  - Put immediately to bed and found within 3 hours- 6 cases
  - Timing unclear but less than 24 hours- 3 cases

Confession group

- Repeated shaking in 16 (55%) cases
- Numbers of admitted episodes between 2 and 30 times, average 10
  - 6 cases described as daily for weeks to months
- 10 perps describe “immediate exhaustion” in babies, and all say they shook the infants repeatedly because it stopped the crying
- 5 admitted impact and 4 of those children died
  - 1 had a skull fracture
  - 2 others without admitted impact also had fracture
- No association between SDH densities and number of times shaken

Quotes

- I was holding my daughter under the arms and I shook her. Her head wasn’t being held and was snapping back and forth.
- I didn’t want to choke him, but I wanted him to stop crying. I picked him up and I shook him; I threw him on the bed and he bounced on the sheets.
- Once or twice I’ve held him at arm’s length and shaken him; I’ve blown a fuse. Over more than a month I’ve shaken him several times.
- I shook her so she’d be quiet, it lasted maybe 5 minutes. I was exasperated; I shook her up and down in from of me, without holding her against me. I was shaking her hard; I was crying just like she was and I was worked up.

Conclusions

- Shaking is employed because it stops infant crying
- Shaking may repeated daily over several weeks or months
  - This is why it is difficult to date SDH by CT or MRI
- There is no association between SDH density and numbers of shakes
  - CT should not be used to determine chronicity
- Recommend routine use of MRI in AHT cases
Corroborative Research

Biomechanical studies in an ovine model of non-accidental head injury
Anderson et al., J Biomech., 2014
- Lambs were manually shaken in repetitive cycles
- Suffered spectrum of AHT injuries
  - DAI, Sinusoidal injury, death

Traumatic axonal injury is exacerbated following repetitive closed head injury in the neonatal pig
Raghupathi et al., J Neurotrauma, 2004
- Piglets underwent single or repetitive head rotations
- No impact
- Suffered more and wider DAI with repeated trauma, deeper injury

Results

- 412 cases of head trauma
  - 124 (30.4%) inflicted, 288 (69.8%) accidental
- Corroborated cases
  - 45 (36.3%) inflicted
  - 39 (13.5%) accidental
- Mechanism of trauma in inflicted cases was shaking in 30 and beating in 15
- Mechanism for accidents: MVC (19), defenestration (5), carriage struck by car (3), fall from arms (3), fall from supermarket trolley (2), fall to sidewalk (2), fall from hospital bed (2), fall from seat (1), walker down the stairs (1)

Results

- Patients with AHT presented with seizures, coma, increased brain pressure, and neurologic deficits
- SDH was the main diagnosis in abuse patients
  - Edema was specific to AHT
- Impact was more common in accidents
  - All cases of trivial falls were minor injuries
- Eye exams available in 97% of AHT and 90% of accidents
  - AHT = 56.8% severe RH
  - Accident = one case of severe RH after impact to eyeball

Results

- AHT required more surgery and longer ICU stays
- AHT had longer overall hospital stays
- More AHT died (11/12 who presented in coma)
  - Both fatal accidents were MVC with multitrauma
- Seizures more common in AHT
- Outcomes of developmental delay, motor delay, behavior problems and visual deficit were more common in AHT

Table 1: Diagnosic value of frontal subdural, parietal subdural, retinal hemorrhage, and absence of signs of impact, for the diagnosis of child abuse.

|              | Sensitivity | Specificity | Positive predictive value | Negative predictive value | Accuracy
|--------------|-------------|-------------|---------------------------|---------------------------|----------
| Brain edema  | 0.267       | 0.971       | 0.421                     | 0.852                     | 0.314    |
| SDH          | 0.822       | 0.523       | 0.561                     | 0.694                     | 0.878    |
| Class impact | 0.822       | 0.523       | 0.561                     | 0.694                     | 0.878    |
| Retinal edema| 0.804       | 0.516       | 0.551                     | 0.684                     | 0.870    |
| Retinal blood| 0.786       | 0.516       | 0.540                     | 0.674                     | 0.864    |

Note: The absence of signs of impact has roughly the same diagnostic value for RH as it has severe retinal hemorrhage. Thesefigures show for this sensitivity, specificity, and positive and negative predictive values of these three features are greater than the specificity and positive predictive values of the three combined. This is true at a level of significance.
Conclusions

This study avoids the circularity associated with other studies by using only corroborated cases.

Study confirms the diagnostic value of SDH, severe RH, and absence of impact to differentiate between AHT and accidents.

Research Frontiers

- Animal testing
- Biofidelic models
- Finite element computer simulation

Corroborative Research

Infant brain subjected to oscillatory loading
Couper and Albermani, Biomech Model Mechanobiol 2008
- Used 2D computer model
- Repeated cycles increase strain
- Deeper structures experience more strain
- Wider CSF spaces increase strain

Mechanical response of infant brain to manually inflicted shaking
Couper and Albermani, J Engineer Med, 2010
- Used 3D computer modeling (simpler model)
- Axonal injury, bridging vein rupture possible

Evidence-based medicine?

“attempts to formally rank the available medical scientific evidence by internationally accepted methods, to determine the degree of confidence that can be held on various claims about the condition termed shaken baby syndrome (SBS).”

Am J of For Med & Path 2003; 24: 239-242
“Shaken Baby Syndrome” was added as a MeSH term in 2002

So what’s wrong with Donohoe’s paper?
- Didn’t actually pose a question
- Used inadequate search terms
- Didn’t define inclusion and exclusion criteria
- Didn’t search multiple databases
- He didn’t actually critically read the papers
- No statistical analysis
- Applied criteria for judging treatment literature on a diagnostic question
- Showed unmistakable bias in his analysis

Why Should You Care About Donohoe’s Paper?
- Quoted in lay press
- Quoted in legal opinions
- Cited by more than 60 other papers
  - Once every other month

On the contrary, the dogma would appear to be ‘mainstream medical opinion’, supported not by evidence9 but by 40 years of repetition; it remains just that: opinion.

N.B. Donohoe was spelled Donahue
The validity of the diagnostic criteria for AHT and the specificity of any retinal findings for abuse have been called into question. An evidence-based appraisal of the literature up to 1998 reported inadequate scientific evidence to validate most aspects of AHT.8"

When a careful meta-analysis of the SBS literature was performed by Donohoe, he found the scientific foundation of SBS to be lacking.112

Challenging the Pathophysiologic Connection between Subdural Hematoma, Retinal Hemorrhage and Shaken Baby Syndrome

192 citations
- 24 from radiology sources (textbooks or publications)
- All others are from other medical journals, legal briefs, Medical Hypothesis, websites and The Wall Street Journal
- Including:

Imaging of Nonaccidental Injury and the Mimics: Issues and Controversies in the Era of Evidence-Based Medicine

Those who cite Donohoe as “evidence-based” are either inexperienced in medical literature appraisal or are being disingenuous; there is no third option.

Greeley, Seminars in Ped Neuro, 2010

**Literature Clues To Note**

- The use of the term “Triad”
- Uncited sweeping generalizations
- Citing non-peer-reviewed sources
  - Particularly websites and blogs
- The use of the journal *Medical Hypotheses*
- Citing the Donohoe paper

127 page document written by a board certified CAP/lawyer, outlining the entire debate and offering scientific evidence useful for the courts
Narang, Sandeep K., Melville, John David, Greeley, Christopher S., Anderst, James D., Carpenter, Shannon L. and Spivack, Betty, A Daubert Analysis of Abusive Head Trauma/Shaken Baby Syndrome—Part II: An Examination of the Differential Diagnosis (July 1, 2013). Available at SSRN: http://ssrn.com/abstract=2288126

Introduction
For reasons inexplicable to many physicians, and understandable to many others, the diagnosis of Abusive Head Trauma/Shaken Baby Syndrome (AHT/SBS) remains a lightning rod for controversy. Public media articles continue to be written. Legal articles continue to be written. And, judicial commentary on the science continues to recur. The most recent

This is what is occurring in the diagnosis of child abuse. A small group of individuals has, during depositions and court room testimony [9, 10], perverted cases by using incomplete statements of the facts and unproven hypotheses to obscure the straightforward historical and physical findings utilized to make the diagnosis of child abuse [11–18]. These individuals have utilized unethical methods to create controversy when there should be none.

Conclusion
There is substantial evidence to support the fact that abusive head trauma is a devastating condition that affects both individuals and society as a whole.