A Review of Inflicted Traumatic Brain Injury Including Perceived Courtroom Controversies
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History of the Concept


- **Auguste Ambroise Tardieu** (4/10/1818-1/12/1879): 19th Century physician described virtually all of the findings generally noted in child sexual and physical abuse, including abusive head trauma. He did not, however, attribute the cranial findings to shaking.
Some Terminology

- **Shaken baby syndrome exists**, but the term is too restrictive to describe the pathology and various etiologies involved in abusive injury to a child’s head.

- **Abusive Head Trauma** is now the preferred term to any nonaccidental trauma to the head (shaking, slapping, punching, slamming on hard or soft surfaces).

- Shaking is a form of AHT.

- **Inflicted traumatic brain injury (ITBI)** is now the suggested term for brain injury arising from abusive head trauma.

Some Anatomy
The Meninges
The Dura Mater
“One Tough Mother”
Bridging Veins
Bridging Veins
Epidural & Subdural Hemorrhage

Epidural Hematoma:
- rapidly expanding with arterial blood
- Skull fracture
- Torn middle meningeal artery
- Dura pushed away by hematoma

Subdural Hematoma:
- slowly expanding with venous blood
- Superior sagittal sinus
- Torn bridging vein
- Dura is attached to the skull, so cannot cross falx, tentorium
- Subarachnoid space

Epidural Hematoma vs Subdural Hematoma
Subdural Hemorrhage
ITBI: What is it?

- A variable constellation of findings including:
  - Intracranial (Inside the skull) bleeding.
    - Markers for shear stress
    - Thin subdural
    - Subarachnoid
  - Retinal bleeding
    - Marker for acceleration/deceleration
    - Variable
    - Usually severe, nearly 360 degree.
Brain tissue injury:

- Traumatic diffuse axonal injury
- Hypoxic/ischemic diffuse axonal injury
- Cerebral edema (brain swelling)
Normal Retina
Retinal hemorrhage
ITBI; What is it?

- And may include:
  - Classic metaphyseal skeletal injury (CML)
    - Injury to the growth plates of the long bones.
  - Rib fractures
    - Particularly posterior
  - Other focal brain, skull, and soft tissue injury due to related trauma.
Classic Metaphyseal Lesions (CML)
ITBI; What is it?

The cause of which is:

Severe acceleration/deceleration

- Violent shaking
- Severe impact (on a hard or soft surface)
- Striking of the child by a caregiver
- Any combination of the above
Predisposing anatomical features of infants & young children

- Large head relative to body size.
  - 15-20% body weight in the infant.
- High water content of the brain
- Weak neck musculature.
- Lack of CNS myelination.
- Short axons (connections between brain nerve cells).
- Immature skeletal structure.
- Relatively flat skull base.
- Thin subarachnoid space provides little support for the brain.
So how much force does it take?

- We don’t know.
- We may never know because you can’t do the experiment.
- The only thresholds that we have for acceleration/deceleration brain injury were derived from adult monkeys during the 1960s space race by Omaya & Thibault.
- Adult monkeys are not human infants.
- It requires violent force to inflict severe acceleration/deceleration injury in human infants.
Primary brain injury

- Severe physical shaking, impact, or blow to the head of an infant
  - *Acceleration/deceleration*
  - *Shear stress across the brain*
- Tensile and shearing strain (stretch & rip!) across the brain tissue & veins
- Traumatic diffuse axonal injury (tDAI)
  - Concussion
  - Subdural/subarachnoid bleeding
  - Swelling
Secondary brain injury

- **Hypoxia** (lack of oxygen) to brain from:
  - Central apnea (cessation of breathing)
  - Seizures.
  - Increased tissue death & swelling
- Increased blood flow to head (compensatory)
  - Blood vessel congestion
- **Ischemia** (inadequate blood flow) from severe congestion/swelling
- Loss of clotting ability
- **Brain death**
  - Brain stem herniation
  - “Big black brain”
Massive cerebral edema & subarachnoid bleeding: shaken toddler
C-spine injury

- Previous criticism of ITBI (shaking) naysayers was that C spine trauma should be found in victims and had not been.
- Reason? WNL (We never looked).
- Studies have now shown a correlation of C spine fractures (largely vertebral compression) in victims of ITBI. Prevalence of such fractures is unknown.
- Ligamentous injury, spinal subdural, and spinal cord contusions are also being found.
- Yet another study has shown correlation between occipital cervical ligamentous injury and brain ischemia in both ITBI & accidental brain injury.

Pathologic evidence of DAI

- Injured axons from trauma, hypoxia, & ischemia:
  - Deterioration over time.
  - Severing
- Leakage of proteins
  - Beta amyloid precursor protein (Bapp)
- Standard hematoxylin-eosin staining.
  - requires 48-72 hrs of survival in order to be useful.
“Retraction balls” of DAI
Communication problems

- Lawyers & medical professionals speak two different languages; ironically both in Latin.
- Both professions are very full of intelligent people who are trained to reason differently.
Communication problems

- Inductive (lawyers):
  - Reason from a known principle to the present problem

- Deductive (medicine):
  - Start with an unknown & reason to an answer.

This is why my lawyer wife (the party of the first part) & I (the party of the second part) drive each other crazy.

The fact is that she is smarter than I am, but I know more confusing terminology than she does.
Communication problems

- A legal ruling by a court goes from a principle (the law) to a legal question, and may become new law, though it may also be overturned by a higher court.

- Unlike the law, no single medical opinion or paper “proves” anything.
  - Medical papers should be peer reviewed before publication (not a guarantee of good science, but it helps).
  - The opinion or results must be upheld by subsequent research and practice in order to become accepted.
  - Lawyers often look for a paper that “proves” their point. It doesn’t exist.
The root of the problem

- Anything published today about AHT is in court tomorrow being used to “prove” guilt or innocence.
- The scientific “vetting” of scientific papers & opinions is taking place in court in an adversarial atmosphere & judged by nonmedical people.
- The results are predictable.
- Any medical “controversy” about AHT exists overwhelmingly in the courts & the media.
The root of the problem

- Some of the medical (& even legal) naysayer literature is generated by defense experts from which to testify.
- Every time naysayer literature is published, researchers have to go to work and publish strong literature to counter it.
- Thus, much time & money that could be used for prevention & treatment are essentially wasted.
- Any limitation in a legitimate scientific study/paper will be disclosed in the publication by the authors.
- All publications/papers have limitations.
Evidence based medicine

As defined by the US DHHS Agency for Healthcare Research & Quality:

“Evidence-based medicine is the integration of best research evidence with clinical expertise and patient values. Evidence-based medicine is an interdisciplinary approach which uses techniques from science, engineering, biostatistics and epidemiology, such as meta-analysis, decision analysis, risk-benefit analysis, and randomized controlled trials to deliver “the right care at the right time to the right patient.”
Evidence based medicine
Evidence based medicine & AHT

Biomechanics:

“It is important to note, however, that in vitro models by their nature are low evidence quality studies that attempt to advance hypotheses but do not address cause & effect. As a whole, biomechanical models, as they pertain specifically to the brain & spine, are mathematically imprecise. Often, endpoints of limited relevance are relied upon (e.g., skull fracture thresholds) which predictably overestimate the in vivo risk of significant injury. Given the increasing role of biomechanical engineering in the interpretation of fatal pediatric head trauma, a heightened awareness of the limitations is warranted”.

Evidence based medicine & AHT

- Randomized, Controlled, Trials:
  - There are no known energy thresholds for traumatic brain injury in infants & children.
  - Randomized, controlled, trials of infant shaking/impact can’t be done.
  - Not even in animal models these days.
Evidence based medicine & AHT

Risk/Benefit Analysis:

- My rather extensive review of the AHT literature, along with 32 years of clinical practice, lead me to believe that:
  - The risk of shaking/slamming/throwing (or any combination thereof) of a child or infant is much greater than any benefit, real or theoretical, that one might potentially derive from it.
  - While there is likely risk/benefit data regarding the treatment of traumatic brain injury in infants & children, I know of none particularly relating to AHT.
Evidence based medicine & AHT

Decision Analysis:


Hettler, J. & Greenes, D. S,: Can the initial history predict whether a child with head injury has been abused?; Pediatrics 2003; 111; 3; 602

Evidenced based medicine & AHT

- **Epidemiology:**
- In spades!
- 20 hits on first two pages of a single search engine query using a single search term (epidemiology abusive head trauma).
Evidence based medicine & AHT

- Meta-analysis/Systematic Reviews:
- Again, over 20 hits on two pages of a single search engine query with a single search term (systematic review abusive head trauma).
Attack the “triad”.

- The “triad” (RH, SDH, & encephalopathy) is largely a construct of defense experts and deniers. Though no longer a medical term, it was used early on in AHT literature.
- The “Triad” has become a straw man.
- Defense wants the jury to believe that medical providers immediately diagnose ITBI if the “triad” is present.
- They then quote medical literature that questions the validity of the construct.
- Speaking of which........
PRISMA standards

**PRISMA** (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is an evidence-based minimum set of items aimed at helping authors to report a wide array of systematic reviews and meta-analyses that assess the benefits and harms of a health care intervention.


“Shaken baby syndrome has typically been associated with findings of subdural hematoma, retinal hemorrhages, & encephalopathy.”

“However, the diagnostic accuracy of this triad in detecting that an infant has been shaken has been questioned.”

“This systematic review indicates that there is insufficient scientific evidence on which to assess the diagnostic accuracy of the triad in identifying traumatic shaking (very low quality evidence).”
Criticisms of the review & paper:

- Inclusion criteria so restrictive that only 30 articles of the hundreds written on the subject were included.
  - Evidence ranking criteria never before used except in the Egyptian Journal of Forensics.
  - Reports must have been witnessed or videotaped.
  - Excluded multidisciplinary (medical & investigatory) reports as “circular reasoning.” (required by PRISMA standards in child abuse reviews).
- Questioned the value of confessions.
- Only a single author had any experience with the “forensic” aspects of ITBI.
- Refused international peer review.
And a sharp response:


“Significant errors in methodologic standards applied with this review.”

Poor research question re: the “triad.”

Inadequate literature search.

No standards of confirmation of key clinical features.

Risk of bias assessment that relies solely on case ascertainment & confirmation of shaking.

Called for retraction.
And also:


The author concludes:

“The evidence base for abusive head trauma encompasses diverse disciplines, including diagnostic imaging, pathology, pediatrics, biomechanics, ophthalmology, epidemiology, & orthopedics. When the varied sources of evidence are pieced together & taken in toto, abusive head trauma is often readily differentiated from alternative explanations of an infant’s injuries.”
Infant abuse diagnosis associated with abusive head trauma criteria: incidence increase due to overdiagnosis?

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Background: The hypothesis of this study is that the diagnosis of infant abuse is associated with criteria for shaken baby syndrome (SBS)/abusive head trauma (AHT), and that changes in incidence of abuse diagnosis in infants may be due to increased awareness of SBS/AHT criteria. Methods: This was a population-based register study. Setting: Register study using the Swedish Patient Register, Medical Birth Register, and Cause of Death Register. The diagnosis of infant abuse was based on the International Classification of Diseases, 9th and 10th revision. Participants: All children born in Sweden during 1987–2014 with a follow-up until 1 year of age (N=2 868 933). SBS/AHT criteria: subdural haemorrhage, cerebral contusion, skull fracture, convulsions, retinal haemorrhage, fractures rib and long bones. Outcomes: Incidence, rate ratios, aetiologic fractions and Probit regression analysis. Results: Diagnosis of infant abuse was strongly associated with SBS/AHT criteria, but not risk exposure as region, foreign-born mother, being born preterm, multiple birth and small for gestational age. The incidence of infant abuse has increased tenfold in Sweden since the 1990s and has doubled since 2008, from 12.0 per 100 000 infants during 1997–2007 to 26.5/100 000 during 2008–2014, with pronounced regional disparities. Conclusions: Diagnosis of infant abuse is related to SBS/AHT criteria. The increase in incidence coincides with increased medical preparedness to make a diagnosis of SBS/AHT. Hidden statistics and a real increase in abuse are less plausible. Whether the increase is due to overdiagnosis cannot be answered with certainty, but the possibility raises ethical and medico-legal concerns.
This is a very complex paper that simply does not make a lot of sense.

Their SBS/AHT definition:

- ICD 9-10 diagnosis of abuse.
- &
- So; a baby diagnosed with abuse due to abusive bruising & who also had a long bone fracture, would be considered to have AHT by author’s definition.
- Whaaaaaat!?
Complex linear regression analysis also doesn’t make any sense.

Product of the statistical analysis, “diagnosis” is not defined.

Authors essentially conclude that a significant increase in child abuse diagnosis in Sweden over a recent period is likely due to a significant increase in AHT diagnosis/overdiagnosis of AHT.

“Diagnosis of infant abuse is related to SBS/AHT criteria.”

This is an amazing over-reach based on very strange reasoning.
Author Dr. Peter Aspelin has publicly discussed his son’s investigation for AHT perpetration (charges dropped) in the US 3 yrs ago.

The Hogburgs are frequent AHT defense experts.

None of the three doctors disclose this information in the paper.
The “raging controversy” approach:

- Defense uses naysayer literature to give the jury the impression that a raging controversy exists among physicians about the validity of ITBI.
- Much is made about “the new science”.
If you only read one medical article, it should be:


  “This consensus statement, supported by the Society for Pediatric Radiology, European Society of Paediatric Radiology, American Society of Neuroradiology, American Academy of Pediatrics, European Society of Neuroradiology, American Professional Society on the Abuse of Children, Swedish Paediatric Society, Norwegian Pediatric Association, & Japanese Pediatric Society, addresses significant misconceptions about the diagnosis of abuse heat trauma in infants and children. It builds on 15 national and international professional medical societies and organizations' consensus statements confirming the validity of the AHT diagnosis. The statement also exposes the fallacy of simplifying the diagnostic process to a “triad” of findings- a legal argument and not a valid medical term.”

- 15 other organizations & institutions have signed on since publication.
Untrue Defenses & Strategies

The reality:


Survey of physicians frequently involved in the evaluation of injured children in “Top Ten” children’s hospitals.

Included Pediatric ED, neurosurg, neurology, child abuse, radiology, ophthalmology & forensic pathologists in the hospitals areas.

Physicians were asked the likelihood that subdural hematoma, severe RH, & coma or death would result from several proposed mechanisms.

1378 physicians surveyed with a 49.5 % response rate. 628 were included in the final sample.

SBS & AHT were considered valid diagnosis by 88% & 93% of respondents respectively.
Untrue defenses & strategies

- More reality:

- Christian, C. et al. Understanding Abusive Head Trauma; Answers From America’s Pediatricians. AAP, 2015.

- No legitimate medical debate among the majority of practicing physicians as to the existence of AHT/SBS.

- Unequivocally clear that inflicted head injury is a relatively common & clearly defined entity & that a differential diagnosis, including medical diseases that can mimic AHT/SBS, can be evaluated by physicians objectively.
Sudden, fatal, rebleed into a small birth subdural many months later.

Small, asymptomatic, subdural bleeds are commonly seen after normal deliveries (26%), but more commonly after C section and instrument deliveries.

These can rebleed, especially if there is some associated atrophy of the brain.

These too are usually asymptomatic, or may cause gradual symptoms if the rebleeds continuously recur.

The defense hypothesizes that the victim in question suddenly collapsed from a rebleed months later.

There is not a single instance of that type of rebleed in the medical literature.
Rebleed


Untrue Defenses & Strategies

- Retinal hemorrhages do not indicate abusive head trauma:
  - True! Sort of...........
  - Many conditions, especially birth, leukemia, bleeding disorders, severe accidental trauma, & overwhelming infection, can cause retinal hemorrhages.

- The RH of ITBI, however, tend to be multilayered, too numerous to count, and distributed throughout the retina out to the ora serrata and may be associated with retinal tearing.

- The organic causes of RH have their own characteristic histories & physical findings, & would be very difficult to confuse with ITBI.
Immunizations can cause subdural hemorrhages:

- Children are immunized frequently during the first year of life, also the peak age for finding ITBI.
- It is no wonder that antivaccine proponents make this claim.

Extensive medical literature exists on the effects and side effects of immunizations in infants. There is no medical literature that implicates vaccines as a cause of the findings in AHT.

Hypoxia causes the brain & eye findings attributed to AHT

- Geddes, J. F., et al; Dural haemorrhage in nontraumatic infant deaths: Does it explain the bleeding in shaken baby syndrome?; Neuropathology & Applied Neurobiology; 29; 1; 14-22.

- Paper concerned a comparison of the dura of 50 infants who died from natural causes with 3 who died of abusive head trauma.

- 72% of those in the natural cases group had intradural (in the dura) bleeding, but not subdural. One had subdural blood, but died of sepsis with DIC.

- Dissection technique might account for the intradural blood.

- Author opined that hypoxia might account for R/H. but eyes were never discussed in the paper.

- Author stated that “It was only a theory” on the witness stand.

- Subdurals are not found in cases of suffocation & drowning.
Barnes, P. D. et al; Infant life threatening events-dysphagic choking vs NAT. Seminars in Pediatric Neurology; 17; 1; 7-11.

Case report of a 4 mo old male who was said to have suddenly collapsed, said to have been caused by “dysphagic choking”.

Roughly 2/3 of 4 mo infants regurgitate daily. They like that look on your face when their warm barf streams down your collar.

Child was found to have severe R/H, subdural/subarachnoid bleeding, & cerebral edema.

Authors offered no explanation of how choking caused these findings.
But the authors left out:

- That some of them served as defense experts in the trial of the father who was thought to have perpetrated AHT on infant.
- That the father was convicted.
- That the baby had a healing rib fracture.
- Report was not peer reviewed.
- Authors would not explain their roles or why there were exclusions from the report.
Hypoxia: The response


There is no DAI, hence no AHT!

- Standard H & E staining will likely not be positive unless the victim survives for 48-72 hrs.
- It is still effective in 82% of cases.
- B-app staining may reveal DAI in as little as 2-3 hrs post injury. Newer stains may be faster.
- Some kids don't even live that long
- Wide spread symmetric sampling is required for either technique. DAI may thus, be missed.
- Background staining of normal structures may complicate B-app staining.
- It may be there even if you can't see it!
Short falls (1.4 M) frequently cause the findings of ITBI.

- In fact the literature is quite firm on this point.
- Risk of death: less than 0.48/million children/year
- We do not see global brain injury, severe RH, & encephalopathy, from otherwise normal infants falling from beds, changing tables, sofas, and so on, ad nauseum.
- The exception is a short fall causing a skull fracture with an underlying epidural (arterial) bleed.
Venous sinus thrombosis causes subdural hemorrhages.

- The venous sinuses are essentially collectors of blood from the dural veins that pool blood before it drains back towards the heart.

- Newborn infants are known to be especially susceptible to clotting of the venous sinuses and are often found to have subdural hemorrhage.

- However, newborn infants often are found to have small subdursals without venous sinus thrombosis.
Venous Sinus Thrombosis

- Frequent causes of venous sinus thrombosis include cancer, CNS infections, dehydration, cyanotic heart disease, head injury (Increased ICP/brain swelling), brain surgery, kidney disorders, and thrombophilic (tendency to clot) disorders.

- Clinical examples of well documented subdural hematoma in infants resulting from venous sinus thrombosis (in the absence of trauma) have not been reported in the post-natal period.
Untrue Defenses & Strategies

The “New Science” of Abusive Head Trauma

- A MUST HAVE PAPER!
- An in-depth critique of the “new science” often referred to in court by defense experts.
The “New Science” of Abusive Head Trauma

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Abstract
Claims that new science is changing accepted medical opinion about abusive head injury have been made frequently in the media, legal publications, and in legal cases involving abusive head trauma (AHT). This review analyzes recently published scientific articles about AHT to determine whether this new information has led to significant changes in the understanding, evaluation, and management of children with suspected AHT. Several specific topics are examined as follows: serious or fatal injuries from short falls, specificity of subdural hematoma for severe trauma, biomechanical explanations for findings, the specificity of retinal hemorrhages, the possibility of cerebral sinus thrombosis presenting with signs similar to AHT, and whether vaccines can produce such findings. We conclude (a) that the overwhelming weight of recent data does not change the fundamental consensus. (b) that abusive head trauma is a significant source of morbidity and mortality in children, (c) that subdural hematomas and severe retinal hemorrhages are commonly the results of severe trauma, (d) that these injuries should prompt an evaluation for abuse when identified in young children without a history of such severe trauma, and (e) that short falls, cerebral sinus thrombosis, and vaccinations are not plausible explanations for findings that raise concern for abusive head trauma.

Keywords  Abusive head trauma · Retinal hemorrhages · Subdural hematoma
PROMOTING JUSTICE FOR VICTIMS OF ABUSIVE HEAD TRAUMA:
INFORMATION AND STRATEGIES FOR EFFECTIVE COURTROOM PRESENTATION

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Overcoming Defense Expert Testimony in Abusive Head Trauma Cases

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