

# Defending Shaken Baby Syndrome/ Abusive Head Trauma Cases

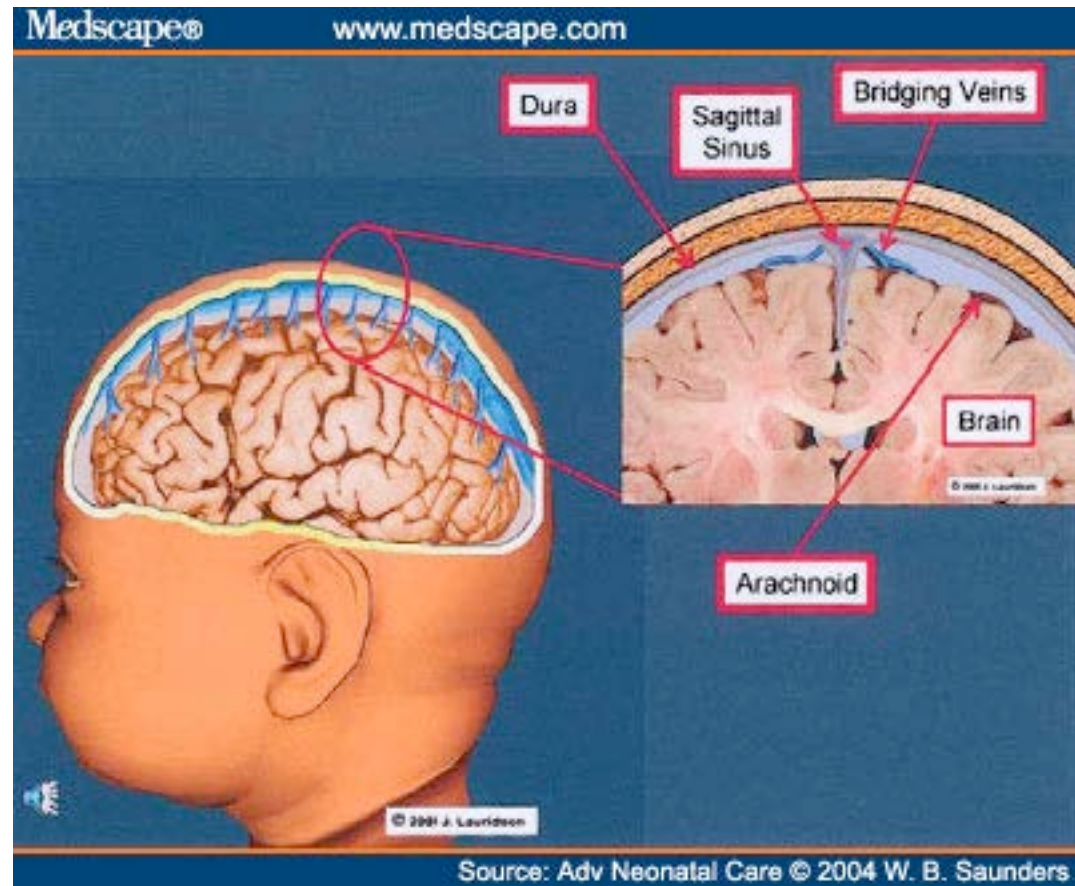
Katherine H. Judson

# Anatomy of Science-Dependent SBS Prosecutions

- The science is used to prove all legal elements of the offense
  - Cause and manner of death or injury
    - Shaking, or shaking with impact
  - Mental state of perpetrator
    - Degree of force used so significant as to prove intent, recklessness, deliberate indifference to human life, etc.
  - Identity of perpetrator
    - Because death or collapse is instantaneous (no “lucid interval”), it had to be the last person alone with the child
- “Medically diagnosed murder” (Tuerkheimer 2009)

# The SBS Hypothesis

1. The “triad”: subdural hemorrhage, retinal hemorrhage, brain swelling (and absence of another explanation)
  - a. The hypothesis: *ruptured bridging veins*, retinal veins, axons
  - b. violent shaking provided the mechanism, physiology, mental state, and timing
  - c. being a parent/caretaker provided the motive and opportunity





# But my case is about abuse, not just shaking...

- The hypothesis and underlying research is the same—only the name has changed
- So—all of the flaws are the same too



# The Non-Issues

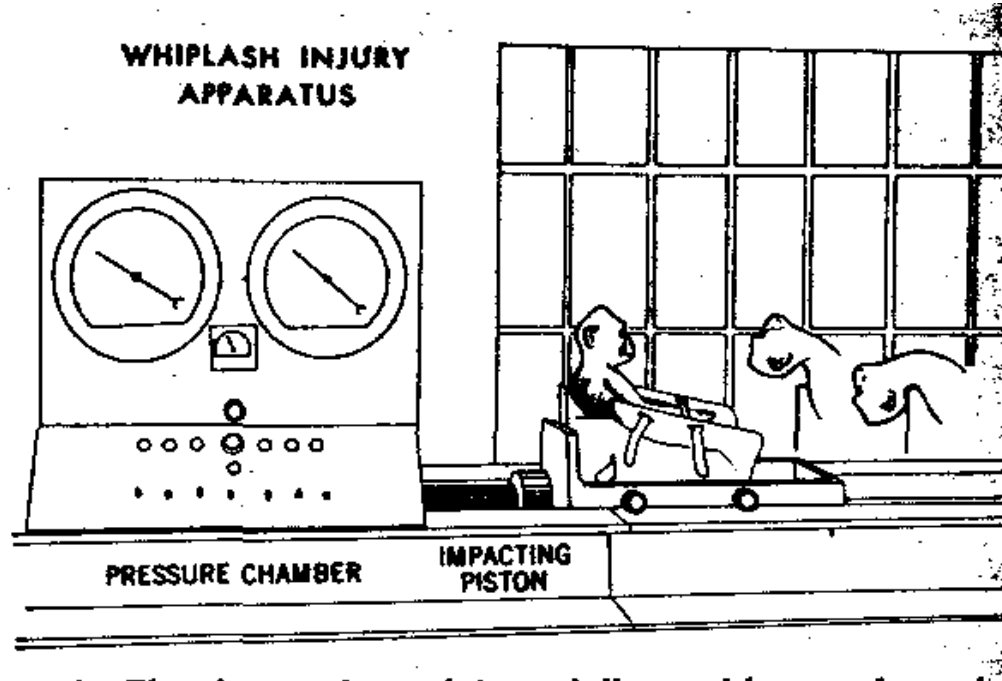
- Child abuse, including abusive head trauma, is real
- Violently shaking an infant can harm the infant
- Adults can be and are properly convicted of abusing children when the evidence beyond medical opinion based on disputed hypotheses supports the conviction

# The Issues

- Can shaking alone cause serious brain damage (subdural hematoma, retinal hemorrhages, cerebral edema, death, etc.)?
- How diagnostic are findings of the brain injuries alone—can they support a conclusion that the child was intentionally subjected to trauma?
  - Raises a whole host of other issues about alternative causes, or “mimics,” of abuse
- Can the medical evidence alone be used to time the injuries and thereby identify the perpetrator?
- Has the science on these questions changed appreciably in recent years?

# 1968

- Ommaya, *Whiplash Injury and Brain Damage*, 204 JAMA 285 (1968)



# Guthkelch (1971)

- First pediatric neurosurgeon in Great Britain
- Wondered why kids who had subdural hemorrhage and who he suspected had been abused showed no outward sign of head injury
- Concluded they may have been shaken
- Relied solely on whiplash study by Dr. Ommaya
- “One must keep in mind the possibility of assault in considering any case of infantile subdural haematoma, even when there are only trivial bruises or indeed no marks of injury at all, and inquire, however guardedly or tactfully, whether perhaps the baby's head could have been shaken.”
  - A. Norman Guthkelch, *Infantile Subdural Hematoma and its Relationship to Whiplash Injuries* 2 BMJ 430, 431 (1971).

## Caffey (1972 and 1974)

- Major figure in the pediatric and child abuse communities
- Admitted he based his conclusions on “manifestly incomplete” data
- Concluded that shaking was a leading cause of cases where children had subdural and retinal hemorrhage
- Advocated education as the appropriate response

# 2001

- SBS endorsed by AAP: “presumption” of abuse in child under 1 year with RH and SDH and no major traumatic event
- “The act of shaking leading to shaken baby syndrome is so violent that individuals observing it would recognize it as dangerous and likely to kill the child. Shaken baby syndrome injuries are the result of violent trauma. The constellation of these injuries does not occur with short falls, seizures, or as a consequence of vaccination.”
- Also endorsed by AAO and NAME

# SBS/AHT: What is the new science?

## *Shaking runs into trouble:*

- a. biomechanics: shaking produces insufficient force to rupture veins or axons; would have neck injury (Duhaime 1987, Ommaya 2002)
- b. brain swelling is hypoxic, not traumatic (Geddes 2001)
- c. subdural hemorrhages have many causes (Frasier 2006)
- d. bridging vein rupture is improbable (Squier & Mack 2009)
- e. retinal hemorrhages have many nontraumatic causes (Lantz 2006, Matshes 2010, Lantz 2013)
- f. lucid intervals are acknowledged (Gilliland 1998)
- g. broad range of alternatives: accidental, birth trauma, natural disease processes, coagulopathies, lumbar puncture, genetic, etc. (Frasier 2006, Barnes 2011)



## 2006

- NAME declined to renew its 2001 position paper on SBS
- At its annual meeting, presentations were made with titles such as “*Where’s the Shaking?: Dragons, Elves, the Shaken Baby Syndrome and Other Mythical Entities*”

*State v. Edmunds,*  
746 N.W.2d 590, para. 15 (Wis. App. 2008)

“Edmunds presented evidence that was not discovered until after her conviction, in the form of expert medical testimony, that a significant and legitimate debate in the medical community has developed in the past ten years over whether infants can be fatally injured through shaking alone, whether an infant may suffer head trauma and yet experience a significant lucid interval prior to death, and whether other causes may mimic the symptoms traditionally viewed as indicating shaken baby or shaken impact syndrome.”

# 2009

- American Academy of Pediatrics states that “advances in the understanding of the mechanisms ... associated with abusive head trauma compel us to modify our terminology”
- Recommends that physicians use the term “abusive head trauma”
- Removes language about the presumption of abuse, and the language stating that these injuries do not occur from short falls, and language saying the injuries can prove intent of the caregiver.
- Acknowledges that accidents and disease are other causes of the findings

# 2011

- *Cavazos v. Smith*, 132 S.Ct. 2 (2011).
  - Evidence sufficient to support conviction even though medical testimony was disputed.
  - But majority also wrote: “Doubts about whether Smith is in fact guilty are understandable.”
  - Dissent: “‘Doubt has increased in the medical community ‘over whether infants can be fatally injured through shaking alone.’”
  - And: “What is now known about shaken baby syndrome (SBS) casts grave doubt on the charge leveled against Smith.”

# 2012

- *Ex Parte Cathy Lynn Henderson*, 384 S.W.3d 833 (Tex. Ct. Crim. App. 2012)
  - Pathologist (Bayardo) who performed autopsy changed opinion
  - Originally testified, “without a scintilla of doubt” that the cause of 3½-month-old child’s death was “abuse, homicide.”
  - Based on subsequent research (largely biomechanical research on short-distance falls developed after trial), original pathologist, joined by 5 other experts, changed his mind: “I cannot determine ... whether [the child’s] injuries resulted from an intentional act or an accidental fall.” And: “I don’t believe it’s a case of child abuse.”



2014

Jennifer Del Prete, Petitioner,  
v.  
Sheryl Thompson, Respondent.  
10 F.Supp.3d 907 (N.D. Ill. 2014)

Matthew F. Kennelly, J.

Holding: New scientific evidence challenging SBS hypothesis establishes that Del Prete meets the *Schlup v. Delo* “actual innocence” standard to permit her to raise otherwise procedurally defaulted constitutional challenges in federal habeas.

“[T]he ... recent [scientific] developments in this area ..., arguably suggest[] that a claim of shaken baby syndrome is more an article of faith than a proposition of science.”



# 2014

## *MM v. Prosecutor-General*

Supreme Court of Sweden (Oct. 2014)

SBS conviction based on the triad reversed and defendant acquitted by the Supreme Court of Sweden:

“21. It can be concluded that, in general terms, the scientific evidence for the diagnosis of violent shaking has turned out to be uncertain. It has not emerged that the facts in this particular case are such that it can be established, despite this uncertainty, that O’s injuries were caused by violent shaking or other violence on the part of MM. On the contrary, certain facts, including the facts that O had previously had RS virus and that there were signs of older haemorrhaging under the dura mater, indicate that there is another explanation for the symptoms that O had.

### *The Supreme Court's conclusion*

22. The conclusion is that it has not been shown beyond reasonable doubt that MM caused the injuries stated by the Prosecutor-General to O. MM shall therefore be acquitted.”



# 2014

STATE OF NEW YORK  
COUNTY COURT                      COUNTY OF MONROE

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THE PEOPLE OF THE STATE OF NEW YORK

**DECISION AND ORDER**

-vs-

Ind. No.: 2001-0490

RENE BAILEY a/k/a RENEE BAILEY,

Defendant.

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# *Bailey Decision*

The Court determines ... that the Defense established that the mainstream belief in 2001-2002, espoused by the Prosecution's expert witnesses at Trial, **that children did not die from short falls, has been proven to be false.** As more fully set forth in the Findings of Fact, the Court credited the testimony of the Defense experts that case studies have demonstrated that children have died from short falls, that biomechanical research has explained the force produced in falls, and that **advances in imaging have undercut the theory that shaking causes fatal injury through the tearing of bridging veins.**

# SHAKEN BABY SYNDROME, ABUSIVE HEAD TRAUMA, AND ACTUAL INNOCENCE: GETTING IT RIGHT

Keith A. Findley, Patrick D. Barnes, David A. Moran, and Waney Squier\*

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We wish to thank Geoffrey Kirkwood for his outstanding research assistance and thoughtful editorial suggestions.

## PROBLEMS OF INFANT RETINO-DURAL HEMORRHAGE WITH MINIMAL EXTERNAL

from a high building or asks for an opinion on intent. Any medical expert who answers in the negative questions such as "Given the injuries that you have described in this case, doctor, have you any doubt that they were inflicted with intent to kill, or at least in total disregard of that possibility?" is exceeding his or her authority. New

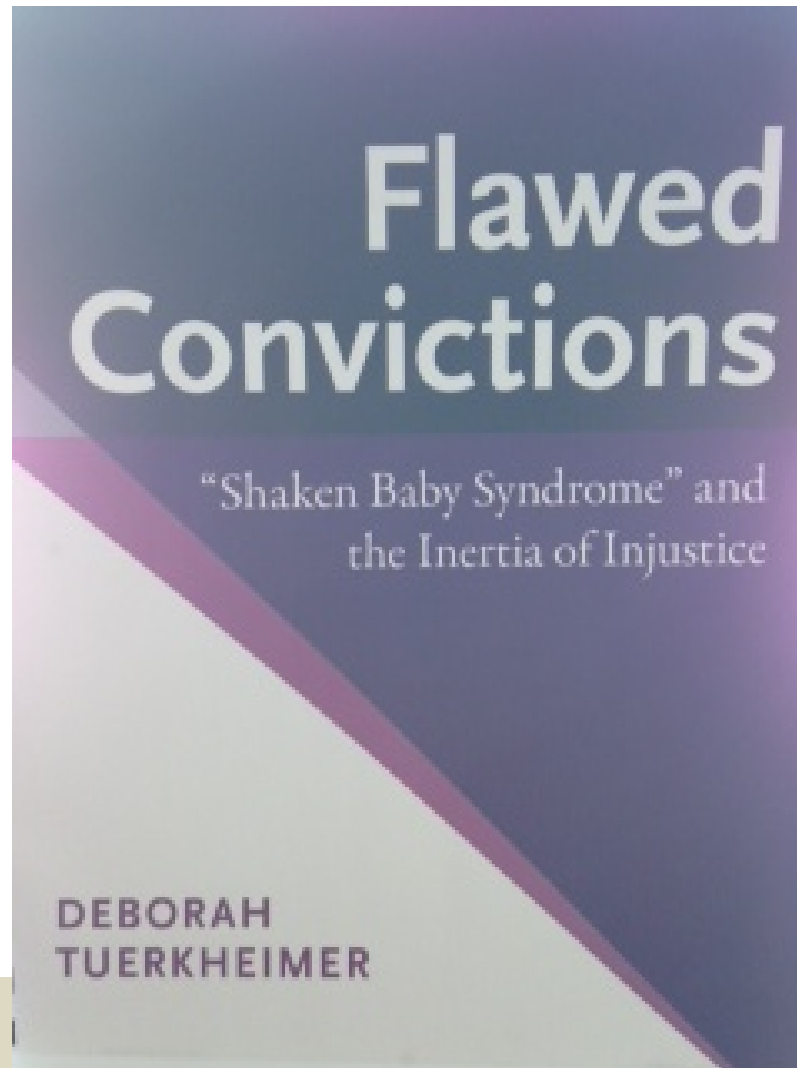
caused a great deal of controversy since it was first described.<sup>1</sup> While controversy is a normal and necessary part of scientific discourse.

imperfectly documented – cases explains some of this disparity.

“Getting it right” requires that we distinguish between hypotheses and knowledge. SBS and AHT are hypotheses that have been advanced to explain findings that are not yet fully understood. There is nothing wrong in advancing such hypotheses; this is how medicine and science progress. It is wrong, however, to fail to advise parents and courts when these are simply hypotheses, not proven medical or scientific facts, or to attack those who point out problems with these hypotheses or who advance alternatives. Often, “getting it right” simply means saying, clearly and unequivocally, “we don’t know.”

This contribution is offered as a reflection—after 40 years’ consideration—on a problem of potential child abuse which has caused a great deal of controversy since it was first described.<sup>1</sup> While controversy is a normal and necessary part of scientific discourse.

2014





# Areas of New Consensus

- The triad is not pathognomonic of abuse
  - Encephalopathy and edema are ubiquitous
  - Subdural hematoma—not unique to SBS or AHT
  - Not even retinal hemorrhages, retinal folds, and retinoschisis in infants are alone pathognomonic of abuse (shaking)
- A differential diagnosis (really a differential etiology) is essential in all cases
- The list of “mimics” of abuse is extensive and growing
- Short falls can kill
- Lucid intervals can occur, making timing impossible



# Remaining Disputes

1. What is the diagnostic value of the triad—
  - subdural hematoma?
  - retinal hemorrhages?
  - cerebral edema?
2. If there is trauma, is it from abuse?
3. What is the diagnostic value of other signs or symptoms, e.g., bruises?
4. When can we rule out alternative causes—e.g., short falls, disease, congenital conditions?
5. When can we rule out the possibility of a lucid interval?

# Issue 1:

What is the diagnostic value of the triad?

- Subdural hematoma?
- Retinal Hemorrhage?
- Cerebral Edema



# What Causes Subdural Hematomas

- “The differential diagnosis (i.e., list of potential causes for subdural hemorrhages (SDH’s)) is extensive.” Narang (2012)
  - But SDH is still held to be highly diagnostic of intentional abuse (not just shaking)
  - Because numerous studies show a higher rate of SDH in abuse cases than in cases with other causes of death or injury
- Signs often associated with abuse, including SDH, are found in many other situations, including accidents, prenatal conditions, congenital malformations, disease, infection, birth injury, toxins, infections, and more
  - Kent P. Hymel, et al., Intracranial Hemorrhage & Rebleeding in Suspected Victims of Abusive Head Trauma: Addressing the Forensic Controversies, 7 CHILD MALTREATMENT 329 (2002)



# What causes retinal hemorrhages?

- State will assert that presence of RH in an infant is powerfully suggestive of abuse & severe retinal hemorrhages are highly specific for AHT/SBS.
- Doctors make that claim because they often observe RH in situations where they believe there has been child abuse – in other words, they see a correlation.
- BUT since no one understands what causes RH, the state cannot claim that there is causation.
- Odds ratio (HT 1028)—is not proof.

# What is happening in the brain to cause RH?

- The State's theory will be:
- In infants and young children, the adherence between vitreous and posterior pole and peripheral retina is particularly strong;
- Repetitive acceleration-deceleration produces shearing forces sufficient to allow vitreous to pull on the retina, leading to splitting of retinal layers (traumatic retinoschisis);
- The same vitreoretinal traction can produce perimacular folds—elevated retinal ridges encircling the macula. “Retinal Hemorrhages in Children, the Role of Intracranial Pressure”, Tiffany Shiau et.al. JAMA Pediatrics, 2012.

## However - Cause of Retinal Hemorrhages Unknown

- “It has been supposed that RH arise from shearing forces between the vitreous and the retina. . . . “[But] there are no direct data supporting the role of the vitreous-retinal traction as the cause of RH in shaking.”
- “Bungee jumping and rapid deceleration in a road traffic accident . . . would be expected to generate some form of intraocular force, but . . . accurate modeling studies are not available and, there are alternative, albeit equally speculative, explanations.” P Luthert, Division “*Why do Histology on RH in suspected non-accidental injury of* Pathology, appended to, (2003) Histopathology

# Is there a difference in RH in child abuse cases? The state will argue:

- RH are different in abuse – more severe and extensive, bilateral and multilayered (HT 1024)
- State will say that in falls, hemorrhages limited in number and are confined to the posterior pole. (HT 1025)
  - But John Plunkett's case study documents that falls can cause extensive hemorrhages -- bilateral multi-layered hemorrhages, not confined to posterior pole.
  - See also: Lantz's TV crush; Watts and Obi; Steinbok.



# New Science on Retinal Hemorrhages

In *People v. Bailey*, Dr. Patrick Lantz testified :

Q. In cases with confirmed non-abuse, where we know this wasn't an abusive situation and you've looked in the eyes and seen retinal hemorrhages, have you seen hemorrhages that were, for example, bilateral?

A. Yes.

Q. And have you seen retinal hemorrhages that were, for example, extensive?

A. Yes.

Q. Or that might be described by someone as too numerous to count?

A. Yes.

Q. And extending to the edge of the retina or the ora serrata?

A. Yes. (HT 210:18.)

# New science on RH con't.

- Q. Have you seen Retinal Hemorrhages develop in the hospital?
- A. Yes. (HT 211)

## Direct of Patrick Lantz con't.

- Q. Any characteristic features of Retinal Hemorrhages that distinguish abuse from non-abuse?
- A. No (HT 198-199)
- Q. Any features of the eyes themselves that allow you to distinguish abuse from other kinds of trauma or disease or accident?
- A. No (HT 199)

# Cross examination of Brian Forbes

## -Other injury can cause RH

Q. You told us that motor vehicle accidents can cause RH; is that right?

- A. Yes (HT 1041)

- Q. We also know that crush injuries cause RH?

- A. Yes (HT 1045)

- We don't know why crush accidents cause RH, do we?

- No (HT 1045)

# Cross of Forbes continues

- Q. We see RH in head injuries resulting from falls down stairs?
- A. Yes. (HT 1049)
- Q. If something happened in the hospital to cause bleeding [in the head] that would cause hemorrhages to develop in the hospital?
- A. It could cause hemorrhages.
- Q. A sudden increase in chest of head pressure can cause RH?
- Yes

# More cross of Forbes

- Q. A single shake could cause hemorrhage, right?
- A. Scant hemorrhages, yeah (HT 1056)
- Q. A fall is a single motion. That what you did to the pig [a single shake] and you caused hemorrhages, right?
- A. Yeah (1064)
- Q. You saw bilateral extensive retinal hemorrhages in a premature infant? (HT 1064)
- A. Yeah . . . Where we did a standard procedure called a scleral depression. (1065)

# Changes in AAP Statements

The 2003 official position paper of the American Academy of Ophthalmology stated at pertinent part:

- When extensive retinal hemorrhage accompanied by perimacular folds and schisis cavities is found in association with intracranial hemorrhage or other evidence of trauma to the brain in an infant, *shaking injury can be diagnosed with confidence regardless of other circumstances.*

The 2010 statement by the same organization added an important clause and changed terminology, explicitly recognizing that alternative causes of retinal hemorrhages are possible:

- When extensive retinal hemorrhage accompanied by perimacular folds and schisis cavities are found in association with intracranial hemorrhage or other evidence of trauma to the brain in an infant, *without another clear explanation*, abusive head trauma can be diagnosed with confidence regardless of other circumstances.

# What else besides shaking causes RH?

- Falls
- Increased Cranial Pressure – Brain Swelling and Hospital intervention
- Crush Injury
- Direct injury to the eye
- Disease, as in diabetes
- Conditions present at the time of birth or shortly after, like retinopathy of prematurity
- Medical treatment, like scleral depression



# Retinal Hemorrhages – the literature

- Ommaya, A. et al., *Bio- mechanics and Neuropathology of Adult and Pediatric Head Injury*, BRITISH JOURNAL OF NEUROSURGERY, 16(3):220-42 (2002) (level of force for RH from shaking is biomechanically improbable; case studies confirm that RH and other ocular findings also found in accidental injury & natural disease processes)
- Leuder, G.T. et al., *Perimacular Retinal Folds Simulating Nonaccidental Injury in an Infant*, 124 ARCHIVES OPHTHALMOLOGY 1782 (2006) (four month old child killed when a six year old fell on him. On examination, four month old had severe retinal hemorrhages)
- Watts P. & Obi, E., *Retinal Folds and Retinoschisis in Accidental and Non-accidental Head Injury*, EYE ADVANCE, 18 July 2008; doi: 10.1038/eye.2008.224
- Matshes, E., *Retinal and Optic Nerve Sheath Hemorrhages Are Not Pathognomonic of Abusive Head Injury*, 16 PROC. OF THE AMER. ACAD. SCI. 272 (2010) (examined eyes at Dallas ME; RH linked to edema & life support.)

# Retinal Hemorrhages

- Eye injuries previously presumed to be caused only by the rotational forces of shaking can be caused by other types of injury

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## *Evidence based case report*

### Perimacular retinal folds from childhood head trauma

P E Lantz, S H Sinal, C A Stanton, R G Weaver Jr

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*Editorials by Geddes  
and Plunkett and  
Harding et al*

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A previously healthy 14 month old child was transferred to our medical centre with a severe head injury. The father had collected the boy and his 3 year old brother from their mother at his workplace car park and taken

#### Postmortem evidence

A forensic autopsy showed no direct trauma to the orbits or eyes. There were prominent bilateral scalp contusions with soft tissue and intramuscular haemorrhage.

BMJ VOLUME 328 27 MARCH 2004 [bmj.com](http://bmj.com)



e.)



129 PEDIATRICS 1388 (2012).

*rrhages in critically ill children,*

2013



# Cause and Manner of Death: Mimics of Child SBS/Abusive Head Trauma

- Accidental trauma (e.g., short falls), congenital malformations, metabolic disorders, hematological diseases, infectious diseases, autoimmune conditions, birth effects, rebleeds, hypoxia, childhood stroke, genetic conditions, etc. Patrick D. Barnes & Michael Krasnokutsky, *Imaging of the Central Nervous System in Suspected or Alleged Nonaccidental Injury, Including the Mimics*, 18 TOP. MAGN. RESON. IMAGING 53, 65-70 (2007); Andrew P. Sirotnak, *Medical Disorders that Mimic Abusive Head Trauma*, IN ABUSIVE HEAD TRAUMA IN INFANTS AND CHILDREN: A MEDICAL, LEGAL, AND FORENSIC REFERENCE 191 (Lori Frasier et al., eds. 2006)



# Innocence Cases with Alternative Causes

- Birth defects
  - Case example: child died shortly after birth, only with parents outside of the hospital for a few hours before collapse, original pathologist testified child had to have been violently attacked; postconviction experts found evidence of severe birth defects, possibly exacerbated by birth trauma
- BEH (Benign External Hydrocephalus)
  - Enlargement of subdural spaces and/or fluid collections in those spaces may predispose children to severe injury from minor trauma
- CVT (pediatric stroke): identified in many cases

# Recognizing False Claims: Shaking Only Cause

18           A.    My opinion is based on the fact that there was no  
19           external signs of trauma; based on what I know of the  
20           Medical Examiner's report that these injuries could not  
21           have been suffered any other way than a Shaken Child  
22           Syndrome.

# Recognizing False Claims

10           Q.    What type of scenario would you need to have an  
11 accidental injury to produce these?

12           A.    I mean I can imagine a tornado or some  
13 electrocution or some device that produces like a  
14 centrifuge that produces these forces or things like that,  
15 in that case it would be accidental.

## Issue 2:

If traumatic in origin, was it abuse, or something else, including accident?

# Biomechanics:

## Insufficient Accelerations

- Shaking an infant cannot alone generate acceleration sufficient to meet estimated injury thresholds.
  - A. C. Duhaime et al., *The Shaken Baby Syndrome: A Clinical, Pathological and Biomechanical Study*, 66 J. NEUROSURG. 409 (1987)
  - M.T. Prange, et. al, *Anthropomorphic Simulation of Falls, Shakes and Inflicted Impacts in Infants*, 99 JOURNAL OF NEUROSURGERY 143 (2003)
  - M.T. Prange et al., *Mechanical properties and anthropometry of the human infant head*, 48 STAPP CAR CRASH JOURNAL 279 (2004)

# Biomechanics of Shaking Toddlers

- Shaking a toddler generates ten times *less* acceleration than shaking an infant.
  - N.G. Ibrahim, B. Coats, & S.S. Margulies, *The Response of Toddler and Infant Heads During Vigorous Shaking*, 22 J. NEUROTRAUMA 1207 (2005)

# Biomechanics: Short Falls & Other Impacts

- Forces from shaking fall well below established injury thresholds and are 1/50<sup>th</sup> the force of impact, including impact on soft surfaces. A. C. Duhaime et al., *The Shaken Baby Syndrome: A Clinical, Pathological and Biomechanical Study*, 66 J. NEUROSURG. 409 (1987)
- The peak rotational accelerations for a shake are less than those in a 1 foot fall onto carpet. Prange et al., *Anthropomorphic Simulations of Falls, Shakes, and Inflicted Impacts in Infants*, 99 J. NEUROSURG. 143 (2003)

# Short Falls

Falls of just a few feet exceed predicted injury thresholds

- M.T. Prange & B.S. Myers, *Pathobiology and Biomechanics of Inflicted Childhood Trauma-Response*, in *INFLECTED CHILDHOOD NEUROTRAUMA: AMERICAN ACADEMY OF PEDIATRICS 237* (R.M. Reece & C.E. Nicholson, eds. 2003)
- N. Ibrahim & S. Margulies, *Biomechanics of Toddler Head During Low-height Falls: An Anthropomorphic Dummy Analysis*, 6 J. OF NEUROSURG. AND PEDIATR. 57 (2010)
  - measuring the accelerations from a known (videotaped) short fall that killed a toddler



# Can Short Falls Kill?

John Plunkett, *Fatal Pediatric Head Injuries Caused by Short Distance Falls*, 22 AM. J. FORENS. MED. PATHOL. 1 (2001)

- 18 documented cases of child deaths from short falls, most presenting subdural hematoma, edema, and retinal hemorrhage (4 of 6 whose eyes were examined)
- Case study #5: 23 month old child from small plastic play structure and hit head on carpeted floor. The fall was captured on videotape. Child suffered subdural hematoma with midline shift and bilateral retinal hemorrhage.



# Short Fall Deaths

- P. Steinbok et al., *Early hypodensity on computed tomographic scan of the brain in an accidental pediatric head injury*, 60 NEUROSURGERY 689 (2007) Barnes, P.D., et al., *Traumatic Spinal Cord Injury, Accidental Versus Non-Accidental Injury*, 15 SEMINARS IN PEDIATRIC NEUROLOGY 178 (2008)
- Van Ee et al., *Child ATD Reconstruction of a Fatal Pediatric Fall*, ASME INTERNATIONAL MECHANICAL ENGINEERING CONGRESS & EXPOSITION, November (2009)
- P.E. Lantz, & D.E. Couture, *Fatal Acute Intracranial Injury, Subdural Hematoma and Retinal Hemorrhages Caused by Stairway Falls*, 56 J. FORENS. SCI. 1648 (2011)

# Biomechanics

- Cory & Jones, *Can Shaking Alone Cause Fatal Brain Injury?: A biomechanical assessment of the Duhaime shaken baby syndrome model*, 43 Med. Sci. Law 317 (2003) results
  - Tweaking the dummy to produce as much angular acceleration as possible, they were able to “exceed the original Duhaime et al. (1987) and span[] two scaled tolerance limits for concussion.”

## Cory & Jones, cont.

In a second series of tests the model was configured such that the parameters which had produced the greatest accelerations individually were combined and a model constructed which would produce the greatest acceleration as a whole (the worst case scenario). In addition, the volunteer was asked to use a shake pattern, which had been shown to produce the greatest level of acceleration, the ‘gravity assisted’ shake pattern. In the

## Cory & Jones, cont.

‘gravity assisted’ shake pattern the arms are extended such that the model is elevated above one shoulder and accelerated downwards to below waist level (using gravity to assist). This results in the back of the head (occiput) impacting with the back of the model. The volunteer’s arms are then pulled upwards, returning to the original position above the shoulders (with the volunteer’s head tilted to avoid collision with the model) and inwards to induce chin-chest impact at the opposite end-point of the shake cycle.

## Cory & Jones, cont.

Our preliminary studies show that shaking the model produced both chin-to-chest and back of head (occiput)-to-back impacts. If this were to occur in infants during shaking, that is, if it is anatomically possible, it will have profound implications to the argument that currently

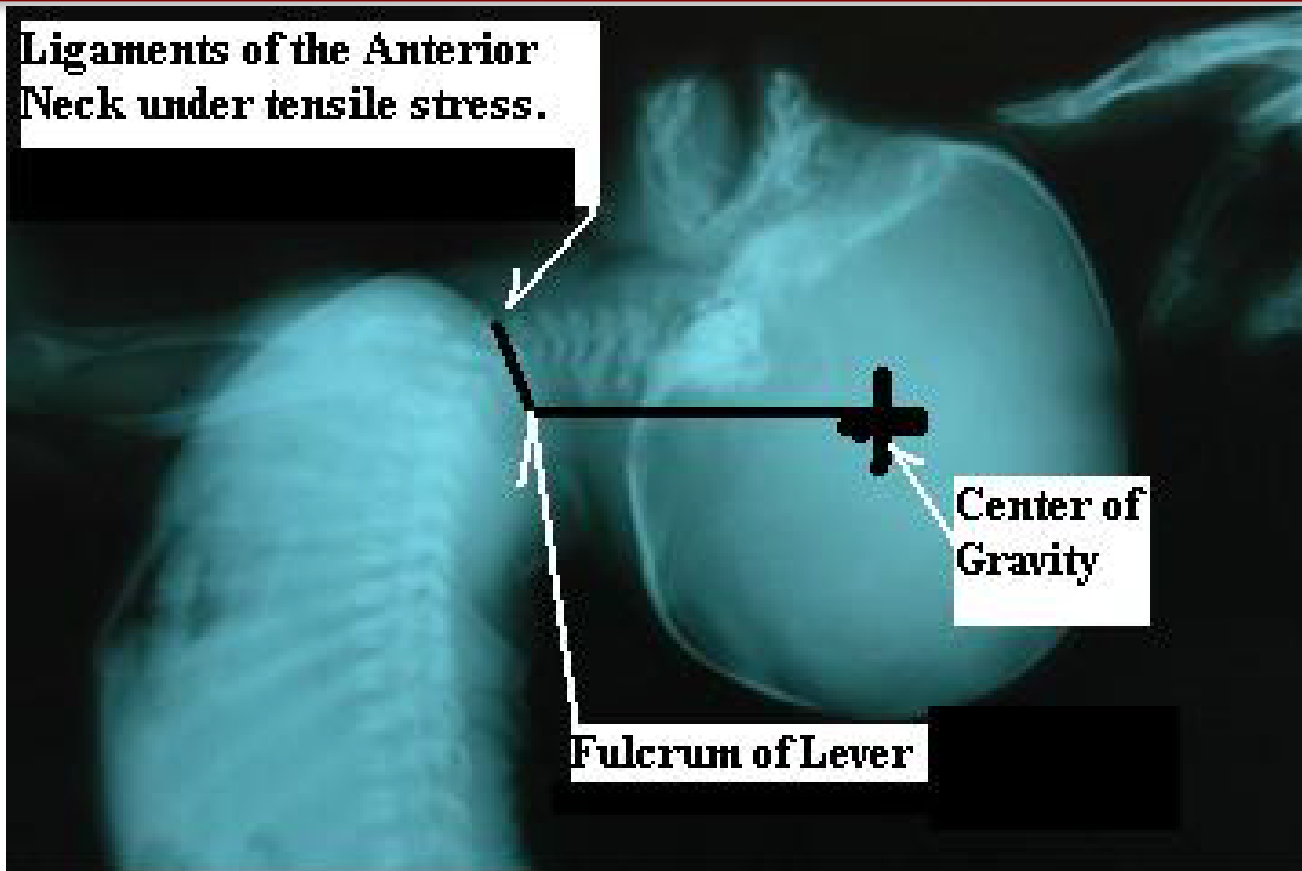
# Dr. William Perloff, State v. Edmunds

**Q:** I see. Okay. Now, if, in fact, what happened in Cory [& Jones] is what's happening in these shaking cases, wouldn't you expect to find bruising on the back of the scalp, bruising on the back, bruising on the chin, bruising on the chest, where these tremendous velocity, this tremendous impact injury to the oral cavity, wouldn't you expect to find those kinds of things if that's the kind of shaking that's happening? ...

**Q:** And [the child in this case] didn't have those kinds of injuries, did she?

**A:** No, she didn't, as the majority of the cases I've seen do not, but some do.

**Ligaments of the Anterior Neck under tensile stress.**



**Note: the Occiput cannot hit the back.**

**Note: With Hyper-Extension puts Tensile Stress concentrated on the Anterior Neck Ligaments only.**

**Note: This appears to represent approximately a 4/1 lever action. This is to say, if 20 to 30 pounds of force are applied at**



# Biomechanics: Neck Injuries

- Shaking could not cause significant brain injuries without first causing massive injuries to the neck and cervical spine.
  - M.T. Prange et al., *Mechanical properties and anthropometry of the human infant head*, 48 STAPP CAR CRASH JOURNAL 279 (2004)
  - F.A. Bandak, *Shaken Baby Syndrome: A biomechanics analysis of injury mechanisms*. 151 FORENSIC SCIENCE INTERNATIONAL 71 (2005)

# Problems with estimating infant injury thresholds

- Scaling from adults and animals
- Cadaver research
- Reconstructions of injuries
- Injury threshold: 50-160 G's
- Shaking alone produces no more than 15 G's
- Burden should be on prosecution to demonstrate match between injury thresholds and the force applied



*rome: A*





case).  
Brittney Sheets did indeed suffer the short fall in this





# Recognizing False Claims: Falls Never Kill

5           A.     Again, I hark back to someone, one of the  
6 attendings when I was in residency, one of the attendings  
7 when I was in medical school as well as reading it in  
8 different textbooks and different journals that it is rare  
9 and, in fact, never has been seen to have a child fall from  
10 less than ten feet or approximately a second story window  
11 result in a serious brain injury.

# Recognizing False Claims: Falls Never Kill (or Never Kill With SBS/AHT-like Symptoms)

18           Q.    Doctor, would you expect to find any  
19           acceleration, deceleration injuries from a child falling  
20           from a chair?

21           A.    No.

# Recognizing False Claims: Falls Never Kill

23 little likelihood -- in fact, there is almost no likelihood  
24 that you can have a fall from less than ten feet for any  
25 child of any age that results in intracranial bleed.

# Recognizing False Claims: Falls Never Kill

20           **A**       Again, we are dealing with a pretty severe injury  
21       here. I mean, to get bruising of the brain itself requires  
22       severe injury. If you look at a fall of a couple of feet,  
23       you never see this kind of damage. You don't see this kind  
24       of injury in a young child. It just doesn't happen.

# Concessions about Changes

Cross-examination of Dr. Sandeep Narang,  
prosecution pediatrician at post-conviction hearing:

Q. So, again, if the doctors at this trial testified that short falls cannot cause this, that's just wrong, isn't it?

A. If they testified to that, yes, sir. (HT at 1302.)

## *People v. Bailey* decision, cont.

“[T]he credible evidence adduced at the Hearing, which was supported by expert testimony from different disciplines and specialties – pediatrics, radiology, pathology, ophthalmology, and biomechanical engineering – established by a preponderance of the evidence that key medical propositions relied upon by the Prosecution at Trial were either demonstrably wrong, or are now subject to new debate.”

# Issue 3:

Beyond the triad: what is the diagnostic significance of other findings, including fractures?

# Fractures

- Meta analyses are in conflict regarding whether skull fractures are significantly correlated with abuse (Maguire, 2011; Piteau, 2012)
- May not exist at all (misdiagnosed)
- Fractures may be the result of rickets, vitamin D deficiency, brittle bone disease or other diseases (some of which also cause subdural bleeding and retinal hemorrhages)
- Fractures can be caused by resuscitation efforts (such as CPR)



# Bruising

- Difficulty of aging
- Specificity?
- Diverse causes
- Possibility of misidentification
- Iatrogenic?

# Misleading/Incomplete Testimony

- 2 A. Not necessarily. There could be squeezing can cause  
3 bruising. Poking a finger in a toddler's eye  
4 intentionally with willingness to cause harm can cause  
5 bruising. Pinching a scrotum can cause bruising.
- 6 Q. Okay. So is it your theory in this case that the  
7 bruising came from the perpetrator pinching the victim  
8 in various places on his body?
- 9 A. It's a plausible mechanism.

# Misleading/Incomplete Testimony

5 Q. Did you know that the medical records make clear that  
6 there was a conclusion reached that was caused at the  
7 hospital by medical personnel?

8 A. I didn't see that.

9 Q. So you didn't know that?

10 A. No.

11 Q. That was part of your diagnosis was the scrotum bruise  
12 was indicative of abuse?

13 A. Well, as part of a constellation of findings.

# Issue 4:

Timing: Can the child  
experience a lucid interval?

# The Rarity of Short Fall Deaths (and other alternative causes)

- Chadwick et al., *The Annual Risk of Death from Short Falls of Young Children: Less Than One in a Million*, 121 PEDIATRICS 1213 (2008)
  - Based on flawed underlying data (subject to the circularity problem)
- Lyons & Oates, *Falling Out of Bed, A Relatively Benign Occurrence*, J. OF THE AMER. ACAD. OF PEDIATRICS (1993)

# The Rarity Argument

- Some of these alternatives are rare
- But statistics embody averages, not individuals
- The chance that any given child will die from leukemia or in a motor vehicle accident is also very small, but some do.
- Nationwide, even small risks may translate into significant numbers.
- Can't tell us whether *this* is one of those rare cases

# Identity: Lucid Intervals

- Lucid Intervals are real; cannot time these brain injuries. Lucid Intervals documented of several hours to 72 hours or more; child may have flu-like symptoms in meantime. M.G.F. Gilliland, *Interval Duration Between Injury and Severe Symptoms in Nonaccidental Head Trauma in Infants and Young Children*, 43 J. FORENSIC SCI. 723 (1998).
  - **See also *Aleman v. Village of Hanover Park*, 662 F.3d 897 (7th Cir. 2011).**
- “The lucid interval is a distinct discomfoting but real possibility.” Dr. Robert Huntington, State’s pathologist testifying that research caused him to change his understanding in this way, in *State v. Audrey Edmunds*.

# False Testimony: No Lucid Interval

Q And according to that story, then, the child would have been up for a period of hours after the accident?

A Yes. That doesn't make sense with this injury.

Q Explain to the members of the jury why not.

A Well, this is the type of injury that's going to give you symptomology if not immediately, within 15 min



# The Changing Science: The Bottom Line

- Scientific advances have undermined the theory that nothing can cause the triad except abuse (mechanism of death)
- Scientific advances have undermined the theory that shaking alone can cause serious brain injury and death with SDH and RH (mechanism and cause of death)
- Scientific advances have undermined the theory the last person with the child must have been the abuser—the injuries cannot be timed (identity)
- Scientific advances have undermined the folklore that the injuries had to have been caused by force equal to a multi-story fall or car crash; can be caused accidentally by short falls (state of mind)
- Scientific advances have established many natural causes for medical findings previously attributed to shaking or abuse



*DAUBERT* CHALLENGES

# Challenging Admissibility of SBS/AHT Testimony

# General Challenges to the SBS/AHT Hypothesis

- Research base
- Circularity
- Failure to explain the mechanism/pathway of injury
- Alternative explanations
- Biomechanical research
- Lack of consensus about many aspects
- Growing recognition of weaknesses in legal, medical, and popular sources

# Differential diagnosis vs determinations about etiology

- Courts have recognized that “differential diagnosis” does not automatically ensure reliability or admissibility
  - [S]imply claiming that an expert used the “differential diagnosis” method is not some incantation that opens the *Daubert* gate to allow an expert's opinions to be admitted at trial. Indeed, it can easily amount to nothing more than medico-legal sophistry used in an attempt to avoid the Court's reliability analysis.

Bowers v. Norfolk S. Corp., 537 F. Supp. 2d 1343, 1360 (M.D. Ga. 2007) aff'd, 300 F. App'x 700 (11th Cir. 2008)

- Courts have recognized that “differential diagnosis” and determinations of etiology are not the same
  - It is too easy to gloss over these two definitions and conclude that they amount to a distinction without a difference. Indeed, courts in various circuits have admitted expert testimony supposedly based on the “differential diagnosis” method, when, in reality, the testimony is based on the “differential etiology” method. The distinction is more than semantic; it involves an important difference. *Id.*



Why is the research base so weak?

Circularity



# Research Objectives & Challenges

- Randomized controlled trials are impossible
- Research typically is retrospective case studies of suspected abuse.
  - Depends on accurately sorting cases into abuse and non-abuse categories

# Methodological Challenges: Sorting Cases of Suspected Abuse

- How do you determine which cases are abuse?
- The circularity challenge
  - Inclusion criteria: SDH, RH, encephalopathy—the very clinical findings being studied

# Attempting to Overcome Circularity: The Typical Hierarchy of Certainty

1. Confessions
2. Legal action taken (whether conviction obtained or not)
3. Strong suspicions of staff (based on the medical signs and a “discrepant” explanation offered by caregiver)

--Suzanne P. Starling, James R. Holden, and Carole Jenny,  
*Abusive Head Trauma: The Relationship of Perpetrators  
to Their Victims*, 95 Pediatrics 259 (1995)



"[C]onfessed shaking ...  
*is the evidentiary basis for  
shaking.*"

Mark S. Dias, *The Case for Shaking, in*  
CHILD ABUSE AND NEGLECT: DIAGNOSIS,  
TREATMENT, AND EVIDENCE, 362, 368  
(Carole Jenny, ed., 2011)

# Confessions: The Gold Standard?

- “The analysis of perpetrators’ admissions of ITBI can be used to evaluate the timing and mechanisms of injury.”  
Starling et al., *Analysis of Perpetrator Admissions to Inflicted Traumatic Brain Injury in Children*, 158 Arch Pediatr Adolesc Med 454 (2004)
- “[A]n argument could be made that the perpetrators were coerced in some manner or that mechanisms were suggested to them. ***An analysis of the investigative techniques involved in eliciting the admissions is beyond the scope of this article.***” *Id.* (emphasis added)

# Confessions

- Not science
- False confessions present in nearly 25% of DNA exonerations
- SBS is especially susceptible to false confessions:
  - Extreme trauma/vulnerability
  - Convincing the suspect he or she is guilty
    - “coerced compliant false confessions”
    - “internalized false confessions”
  - Innocent “shaking”: jostling to alert child, etc.
    - Dr. Caffey’s seminal 1972 article includes “burpings,” a mother’s “confession” that “she and her husband ‘might have shaken [the infant] when he cried at night,’” and a case in which a mother said she yanked a child to prevent him from falling off a bassinet onto the floor.

# 2011

- *Aleman v. Village of Hanover Park*, 662 F.3d 897 ( 7<sup>th</sup> Cir. 2011):
  - Posner, J.: “Not being a medical expert, Aleman could not contradict what was represented to him as settled medical opinion. He had shaken Joshua, albeit gently; but if medical opinion excluded any other possible cause of the child's death, then, gentle as the shaking was, and innocently intended, it *must* have been the cause of death. Aleman had no rational basis, given his ignorance of medical science, to deny that he had to have been the cause.”

“If a question has only two answers—*A* and *B*—and you tell the respondent that the answer is not *A*, and he has no basis for doubting you, then he is compelled by logic to “confess” that the answer is *B*. That was the vise the police placed Aleman in. They told him the only possible cause of Joshua’s injuries was that he’d been shaken right before he collapsed; not being an expert in shaken-baby syndrome, Aleman could not deny the officers’ false representation of medical opinion. And since he was the only person to have shaken Joshua immediately before Joshua’s collapse, it was a logical necessity that he had been responsible for the child's death. Q.E.D. A confession so induced is worthless as evidence....”

# 2014

## *People v. Adrian Thomas*

22 N.Y.3d 629 (2014)

Confession to SBS/AHT was coerced:

“Every scenario of trauma induced head injury equal to explaining the infant’s symptoms was suggested to defendant by his interrogators. Indeed, there is not a single inculpatory fact in defendant’s confession that was not suggested to him.”



# Bottom Line: Without the Triad There Are No Standardized Diagnostic Criteria

SBS/AHT looks different to  
different health care providers

# Diagnosis without Criteria

- “Gold standard definitional criteria for AHT do not exist. ... [I]n the absence of a gold standard, clinicians rarely confirm or exclude AHT with complete certainty and are compelled instead to adopt a probabilistic approach to the diagnosis.”
  - Kent P. Hymel, *et al. Derivation of a Clinical Prediction Rule for Pediatric Abusive Head Trauma*, 14 (No. 2) PEDIATR CRITI CARE MED. 2013 Feb;14(2):210-20, 212.



# Without Standards, What Does One Even Look For?

- Queens case: child suffered seemingly insignificant fall at mall playground, later died, discovery of mall surveillance videotape caused doctors to seek non-abusive cause
  - Child found to have Factor 13 deficiency, rare clotting disorder; difficult to diagnose because blood test results are normal; requires special testing
- Antwerp case: child suffered repeated incidents of SDH with different caregivers and no major trauma, caused doctors to seek non-abusive cause, found delta storage pool disease, rare disorder not discoverable with routine tests; requires special and expensive tests.

# Cross-Examination of Dr. Sandeep Narang in *People v. Bailey*

Q. ... And would you agree that in fact diagnosis of abusive head trauma and even more so Shaken Baby Syndrome is particularly challenging because there are no gold standards -- no gold standard definitional or diagnostic criteria?

A. That's true for many medical diseases, sir.

Q. It's certainly true here?

A. Yes, sir.

Q. For example, you might find Shaken Baby Syndrome in part based on the presence of subdural hematomas?

A. Correct, sir.

Q. But you also might find if there are no subdural hematomas?

A. Correct, sir.

Q. You might find it if there are retinal hemorrhages?

A. Correct, sir.

Q. But you might find it if there are not retinal hemorrhages?

A. Correct, sir.

Q. You might find it if there are contusions?

A. Correct, sir.

Q. You might find it if there are not contusions?

A. Correct, sir.

Q. You might find it if there's skull fractures?

A. Yes, sir.

Q. Or not skull fractures?

A. Yes, sir.

Q. So I think this goes to the judge's question earlier what is the diagnostic standard here?

A. The diagnostic standard you have to collate all the pieces of evidence that are presented with a particular case, rule out other possible causes that includes history causes and come to your best probable estimate of what the diagnosis is.

# Clinical Judgment

- Proponents of the hypothesis: In the absence of high-quality research, must rely on clinical judgment. (Narang, *A Daubert Analysis of Abusive Head Trauma/Shaken Baby Syndrome*, 11 Hous. J. Health L. & Pol'y 505 (2011)).
- Introduces subjectivity that infects other forensic sciences
- Is different than clinical judgment in treatment contexts
- Barred by *Daubert*: “in circumstances when experience alone does not resolve the main doubts about reliability, it would be irrational, and therefore an abuse of discretion to rely upon it.” (Risinger, *Defining the “Task at Hand”: Non-Science Forensic Science after Kumho Tire Co. v. Carmichael*, 57 Wash. & Lee L. Rev. 767, 773 (2000).)

# The *ipse dixit* of a proposed expert is not a methodology



- The number of cases a doctor has treated, however impressive, is not a valid method of diagnosis
- Method must rest upon scientific principles
- Method must be able to be tested
- Method should be articulable

# Error in Medical Diagnosis

- Graber et al., *Bringing Diagnosis Into the Quality and Safety Equations*, 308 JAMA 1211 (2012)
  - “Cases of delayed, missed and incorrect diagnoses are common, with an incidence in the range of 10%-20%.”
  - Error is higher in clinical diagnoses and lower with respect to diagnostic tests
- Berner & Graber, *Overconfidence as a Cause of Diagnostic Error in Medicine*, Amer. J. of Med. (2008) Vol. 121, S2-S23
  - “[I]t is clear that an extensive and ever-growing literature confirms that diagnostic errors exist at nontrivial and sometimes alarming rates. These studies span every specialty and virtually every dimension of both inpatient and outpatient care.”

# The ear infection analogy

Narang & Greeley, *What Child Welfare Attorneys Need to Question About the Innocence Project's Information on Shaken Baby Syndrome/Abusive Head Trauma*, NACC The Guardian, Vo. 37 No. 03 April/May 2015:

“For example, ear infections can be diagnosed with any of the following criterion: fever, ear pain, a red ear drum, pus or fluid behind the ear drum, and a lack of mobility of the ear drum. Thus, can an ear infection be diagnosed with or without “fever”? Yes. Can it be diagnosed with or without “ear pain”? Yes. Can it be diagnosed with or without “a red ear drum”? Yes. Can it be diagnosed with or without “pus or fluid behind the ear drum”? Yes. As is patently clear, the lack of a necessary criterion has no logical bearing upon the validity of the diagnosis.”



# The ear infection analogy

But even at that, the data show that pediatricians *misdiagnose* ear infections an average of 50% of the time.

- Pichichero & Poole, “Assessing Diagnostic Accuracy and Tympanocentesis Skills in the Management of Otitis Media,” 155 Arch Pediatr Adolesc Med. 1137 (2001).

The high rate of misdiagnosis of ear infections consists largely of *over-diagnosis* (type 1 errors) and over-reliance on antibiotics.

- Pichichero & Poole, “Assessing Diagnostic Accuracy and Tympanocentesis Skills in the Management of Otitis Media,” 155 Arch Pediatr Adolesc Med. 1137 (2001); Rosenfeld R. Diagnostic certainty for acute otitis media. 64 Int J Pediatr Otorhinolaryngol. 89 (2002); Pichichero ME, Poole MD, Comparison of performance by otolaryngologists, pediatricians, and general practitioners on an otoendoscopic diagnostic video examination. 69 Int J Pediatr Otorhinolaryngol. 361 (2005 ).

# The Ear Infection Analogy

- And the reason cited for this in the literature is that there is no gold-standard diagnostic standard for ear infection.
  - See, e.g., Coker et. al. “Diagnosis, Microbial Epidemiology, and Antibiotic Treatment of Acute Otitis Media in Children: A Systematic Review” 304 JAMA 2161 (2010)
- For ear infection, there in fact is ultimately a confirmatory test such that the rate of error can be objectively quantified: ear infection can be confirmed by draining the fluid in the ear, looking at it under the microscope, and culturing it for bacteria (although even this method has significant room for error and is not always accurate).

# Cognitive Errors

- Berner & Graber:
  - *Cognitive errors*: “reflect problems gathering data, such as failing to elicit complete and accurate information from the patient; failure to recognize the significance of data, such as misinterpreting test results; or most commonly, failure to synthesize or ‘put it all together.’”

- Berner & Graber on cognitive biases and diagnostic “overconfidence”:
  - Faulty heuristics
  - Premature closure—narrowing the choice of diagnostic hypotheses too early in the process
  - Two alternative models:
    - The hypothetical deductive mode of diagnostic reasoning, much like the scientific method (develop an initial hypothesis and then gather more data to evaluate the hypothesis); vs.:
    - Pattern recognition process: Top-down processing common among experts, involving recall of prior similar cases, attending to prototypical features, or similar strategies

# Bias in Patient History

Q. Nowhere in the history that you reviewed did anyone report seeing Rene Bailey do anything abusive to Brittney, right?

A. That's correct.

Q. And nobody reported her shaking Brittney, right?

A. That's correct.

Q. In fact, the two -- of the two witnesses that were present when Brittney had her fatal event, one child said she jumped or fell off the chair and the other one said I didn't see anything, correct?

A. That's correct. Cameron was the only one who spoke of it or had seen it, thought he had seen it.

Q. I guess my question is how is that history inconsistent with a fall?

# Context Biases

How much “history” should the physician consider. E.g., one pediatrician recently testified that his assessment of the history includes:

“How did the caretaker react when the child was injured? Did they go have a smoke before they called 911 after the kid stopped breathing?”

# Berner & Graber

- Major source of diagnostic error, related to physician overconfidence:
  - **Inadequate feedback:** “[F]eedback that is delayed or absent may not be recognized for what it is, and the perception that ‘misdiagnosis is not a big problem’ remains unchallenged. That is, in the absence of information that the diagnosis is wrong, it is assumed to be correct ....”

# The Problem of Absent Feedback

- Gordon D. Schiff, *Minimizing Diagnostic Error: The Importance of Follow-up and Feedback*. American Journal of Medicine (2008) Vol. 121, S38-S42
  - “An open-loop system (also called a ‘nonfeedback controlled’ system) is one that makes decisions based solely on preprogrammed criteria and the preexisting model of the system. This approach does not use feedback to calibrate its output or determine if the desired goal is achieved. ... [Such systems] cannot engage in learning.”
  - “[F]eedback on patient response is critical for knowing not just how the patient is doing but how we as clinicians are doing.”



# Feedback as an Antidote to Cognitive Bias

- Schiff: “Carefully refined signals from downstream feedback represent an important antidote to a well-known cognitive bias, *anchoring*, i.e., fixing on a particular diagnosis despite cues and clues that such persistence is unwarranted.”

The feedback gap in medicine is  
especially pronounced in the  
diagnosis of child abuse

# The effects of bias on clinical judgment

- People's brief: "Dr. Waldman testified that the biomechanical testimony from Kenneth Monson, which he listened to, does not change his opinion because that testimony does not match up with what he has seen as a pediatric neurosurgeon; he has not seen Brittney's pattern of injuries resulting from short."
- This is confirmation bias and circular reasoning in action. Of course Dr. Waldman never sees injuries like Brittney's from short falls *if he believes that short falls cannot cause such injuries and therefore always concludes that the cause must be abuse.*

# Specific *Daubert/Frye* Challenges—Exclude Proven False Claims

- Certain symptoms are pathognomonic of abuse (cannot be caused by anything else)
- Short falls can't kill/aren't dangerous
- The force required to cause the signs commonly associated with abuse or shaking are massive, equivalent to a multistory fall or a car accident
- Lucid intervals can't happen
- Chronic subdural collections cannot rebleed
- Fractures mean abuse
- The likelihood that a particular case is abuse, given the signs present, is X%
- Qualifications of the particular expert to testify about matters beyond her expertise



# Putting it All Together: The Meta-Analyses

- Maguire, S.A., et al., Estimating the probability of abusive head trauma: A pooled analysis, 128 PEDIATRICS 550 (2011)
- Piteau, S.J., et al., Clinical and Radiographic Characteristics Associated With Abusive and Nonabusive Head Trauma: A Systematic Review, 130 PEDIATRICS 315 (2012)

# Piteau

## Limitations of the Review

The meta-analysis for this review was made difficult by inconsistencies in the criteria used to determine the etiology for head trauma, inconsistencies in defining and reporting clinical and radiographic variables, and a moderate to high degree of statistical heterogeneity between studies. As there are no standardized criteria for the definition of abuse, most authors developed their own criteria, and many of these are fraught with circular reasoning. The di-

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# Piteau's Results

Subdural hemorrhage(s)					
All studies	15	8.92	(6.77–11.74)	0	<.001
High-quality studies	14	8.90	(6.75–11.73)	0	<.001
Epidural hemorrhage(s)					
All studies	10	0.15	(0.08–0.29)	0	<.001
High-quality studies	9	0.13	(0.06–0.26)	0	<.001
Subarachnoid hemorrhage(s)					
All studies	13	1.42	(0.67–3.0)	76	.36
High-quality studies	11	1.31	(0.58–3.0)	80	.52
Cerebral edema					
All studies	9	2.17	(1.06–4.45)	54	.03
High-quality studies	7	2.05	(0.82–5.10)	65	.12
Retinal hemorrhage(s)					
All studies	14	27.12	(15.70–46.84)	24	<.001
High-quality studies	12	28.24	(15.37–51.90)	35	<.001
Metaphyseal fracture(s)					
No adequate history					
All studies	9	46.94	(12.91–170.63)	69	<.001
High-quality studies	8	52.72	(12.79–217.33)	72	<.001

# Maguire

Diagnostic studies in this field are open to criticism of circularity because of their dependence on a constellation of clinical features, as opposed to a single gold-standard diagnostic test, which does not exist. Ultimately, in any individual case, a child either has, or has not, suffered AHT and, consequently, a diagnosis of AHT either is, or is not, correct. However, except in cases of independently witnessed injury, a diagnosis must rest on a probabilistic assessment of how likely it is that AHT took place. It is not possible to restrict research in this field to independently witnessed abuse, which represents a tiny proportion of cases.

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# Maguire's Results

of AHT. We have shown that in a child younger than 3 with an ICI and 1 or 2 of the key clinical features, the probability of AHT varied depending on the number and specific features present, with RHs and rib fractures being the most discriminating. Three or more of the key features were highly predictive of AHT. This analysis offers the potential

even for strongly influential features, such as RHs, not all cases were because of AHT, as shown by a PPV of 58% for those children with an ICI and RHs and no other clinical features. These data includes the most challenging clinical scenario, namely the likelihood of abuse when a child has ICI but none of the other distinguishing clinical features. For a child younger than 3 with an ICI alone, the estimated probability that the brain injury is an AHT is 4% in this data set.

# Resources

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