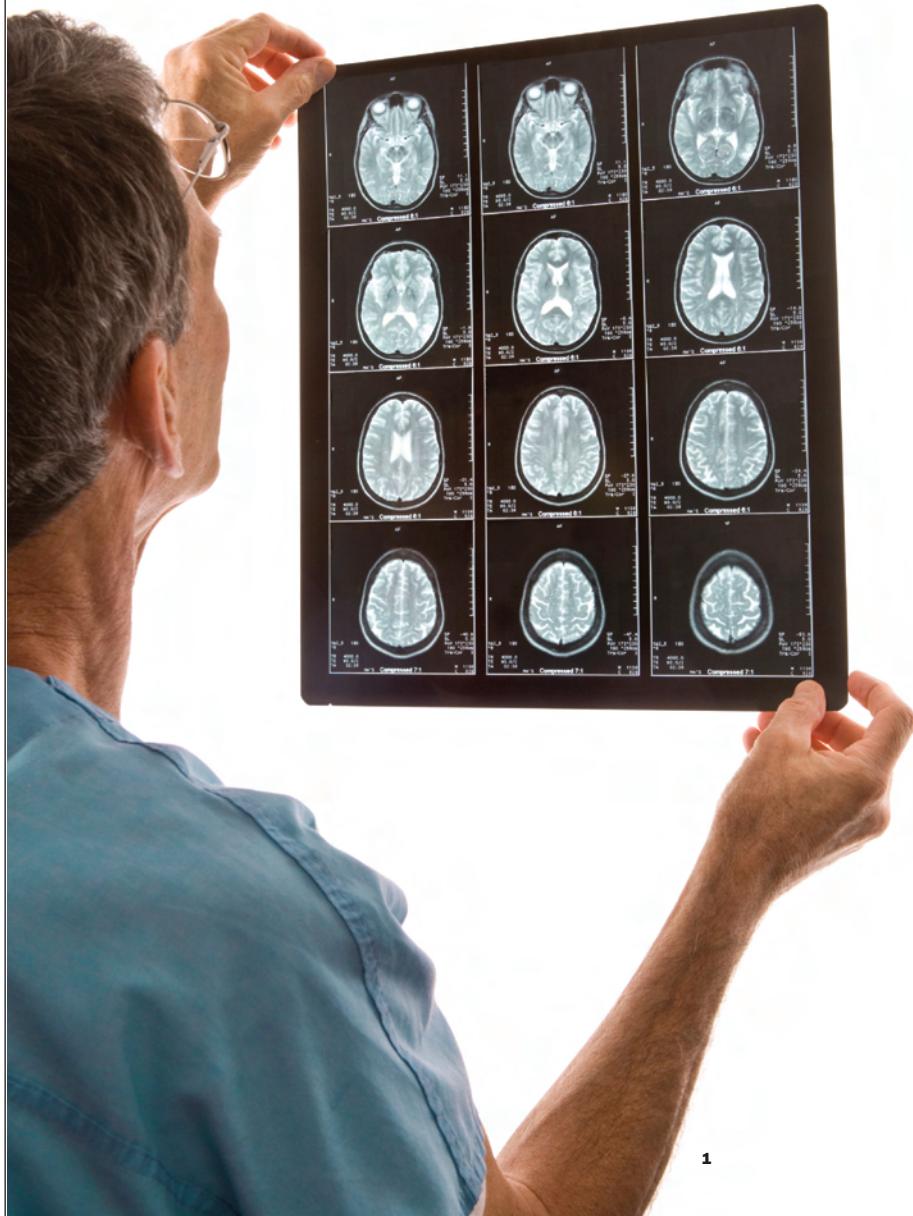


A Critical Look at the Shaken Baby Syndrome

By Roger H. Kelly and Zachary M. Bravos

Recent research shows that factors other than abuse may be the cause of damage thought to result from shaking, these defense lawyers argue.

Approximately 1,400 infants and young children are reported to suffer brain injury as a result of abuse each year in the U.S.¹ Violent shaking is considered to be a leading cause of those injuries.² The theory that violent shaking causes brain injuries in infants and young children is referred to as shaken baby syndrome. Is the theory valid?



That question is critically important to those accused of shaking a child. Each year, many parents and child caregivers are accused of child abuse as a result of shaken baby syndrome. Two specific findings, subdural hematoma (bleeding between the brain and the skull) and bilateral retinal hemorrhaging (bleeding behind the eye), are considered classic signs of shaken baby syndrome.

And in the classic case, the allegation of shaking is sustained solely by these two findings of internal bleeding. There are no long-bone injuries, spiral fractures, skull fractures, evidence of impact or blunt trauma, bruising, or other indications or evidence that abuse has occurred.

Neglect and abuse proceedings and lengthy prison sentences often result from prosecutions based on the shaken baby syndrome. These serious, life-changing outcomes for those accused demand that

1. Center for Disease Control: *Facts for Physicians*, http://www.cdc.gov/ncipc/tbi/Facts_for_Physicians_booklet.pdf, p10.

2. Center For Disease Control: *Preventing Injuries in America: Public Health in Action*, http://www.cdc.gov/ncipc/fact_book/Preventing%20Injuries%20in%20America%20Public%20Health%20in%20Action-2006.pdf, p 42.

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the theory be scrutinized and its validity tested.

Though shaken baby syndrome is still embraced by the medical establishment, some forensic scientists sharply criticize the theory as rooted in anecdote, bad study, and speculation. Some biomechanical experts, pathophysologists, physicians, medical specialists, and medical researchers have tested elements of the theory and have established a growing body of evidence challenging many of its assumptions.

This article briefly discusses this scientific evidence. But first it looks at court rulings that have critically examined the foundations of the shaken baby syndrome.

Some courts question the syndrome

Recent challenges have been successful at the trial court level in *Frye* and *Daubert* hearings.³ In April 2006, a Kentucky circuit court ruled that in the absence of other evidence of abuse, the

Similarly, in late 2001, the supreme court of the Australian Capital Territory reviewed the science behind an accusation of shaking based upon subdural hemorrhages and bilateral retinal bleeding in the absence of other injuries.⁷ The Crown's theory was that the "constellation" of injuries was caused by shaking. Seven Crown experts testified, over objection, in support of the theory. Nevertheless, the court found "The evidence revealed a paucity of empirical research on potentially critical issues."⁸ The high court ruled as follows:

I find that the evidence was not admissible to the effect that the injuries were caused in that manner [shaking], whether by the accused or otherwise, or that they could only have been caused in that manner. The evidence suggests that such opinions would not be based wholly or even substantially on the expert's specialized body of knowledge as a pediatrician but [] on a combination of speculation, inference, and a process of reasoning beyond the relevant field of expertise.⁹

Empirical research is now being conducted that examines the basic hypothesis behind the theory that shaking can and does cause the injuries observed.

en Infant Syndrome.¹³ He drew upon the Guthkelch article, a *Newsweek* magazine article, and the work of Ommaya.

However, in 2002 Ommaya questioned the applicability of his research to support the shaken baby syndrome theory, commenting as follows:

[O]ur experimental results were referenced as providing the experimental basis of the "shaken baby syndrome" (SBS) by Caffey, Gulthkelch and others by analogy not realizing that the energy level of acceleration in our work related to speeds at motor vehicle crashes at 30 mph.¹⁴

In suggesting that the associated findings of subdural hematoma and retinal hemorrhages could be sufficient diagnostic criteria to determine abuse, Caffey acknowledged that the evidence supporting his theory was contrary to medical expectations.

The most characteristic pattern of physical findings in the whiplashed infant is the absence of external signs of trauma to the head and the soft tissues of the face and neck, and of the facial bones and calvaria, in the presence of massive traumatic intracranial and intraocular bleedings. This is an extraordinary diagnostic contradiction.¹⁵

Recent challenges to the theory have been successful at the trial court level in *Frye* and *Daubert* hearings.

theory of shaken baby syndrome could not be introduced.⁴ The Wisconsin Appellate Court recently acknowledged the controversy regarding the shaken baby syndrome theory by granting a new trial to a convicted babysitter who had been imprisoned for over 10 years.⁵

Overseas courts have also ruled against the admissibility of the theory. In 2005, the court of appeals in the United Kingdom overturned two convictions for murder and reduced the charges on a third, all of which were based upon the theory of shaken baby syndrome.⁶ In each case, there was no other evidence about what happened and no evidence of earlier ill treatment. The court rejected the claim that subdural hematoma and retinal hemorrhaging automatically lead to a conclusion of unlawful killing or injury.

dren of "proved or strongly suspected parental assault." He did not disclose how these assault determinations were made.

Of this group, five children had subdural hematoma with no evidence of direct trauma to the head. Guthkelch theorized that repeated shaking rather than direct impact was the cause of these hematomas. He compared such shaking to two cases of adults suffering subdural hematoma as a result of automobile whiplash injury in rear-end collisions published by Dr. Ayub Ommaya in 1968.¹¹

The shaken baby syndrome theory was brought further attention by Dr. John Caffey in his 1972 article *On the Theory and Practice of Shaking Infants*¹² and his 1974 paper *The Whiplash Shak-*

3. Florida (*Johnson v Florida*, 933 So2d 568 (Fla 2006); and *Florida v Sanidad*, 00-524 CFFA (Cir Ct Flager Cty 2006); Oklahoma (*Oklahoma v Watts*, CF-2001-43 (D Ct Woods Cty, Okla 2002)); Missouri (*Missouri v Hyatt*, 06 M7-CR00016-02 (Cir Ct Shelby Cty, MO), Order dated November 6, 2007); Tennessee (*People v Maze*, M2000-02249-CCA-R3-CD (Tenn Ct App Davidson Cty Tenn 2002); and Ohio (*Ohio v Mills*, 2006 CR 100315 (Ct Com Pleas, Tuscarawas Cty, Ohio 2006)).

4. *Commonwealth Of Kentucky v Davis*, 04 CR 205. Trial Court Opinion April 17, 2006 (Greenup Circuit Court). <http://www.aapsonline.org/sbs/daubert.pdf>.

5. *State v Edmonds*, 308 Wis 2d 374, 746 NW2d 590 (2008).

6. *Shaken baby convictions overturned*, <http://www.guardian.co.uk/society/2005/jul/21/childrensservices.childprotection>.

7. *The Queen v Stuart Lee*, SCC 69 of 2000 (Sup Ct Australian Capital Territory, Canberra), 2002 WL 14350.

8. Id at para. 46.

9. Id at para. 52.

10. A. N. Guthkelch, *Infantile Subdural Haematoma and its Relationship to Whiplash Injuries*, British Medical Journal 2, 430-31 (1971).

11. A. Ommaya, F. Faas, P. Yarnell, *Whiplash, Injury and Brain Damage*, JAMA, 204(4) 285-89 (1968).

12. J. Caffey, *On the Theory and Practice of Shaking Infants*, American Journal of the Disease of Children 124, 161-69 (1972).

13. J. Caffey, *The Whiplash Shaken Baby Syndrome: Manual Shaking by the Extremities With Whiplash-Induced Intracranial and Intraocular Bleedings, Linked With Residual Permanent Brain Damage and Mental Retardation*, Pediatrics 54, 396-403 (1974).

14. A. Ommaya, W. Goldsmith, L. Thibault, *Bio-mechanics and Neuropathology of Adult and Pediatric Head Injury*, British Journal of Neurosurgery, 16(3):220-42 (2002).

15. Caffrey, *The Whiplash Shaken Baby Syndrome* at 403 (cited in note 11).

This “extraordinary diagnostic contradiction” remains unresolved. Indeed, the lack of external evidence of trauma is the most troubling aspect of the shaken baby syndrome theory because it raises the obvious question: can an infant be shaken with sufficient force to cause brain injury and leave no external evidence of trauma?

Many articles and papers advanced in support of the shaken baby syndrome

reasonable person would expect injury. It is extremely violent and clearly abusive. A defendant’s claim of innocence often fails in the face of the expert testimony that the only way subdural hematoma and retinal hemorrhages can be caused (other than some extremely rare genetic conditions) is through violent shaking.

However, obvious questions arise. Why is there no evidence of external trauma? Why are there no grab marks on the body? Why are there no injuries to the infant neck, a structure that seems so weak and vulnerable? This is Caffey’s “extraordinary diagnostic contradiction.”

Can an infant be shaken so violently as to cause the shaken baby markers without any sign of external injury? The science of biomechanics, the application of mechanical principals to living organisms, has studied this question.

Experiments have called into question the shaken baby syndrome theory.

In 1987 Ann-Christine Duhaime, et al¹⁷ sought to quantify the forces involved in manual shaking of an infant. Model dolls were constructed, fitted with accelerometers, and then shaken.

The results demonstrated that shaking alone could only generate about 25 percent of the angular acceleration needed to cause brain concussion and only about 7 percent of the angular acceleration required to cause subdural hematoma. The authors concluded that “the angular acceleration and velocity associated with shaking occurs well below the injury range.”¹⁸

This result has since been replicated. In 2003, Prange, et al, used more realistic baby models and obtained similar

results. Shaking, even with impact on foam, could not produce enough force to cause brain injury, including subdural hematoma.¹⁹

Even Dr. Ommaya, whose primate studies were used by Caffey and Guthkelch, confirms that shaking alone produces maximum angular acceleration “well below thresholds for cerebral concussion, SDH (subdural hematoma), subarachnoid haemorrhage, deep brain haemorrhages and cortical contusions.”²⁰

Other causes of subdural hematoma

A variety of conditions known and unknown can cause subdural hematomas. For example, subdural hematomas are a known complication of childbirth.²¹ They can occur with no history of birth trauma and have even been described prenatally.²² Hemorrhages have been found in 70 percent of infants who died from non-traumatic causes, some with bleeding identical to cases presented as classic “Shaken Baby Syndrome.”²³

In a recent survey of asymptomatic newborns, 16 percent had subdural hematomas. Fully 26 percent had some form of intracranial bleed.²⁴ There is no suggestion that these children were abused.

Older infants with external hydrocephalus commonly suffer subdural hemorrhages.²⁵ Children with external

16. M. Donohoe, *Evidence-Based Medicine and Shaken Baby Syndrome Part I: Literature Review*, 1966–1998, American Journal of Forensic Medicine and Pathology 24(3), 239–42 (2003).

17. A. C. Duhaime, T. Gennarelli, L. Thibault, D. Bruce, S. Margulies, R. Wiser, *The Shaken Baby Syndrome, A clinical, pathological, and biomechanical study*, Journal of Neurosurgery 66: 409–15 (1987).

18. Id at 414.

19. M. Prange, B. Coats, A. C. Duhaime, S. Margulies, *Anthropomorphic simulations of falls, shakes, and inflicted impacts in infants*, Journal of Neurosurgery 99, 143–50 (2003).

20. A. Ommaya, W. Goldsmith, L. Thibault, *Biomechanics and neuropathology of adult and pediatric head injury*, British Journal of Neurosurgery, 16(3):220–42 (2002).

21. S. Chamnanvanakij, N. Rollins, J. Perlman, *Subdural Hematoma in Term Infants*, Pediatric Neurology 26(4), 301–04 (2002).

22. Id.

23. J. Geddes, R. Taskert, A. Hackshaw, C. Nickols, G. Adams, H. Whitwell, I. Scheimberg, *Dural haemorrhage in non-traumatic infant deaths: does it explain the bleeding in ‘shaken baby syndrome’?*, Neuropathology and Applied Neurobiology 29, 14–22 (2003).

24. C. Looney, et al, *Intracranial Hemorrhage in Asymptomatic Neonates: Prevalence on MR Images and Relationship to Obstetric and Neonatal Risk Factors*, Radiology, 242(2) 535–41 (2007).

25. P. McNeely, J. Atkinson, G. Saigal, A. O’Gorman, J. Farmer, *Subdural Hematomas in Infants with Benign Enlargement of the Subarachnoid Spaces Are Not Pathognomonic for Child Abuse*, American Journal of Neuroradiology, 27:1725–28 (2006).

Discover looks at SBS

The lay science magazine *Discover* took up the syndrome last December in its article *Does the Shaken Baby Syndrome Really Exist?* In addition to reviewing the scientific debate, it discusses a Rantoul case in which charges against a parent were ultimately dropped and includes quotes from Urbana lawyer and ISBA member Kristen Fischer.

The article is on the Web at <http://discovermagazine.com/2008/dec/02-does-shaken-baby-syndrome-really-exist>.

hydrocephalus are subject to spontaneous subdural hematoma at a rate of up to 11 percent.²⁶

Other causes of retinal hemorrhages

Proponents of shaken baby syndrome argue that retinal hemorrhages are caused by mechanical traction on the optic nerve and retina during shaking.²⁷ However, the exact cause of retinal hemorrhages remains unknown.²⁸ There appears to be a relationship to increased intracranial pressure, which has been known for decades.²⁹ Extensive, bilateral retinal hemorrhages that in other contexts could lead to diagnoses of shaken baby syndrome have been described in cases of external hydrocephalus.³⁰

Retinal hemorrhages are common. Approximately 30 percent of children are born with them.³¹ Since children are not routinely screened for retinal hemorrhage, there is no good data regarding their rate of occurrence for older infants. However, the fact that they are common and related to many other conditions, known and unknown is well documented.³²

Concurrence of subdural hematoma and retinal hemorrhage

Retinal hemorrhage and subdural hematoma are found together, at reported rates of 65-95 percent.³³ However, the relation, if any, between these two conditions remains unproven.

Proponents of shaken baby syndrome assert that manual shaking causes these conditions. However, the cause(s) of retinal hemorrhages, as already noted, is unknown, with several theories postulated but none proven.

Both subdural hematoma and retinal hemorrhage can appear at birth or from multiple non-traumatic causes. To argue that they are causally related to manual shaking goes beyond the evidence. They may be related as a result of a third or even multiple different causes as yet undetermined.

For example, there is a body of research that asserts that retinal hemorrhages are caused by increased intracra-

nial pressure.³⁴ Further, subdural hematoma is a competent medical cause for increased intracranial pressure.³⁵

Therefore, it follows that subdural hematoma, from whatever cause, may also be associated with retinal hemorrhage. In other words, subdural hematoma and retinal hemorrhages may be correlated by a third factor – increased intracranial pressure – not presumed shaking.

To conclude that manual shaking causes both subdural hematoma and retinal hemorrhage because they occur together in instances where it is theorized that manual shaking has occurred is to construct a circular argument that fails in its proof because the truth of what it seeks to prove is assumed.

Biomechanics and the neck

If an act of manual shaking is sufficiently violent to cause subdural hematoma and retinal hemorrhaging, how then does the violently shaken infant escape serious neck injury?

The mechanical limitations of the infant neck can be determined. In 2005, Dr. Faris Bandak performed biomechanical research on infant shaking and its consequences on the head-neck to determine if it is possible for the infant neck to withstand Shaken Baby Syndrome defined levels of head accelerations without injury.³⁶ The study concluded that cervical spine or brain stem injuries, perhaps even lethal injuries, would occur “at levels well below those reported for the Shaking Baby Syndrome.”³⁷ Peer review of this work is supportive.³⁸

Conclusion

No one would disagree that the protection of innocent children is a laudable goal. However, this protection must be grounded in reproducible scientific concepts. We have an obligation to put science to the test lest the innocent become victims themselves.

The history of medicine is filled with unwise and unfortunate diagnostic approaches and failed theories of causation, healing, and disease. Until we learn all that there is to know about all aspects of medical science, such failures are to be

expected and represent a normal course of learning.

As attorneys we are not only advocates, we are an integral part of the legal system, a system engaged in the truth seeking process. Justice is served when we are open to considering well-grounded research, even when it challenges long-established theories. ■

26. J. Piatt, *A pitfall in the diagnosis of child abuse: external hydrocephalus, subdural hematoma, and retinal hemorrhages*, Neurosurgical Focus 7 (4): Article 4, (1999).

27. A. Ommaya, W. Goldsmith, L. Thibault, *Biomechanics and neuropathology of adult and pediatric head injury*, British Journal of Neurosurgery, 16(3):220-42 (2002).

28. A. C. Duhaime, C. Christian, L. Rorke, R. Zimmerman, *Nonaccidental Head Injury in Infants - The "Shaken-Baby Syndrome,"* The New England Journal of Medicine, 338(25):1822 – 1829 (1998). J. Geddes, G. Talbert, *Paroxysmal coughing, subdural and retinal bleeding: a computer modeling approach*, Neuropathology and Applied Neurobiology 32, 625-34 (2006).

29. P. Muller, J. Deck, *Intraocular and optic nerve sheath hemorrhage in cases of sudden intracranial hypertension*, Journal of Neurosurgery 41, 160–66 (1974). A. Ommaya, W. Goldsmith, L. Thibault, *Biomechanics and neuropathology of adult and pediatric head injury*, British Journal of Neurosurgery, 16(3):220-42 (2002). R. Uscinski, *Shaken Baby Syndrome: fundamental questions*, British Journal of Neurosurgery, 16(3): 217-19 (2002).

30. J. Piatt, *A pitfall in the diagnosis of child abuse: external hydrocephalus, subdural hematoma, and retinal hemorrhages*, Neurosurgical Focus, 7(4): Article 4, (1999).

31. J. Baum, C. Bulpitt, *Retinal and Conjunctival Haemorrhage in the Newborn*, Archives of Disease in Childhood 45, 344-49 (1970).

32. P. Barnes, *Ethical Issues in Imaging Nonaccidental Injury: Child Abuse*, Topics in Magnetic Resonance Imaging 13(2), 86-93 (2002). H. Gardner, *A Witnessed Short Fall Mimicking Presumed Shaken Baby Syndrome (Inflicted Childhood Neurotrauma)*, Pediatric Neurosurgery 43, 433-35 (2007). Geddes and Talbert, *Paroxysmal coughing at 625-34* (2006) (cited in note 24). M. Goetting, B. Sowa, *Retinal Hemorrhage after Cardiopulmonary Resuscitation in Children: An Etiologic Reevaluation*, Pediatrics 85(4), 585-88 (1990). P. Lantz, *Researchers Say Criterion for Diagnosing Child Abuse Not Always Accurate*, Science Daily, 02-26-2006. P. Lantz, S. Sinal, C. Stanton, R. Weaver, *Evidence based case report, Perimacular retinal folds from childhood head trauma*, British Medical Journal 328, 754-56 (2004).

33. Duhaime, et al, *Nonaccidental Head Injury at 1822-29* (cited in note 24).

34. Muller and Deck, *Intraocular and optic nerve at 160–66* (cited in note 25).

35. Uscinski, *Shaken Baby Syndrome at 217-19* (cited in note 25).

36. F. Bandak, *Shaken baby syndrome: a biomechanics analysis of injury mechanisms*, Forensic Science International, 151(1): 71-79 (2005).

37. Id.

38. Geddes and Talbert, *Paroxysmal coughing at 625-34* (2006) (cited in note 24). R. Uscinski, *Shaken Baby Syndrome: An Odyssey*, Neural Med Chir (Tokyo) 46, 57-61 (2006).

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