Can Shaking Hurt Babies?

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Has a Flawed Diagnosis Put Innocent People In Prison?

A RE-EXAMINATION OF SHAKEN-BABY SYNDROME.

BY EMILY BRECLON
Shaken-Baby Syndrome Faces New Questions in Court

Noah Whitmer, now 2, with his parents, Erin and Michael Whitmer, can nod his head “yes,” but he is not yet talking. He wears a patch for a period of time each day to correct his vision.

By EMILY BAZELON
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Is there Credible Evidence for Abusive Head Trauma?

- “Shaken baby syndrome is a theory only”
- Not true—multiple people have told every doctor who takes care of abused children that they have shaken their babies and the babies collapsed in my arms.
- Research confirms this—
Is there Credible Evidence for Abusive Head Trauma?

“The biomechanical literature demonstrates to a reasonable degree of scientific certainty that injuries seen in abusive head trauma cannot be caused by shaking alone.”
The shaken baby syndrome

A clinical, pathological, and biomechanical study

Ann-Christine Duhaime, M.D., Thomas A. Gennarelli, M.D.,
Lawrence E. Thibault, Sc.D., Derek A. Bruce, M.D.,
Susan S. Margulies, M.S.E., and Randall Wiser, M.S.E.

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Because a history of shaking is often lacking in the so-called “shaken baby syndrome,” diagnosis is usually based on a constellation of clinical and radiographic findings. Forty-eight cases of infants and young children with this diagnosis seen between 1978 and 1985 at the Children’s Hospital of Philadelphia were reviewed. All patients had a presenting history thought to be suspicious for child abuse, and either retinal hemorrhages with subdural or subarachnoid hemorrhages or a computerized tomography scan showing subdural or subarachnoid hemorrhages with interhemispheric blood. The physical examination and presence of associated trauma were analyzed; autopsy findings for the 13 fatalities were reviewed. All fatal cases had signs of blunt impact to the head, although in more than half of them these findings were noted only at autopsy. All deaths were associated with uncontrollably increased intracranial pressure.

Models of 1-month-old infants with various neck and skull parameters were instrumented with accelerometers and shaken and impacted against padded or unpadded surfaces. Angular accelerations for shakes were smaller than those for impacts by a factor of 50. All shakes fell below injury thresholds established for subhuman primates scaled for the same brain mass, while impacts spanned concussion, subdural hematoma, and diffuse axonal injury ranges. It was concluded that severe head injuries commonly diagnosed as shaking injuries require impact to occur and that shaking alone in an otherwise normal baby is unlikely to cause the shaken baby syndrome.

Key Words • shaken baby syndrome • head injury • child abuse
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<th>Duhaime's data</th>
<th>Adult injury threshold</th>
<th>Infant injury threshold</th>
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<td>Peak tangential acceleration</td>
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<td>Time of applied force</td>
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Duhaime’s Data on Effects of Shaking an Infant Model

- Peak linear acceleration (top of head) = 9.29 G
- Peak angular velocity = 60.68 rad/sec
- Peak angular acceleration = 1168.54 rad/sec²

“...shaken baby syndrome, at least in its most severe acute form, is not usually caused by shaking alone. Although shaking may, in fact, be a part of the process, it is more likely that such infants suffer blunt impact.”
Sagital rotation of head on base of neck:

Mean Forward
88 degrees

Mean Back
133 degrees

Mean Total
221 degrees

Maximum Total 248 degrees
Peak Angular Acceleration vs. Peak Angular Velocity, Shaking Without Impact

Gary A. Lasher & Glenda S. Verber

McGraw-Hill Companies, Inc.
Using Aprica 2.5, shaking generated substantially higher forces than previously reported.

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Role of biomechanics in evaluating cases—Difficult in pediatrics

- Injury threshold levels have not been established for infant brains.
Role of biomechanics in evaluating cases—Difficult in pediatrics

- INJURY THRESHOLD LEVELS HAVE NOT BEEN ESTABLISHED FOR INFANT BRAINS.

- Injury levels in adults were largely derived from adult animal models.
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Injury levels in adults were largely derived from adult animal models.

INFANTS ARE NOT LITTLE ADULTS—to scale adult injury thresholds to infants on the basis of brain mass alone is not valid.
Characteristics of effective animal models for biomechanical modeling

1. The geometry of the structures must be similar. FALSE
2. The composition of the materials must be representative. FALSE
3. The deformation and biomechanical characteristics of the materials must be similar. FALSE
4. The brain’s response to injury must be the same. FALSE
Many things are different in infant brains

- Infants have different biochemical response to trauma. They have been shown to have more cell death from trauma than adults. (Johnston MV: Neurotransmitters and vulnerability of the developing brain. *Brain & Development* 1995; 17:301–306)

- The immature nervous system has poor autoregulation of cerebral blood flow. Following rotational injury, infant animals experience a severe, prolonged drop in cerebral blood pressure. (Margulies S, et al)
Many things are different in infant brains

- Secondary metabolic response to injury is fundamentally different in young infants
- Apoptosis or pruning of brain cells

- Metabolic response to injury is not comparable!
Many things are different in infant brains

1. Infants are not small adults.

2. Injury thresholds for infants have not been established.

3. **THERE IS OVERWHELMING EVIDENCE THAT THE RESPONSE TO A GIVEN INJURY IN AN INFANT IS MUCH WORSE THAN THAT OF A SIMILAR INJURY IN AN ADULT.**
SDH are common after birth (46%) in asymptomatic babies. Most are posterior fossa, around the tent. In prospective studies all heal without symptoms or persistence.
Many children re-bleed into old subdurals.

Re-bleeds are low-pressure ‘oozes’ into old clots.
Rarely are children ever symptomatic with re-bleeds, unless a large amount of blood accumulates over time (theoretical?).
Low-pressure, re-bleeds into existing subdurals from minor trauma do not present as serious brain injury.
Re−bleed of an Old Subdural

It could be:

- A re−bleed of an old subdural
Re-bleed of an Old Subdural

It could be:

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- A hyperacute subdural hematoma.
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- A re-bleed of an old subdural.
- A hyperacute subdural hematoma.
- An old injury, unrelated to the acute injury, especially a birth injury.
- A new assault on a previously abused, head-injured child.
THERE IS NO CREDIBLE SCIENTIFIC EVIDENCE THAT "REBLEEDING" OF AN OLD SUBDURAL CAUSES RETINAL HEMORRHAGES.
Hypoxia and anoxia

Dysphagic choking type of ALTE causes SDH and RH.

A BS HYPOTHESIS BASED ON A SINGLE FALSIFIED CASE REPORT.
THEY LOOK VERY DIFFERENT ON X-RAY!
What about SDH resulting from benign extraaxial effusions of infancy

- Benign collections of extraxial fluid collections are common in infants.
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- Benign collections of extraxial fluid are common in infants.
- Fluid is subarachnoid rather than subdural.
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Fluid is subarachnoid rather than subdural.

There is no evidence in the medical literature that subdural hematomas result from benign extraaxial fluid of infancy (in the subarachnoid space).

Might cause small localized SDH at site of impact, but not bad brain injury.
What do we know about the onset of symptoms after violent abusive head trauma?
"Conventional Wisdom"

1. After head injury, an evolution of symptoms occur—speed of change depends on severity of injury.
INJURY → STUNED APPEARANCE → ALTERED BREATHING → DECREASED LEVEL OF CONSCIOUSNESS → VOMITING → CONVULSIONS → COMA → DEATH
“Conventional Wisdom”

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2. Infants demonstrate symptoms immediately after injury—look for the time the baby changes—

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4. Can infants look normal after serious head injury???
CONFESSION CASE

- Thursday—Dad baby-sits, gets angry, shakes baby violently. Baby “falls asleep”.
- Friday—Mom is concerned baby is “not himself”, but he’s eating well and alert. Goes to ER. ER doc records full exam and declares baby normal.
- Monday—Mom thinks baby is just fine.
- Tuesday—Dad baby-sits again. Shakes baby violently. Baby collapses and dies immediately.
We need to be extremely cautious when evaluating histories and relating them to injury timing.

- History should be meticulous and detailed. Watch for subtle and not so subtle changes.
- Consider alternative hypotheses.
- I STILL THINK THAT SEVERELY INJURED BABIES DON’T LOOK NORMAL!!
52 (91%) of 57 cases where time of onset of symptoms was described, they appeared immediately.

5 cases (9%), the timing was less clear, but occurred within 24 hours.

None of the children were described as behaving normally after the event.

Subtle changes in the infant neck after shaking may cause hypoxia and affect outcome.

Bleeding and axonal injury can occur at C1 at the junction of the brain and spinal cord.

Importance of neck injuries still being studied.

- 41 infants who died of AHT
- 29 (71%) had cervical cord injuries.
- 6 children with AHT had no evidence of impact to head. All 6 had primary spinal cord injury.
- None of the children had spinal fractures, but 6 of the 29 (21%) had ligamentous and muscular neck injury.
- 14 of the 29 (46%) had brainstem injury.
“The infant may have been dropped.”

- “Injury thresholds for infants for subdural hematomas are not precisely known but actual injury scenarios have been analyzed and indicate that head impacts from 1 – 2 feet can produce subdural hematomas in infants.”
- “One such case report, that of Piatt, provided information of an approximate <2 foot fall of a baby who happened to have an extracerebral collection who then suffered an ALTE. It thus appears tat at least for a drop or fall scenario, it would be possible for this baby to have suffered a subdural hematoma and the consequences it ultimately did.”
SHORT FALLS KILL CHILDREN

Reviewed—
- 5 book chapters
- 2 medical society statements
- 7 major literature reviews
- 3 public injury databases
- 177 peer-reviewed peer-reviewed papers
- Every fall/kids paper in the NLM database
- *Short fall* = < 1.5 M (4.7 feet); *Child* = <5 yo
Results

- Risk of death from falls among children under 5 falling < 1.5M is 0.5% per 1 million children per year.
- In studies of short falls that were reliably witnessed, no deaths occurred.
Retinal hemorrhages occur frequently and have nothing to do with AHT
“No credible scientific evidence that shaking produces retinal hemorrhages”
Other “expert” opinions

“Retinal hemorrhages occur as a complication of increased intracranial pressure.”

“Retinal hemorrhages may occur in as many as 20% of cases coming to any autopsy service (adults and children) where there is no history of shaking or abuse.”

Did careful ophthalmology exams in children admitted to ICU at Great Ormand Street. Excluded children with AHT. 15.1% had RH. Only 3.7% H. 3 had leukemia, 2 has severe accidental head injuries, and 1 had severe coagulopathy.
Other “expert” opinions

“Retinal hemorrhages occur as a complication of increased intracranial pressure.”

Review of the entire worlds literature shows not a single case of extensive RH from increased ICP in the absence of traumatic head injury.
“You can get retinal hemorrhages from short fall and from seizures.”

“CPR may have caused the retinal hemorrhages.”
Many papers (prospective studies) have shown this is not the case.
