No. 94-2034
In the 299th District Court of Travis County, Texas

Ex Parte Cathy Lynn Henderson

Affidavit of Peter J. Stephens, M.D. In Support of Subsequent Application for Post-Conviction Writ of Habeas Corpus

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CAPITAL CASE: EXECUTION DATE JUNE 13, 2007

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Of Counsel to Applicant
Cathy Lynn Henderson

Affidavit of Peter J. Stephens, MD.

Peter J Stephens, being duly sworn states as follows:

I am a physician licensed in Wisconsin and Indiana. I am certified by the American Board of Pathology in three areas, Anatomical Pathology, Clinical Pathology, and Forensic Pathology. I graduated from McGill University, Montreal, Canada in May 1965 with the degrees of Doctor of Medicine and Master of Surgery (M.D., C.M.) and completed a Rotating Internship at the Royal Victoria Hospital, Montreal, Canada. I then completed residencies in Anatomical and Clinical Pathology Residency at the Medical College of Virginia, Richmond, VA and the University of Western Ontario, London, Ontario, Canada. I was Board Certified by the American Board of Pathology in November 1970 in Anatomic and Clinical Pathology and in the subspecialty of Forensic Pathology in May 1984. Following thirty years in practice as a hospital and forensic pathologist in Battle Creek, MI, Davenport, IA and Cedar Rapids, IA, I retired from full time practice in February 2001. Since then, I have maintained a part time consulting practice in Forensic Pathology. I have attached a copy of my CV.

I have reviewed the following information relating to the death of Brandon Baugh:

1. Motion to vacate order setting execution date and exhibits.
2. Affidavit of George A. Edwards M.D. dated 29 March 2007.

1. It is my opinion, to a reasonable degree of medical certainty, that biomechanical consultation and testimony is essential to the understanding of any impact injury to the head and is mandatory for any case proceeding to litigation, civil or criminal. While some physicians pursue an interest and study biomechanics, most physicians do not and are not competent to evaluate the complexities that are innate in pediatric head injury. Biomechanical analysis by doctoral level scientists affords a valuable added dimension to the understanding of head injury causation in patients of all ages. Modern understanding indicates that these studies should have been done in this case. In the light of knowledge gained in the past twelve years, it is certain that the failure to provide such consultation deprived the trier of fact of additional scientific information that would have helped in resolving the question of accidental versus intentional injury.

2. I would not contemplate assigning a cause and manner of death in any controversial case involving head impact injury without obtaining, or recommending counseling, a biomechanical evaluation. Personal competent to perform such evaluations are readily available throughout the United States.

3. The affidavit of George A. Edwards M.D. dated 29 March 2007 contains numerous errors fact indicating that he is unfamiliar with much of the

modern neuropathological and biomechanical literature. It is incorrect to state that such skull fractures are not generated in typical accidental household falls. They can be, and often are. In addition, he makes the further error of confusing "usually" or "generally" with "always". This is a mistake classically decried in medical science where it is generally agreed that a diagnosis should not be excluded simply because it is less common, but only after complete evaluation with all of the tools available to the scientific physician.

4. While I am unfamiliar with the specific practice of "spinning" and infant to soothe him or her, my experience has been that there is a very wide range of folk remedy practices and beliefs and have seen far less believable methods used in an attempt to achieve a therapeutic result. The spinning motion, by its gyroscopic effects on the body as a whole, and its potential to destabilize the vestibular system of the inner ear (commonly known to the average person as "dizziness", would be highly likely to cause a fall. If the fall was to a concrete surface, or the adult holding the infant fell onto him, serious injury would be inevitable.

Signed on this 17th day of April, 2007

Peter J. Stephens, MD

SUBSCRIBED AND SWORN TO before me on this 17th day of April, 2007

My commission expires: 12-9-09

Yancey
Patty Stafford

Peter J. Stephens, MD

17th April 2007
Patty Stafford

12-9-09

Peter J. Stephens, M.D.

Forensic Pathologist

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17April 2007

Molly Moriarty Lane, Esq.
Morgan, Lewis & Bockius, L.L.P.
One Market, Spear Tower
San Francisco, CA 94105

Re: Cathy Henderson

Dear Ms. Lane:

At your request I have reviewed the following materials relating to the death of Brandon Baugh:

1. Motion to vacate order setting execution date and exhibits.
2. Affidavit of George A. Edwards M.D. dated 29 March 2007.

There have been major changes in the study of pediatric head injury since the original trial in 1995. A substantial number of pathologists, pediatricians and radiologists, including myself, have radically changed their views on the cause and timing of head injuries in children since that date. This number includes many highly respected physicians such as Patrick D. Barnes M. D., chief of pediatric neuroradiology at Lucille Packard Children's Hospital and Professor, Stanford University, and George R. Nichols M. D., longtime chief medical Examiner of the Commonwealth of Kentucky. These physicians, together with Robert W. Huntington M. D., an experienced and respected forensic pathologist from Madison, Wisconsin, testified recently to some of these changes [1].

These changes include, but are not limited to, improved understanding achieved as a result of the increasing use of magnetic resonance imaging, advances in neuropathology (the study of injury and diseases of the brain), more detailed studies

of the eyes of patients dying of a wide variety of natural and accidental causes, advances in the understanding of disease processes that mimic abusive injury in children and, most importantly the contributions of biomechanical scientists.

Biomechanical scientists are typically M.D. or Ph.D. level scientists who have received specific training in the application of force to the human body and the effects of impact on the human body. Some of them conduct detailed studies of the strength of bone and other body components such as the bridging veins of the head, the limbs and soft tissues. Many are involved in the development of infant car seats, air bags and other restraint systems in the automotive industry. In 1995, biomechanical experts were already being consulted in some cases of pediatric head injury, however unfortunately, many cases of pediatric head injury were litigated without biomechanical expertise. Today, it is common for such scientists to review and contribute to the investigation and understanding of impact injuries to the head of patients of all ages. The value of biomechanical evaluation is typified by a presentation at the 2004 annual meeting of the American Academy of Forensic Sciences by John B. Lenox, M.D., Ph.D., PE of the Department of Mechanical Engineering and Biomechanics, University of Texas at San Antonio [2]. I have referenced other papers (below) that will give you more of an idea as to what their skills can offer [14,15,16,17].

Prior to 1995, most physicians regarded significant injury to an infant or child as a result of a fall to be so unusual as to be almost diagnostic of abusive injury. Those unfamiliar with the more recent medical literature still do. In 1993, Reiber reviewed short distance falls but did not fully realize the significance of his observations [3]. Since 2000, physicians have increasingly recognized that lethal injury to the infant head can, and does, occur as from an accidental fall, even of a short distance. General acceptance of this possibility started in about 1998 at a meeting of the National Association of Medical Examiners when John Plunkett M.D. showed a videotape made by a relative of a child who sustained a short distance fall and subsequently died. Shortly thereafter he published a series of short distance falls causing death in children, occurring in a variety of accidental situations [4]. This evidence was sufficiently compelling that it progressively gained traction.

Other reports subsequently appeared in the medical literature, such as those of Denton and Mileusnic[5]. In my own practice, I have seen a case in which a similar massive and complex skull fracture in a two-year-old resulted from a fall from a chair[6]. It is simply incorrect to state that only a fall from a bunk bed, balcony or upper story window can cause such an injury. Forensic pathologists, biomechanical scientists and many pediatricians now agree that such comparisons are without scientific merit and should not be made. It is not only in the medical literature that such cases are recognized: there is a recorded civil lawsuit resulting from a situation in which an infant sustained an accidental skull fracture from a low-energy impact in a hospital. In this case the accidental cause of the skull fracture was not at issue, it was a false allegation against the parents and an attempted cover-up which was the reason for the suit [7].

It is well documented that many infant and child injuries occur when an adult who is holding them falls [8]. Falls are generally random events requiring consideration of such diverse factors as the smoothness of the surface, the type of footwear, whether or not the adult fell on the infant or vice versa, the strength of the individual skull and whether or not any congenital or acquired abnormalities of bone were present. As Dr. Lenox pointed out in his presentation to the American Academy of Forensic Sciences, there are very complex medical and mechanical issues involved.

It is now generally accepted that some higher level falls do not cause severe injury while other shorter distance falls may cause significant injury and death. The presence of a skull fracture is not essential to cause major injury, but obviously it indicates a significant impact. It is thus now understood that while most short distance falls do not lead to serious injuries, a subset of short distance falls result in skull fractures and lethal intracranial hemorrhage. In this regard, I would note that Denton and Mileusnic's case involved a short distance fall with a major skull fracture that proved accidental after an exhaustive investigation by both the police and the medical examiner's investigators. Serious head injury, skull fractures and other serious injuries have been reported in falls from stairs, bouncy chairs & car seats. shopping Carts, from high chairs and even from toys dropped on children [9,10,11,12,13]. Many of these reports are from the pediatric and public health literature and many public health agencies (such as the US Consumer Product Safety Commission and individual state and city health departments) and hospitals carry cautionary warnings to parents on their web sites.

There is no simple correlation between the "high-energy forces" injuries and those which can be sustained from lesser impact. Most scientists working in this field regard it as inappropriate to infer the height of a fall based on the configuration of the injuries. While it is true that most short distance falls in children are survivable, major injuries may result from much lower energy forces, especially falls onto concrete although falls to "softer" surfaces have been accompanied by injury. Accidental injury should not be excluded simply because lower-level falls are generally survivable.

Sincerely,

Peter J. Stephens, MD
PS/wp

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MEDICAL MALPRACTICE

An Oklahoma jury ordered a university hospital to pay $18 million to parents who were investigated for abusing their 9-month-old son after a CAT-scan showed the boy had a fractured skull.

The injuries had actually occurred when a nurse at the hospital accidentally bumped the infant's head on a nightstand, but she failed to report the incident and the parents became the prime suspects.

Although this suit was filed as a straight medical negligence case, the last-minute evidence of the hospital's alleged cover-up prompted a $9 million punitive damage award, according to the plaintiffs' attorney, Gerald Durbin.

The accident

Nathan Shinn was born with severely limited mental capacity, an inability to speak and several health problems, including an inability to walk and difficulty holding down food.

When he was 9 months old, the boy's parents, Brandon and Brittany, took him to the hospital for tests and observation related to his inability to gain weight. The hospital - HCA Health Care Systems of Oklahoma, Inc. - decided to keep him overnight. The next day, when his parents arrived to take the boy home, Brandon saw that his son's head was swollen. When he touched Nathan's head, the boy turned away in apparent pain.

The couple expressed their concern and the hospital conducted a CAT scan, revealed multiple skull fractures and bleeding on the brain.

According to Durbin, there was nothing in the medical chart to explain these injuries - so the hospital notified police, who investigated the Shinns for child abuse. (The Shinns had spent several hours alone with their son in the hospital the night before).

The police asked the Shinns to submit to a lie-detector test, and Nathan's father contacted Durbin for advice. After speaking with the Shinns, Durbin was convinced they were telling the truth and advised them to take the test. When they passed, the police turned their attention to the hospital and asked attending personnel if they, too, would submit to the lie detector.

At that point, the nurse confessed that she had hit Nathan's head on a nightstand while she had him in her arms and was bending over to pick up the boy's feeding tube, which had fallen onto the floor. The nurse, an LPN, said she put the boy back in bed and didn't report the incident.

Shortly thereafter, the Shinns filed suit.

A cover-up?

Durbin said that during discovery hospital personnel claimed that the nurse had been fired and had also been reported to the state nursing board.

But according to Durbin, it wasn't until the Friday prior to the start of the trial that the plaintiffs' team found out the discipline had not occurred. In fact, the nurse had confessed and resigned five days before the parents were notified.

Durbin didn't learn of this until the hospital finally delivered 750 pages of documents it had been ordered by the court to produce as part of discovery.

"When we opened the nurse's file, I honestly expected to find a termination memo there," Durbin said. "I expected to find something like 'lied to police,' 'fractured baby's skull,' 'did not document medical chart,' 'did not report to attending physician,' because that's what they'd been telling us. But there wasn't anything there. In fact, the personnel file made it look like she was still working there."

Durbin inquired about the nurse's status that afternoon and learned that she had quit immediately after confessing to causing the boy's injuries.

The last-minute documentation showed that the hospital had knowledge of what happened five days before the parents were notified and decided not to document the event because writing the truth on her personnel file would have been "an admission against interest" for the hospital.

"It was very clear that they wanted nothing in writing that a lawyer like myself could hold up to the jury and say, 'Here, in the hospital's own writing, they admit that their nurse did this.' Therefore, they documented nothing of what happened," said Durbin.

That afternoon, Durbin said, his trial theme became clear: The hospital covered up.

Punitive damages

The trial took four days. The plaintiffs called no experts, while the defendant relied on testimony from various treating doctors who, according to Durbin, testified that the injury to the boy's head and brain had not detrimentally affected him.

But Durbin believes that by the time the doctors took the stand, the jury was strongly biased against them.

"Here you've got a 9-month-old baby with a fractured skull, bleeding on the brain, and these doctors come on and say, 'Oh, it's no big deal.' It just didn't pass the muster test," he said.

When the jury began its deliberations, "I knew we were going to get a verdict and I knew it was going to be substantial," said Durbin.

The jury deliberated for about three hours before awarding $9 million in compensatory damages - $5 million for Nathan and $4 million for his parents.

During the punitives phase, Durbin said the defense suggested to jurors that awards against the hospital would harm its ability to care for the state's poor.

"That's known in the Rules of Evidence as a plea of poverty. Once you open the door like that, if there is, in fact, insurance to pay for the judgment, which there was, you're entitled to tell the jury that."

Judge Barbara Swinton allowed Durbin to inform the jury of the insurance, and jurors took just one hour to award $9 million in punitive damages.

In December, Nathan Shinn died at age 2, but Durbin said there's nothing to suggest that the injuries he sustained in the hospital were connected to his death. He said doctors told him that the boy's condition meant that he would live a very short life.

The entire award remains in place for the family. Meanwhile, the hospital has appealed the verdict to the Oklahoma Supreme Court.

Plaintiffs' attorneys: Gerald Durbin, Glen Mullins and Sarah Lee Parrish of Durbin, Larimore & Bialick in Oklahoma City, Okla.

Defense attorneys: Brent Thompson and Dennis Roberts of Rodolf & Todd in Tulsa, Okla.

The case: Shinn v. HCA Health Systems of Oklahoma, Inc., Nov. 10, 2006; Oklahoma County District Court; Judge Barbara Swinton.

Questions or comments can be directed to the writer at: dick.dahl@lawversusaonline.com

FATAL PEDIATRIC HEAD IMPACT BIOMECHANICS: HOMICIDE VS. ACCIDENT

By

John B. Lenox, M.D., Ph.D., P.E.
Department of Mechanical Engineering & Biomechanics
College of Engineering
University of Texas at San Antonio

INTRODUCTION

- *14 Month-Old Boy Sustained Severe Closed Head Injury (CHI) at Day-Care Center.
- *Victim in Good Health Prior to Sustaining Closed Head Injury.
- *Private Home in Use as Unlicensed Day-Care Center.
- *Present At Day-Care Center When CHI Was Sustained Were:
  - *One Adult Female Day-Care Supervisor.
  - *Four Children:
    - (1) 14 Month-Old Boy CHI Victim
    - (2) 3 Year-Old Boy
    - (3) 3 Year-Old Boy
    - (4) 6 Week-Old Infant

2

INTRODUCTION (Cont'd.)

- *14 Month-Old Victim Crying When EMS First Arrived; CPR Required En-Route to Hospital.
- *Brain CT Scan Results:
  - *Large Occipital Fracture; No Significant Depression of Skull Bone.
  - *Diffuse Cerebral Edema.
  - *Tentorial Subarachnoid Hemorrhage; No Mid-Line Shift.
- *14 Month-Old Boy Died in Hospital Few Hours Later.
- *No PMHx of Child Abuse; No Evidence of Other Acute Injuries; No Evidence of Other Injuries Having Been Sustained In Past.
- *Autopsy Performed 27 Hours Post Death.

3

AUTOPSY REPORT

- *Blunt Force Craniocerebral Injury:
  - *No Lacerations, Abrasions or Contusions Found Anywhere on Body.
  - *15x11 cm Area of Subscalpular & Periosteal Blood Extravasation in Occipital and Posterior Parietal Regions.
  - *Extensive Displaced Fractures of Occipital Bones Extending Into Posterior Aspect of Both Parietal Bones.
  - *Estimated 10 ml of Liquid & Partially Clotted Subdural Blood Extravasation, Predominately Over Vertices of Cerebral Hemispheres and Over Base of Skull.

4

AUTOPSY REPORT (Cont'd.)

- *Blunt Force Craniocerebral Injury (Cont'd.):
  - *Moderate Diffuse Subarachnoid Blood Extravasation Over Entire Brain with Increased Concentrations in Left Para Sagittal/Sagittal Cortex & Left Temporal Lobe.
  - *Apparent Tear of Falx Cerebri Anteriorly.
  - *2x1.5 cm Contusion, Right Cerebellar Hemisphere.
  - *1 cm Contusion, Right Parieto-Occipital Hemisphere.
  - *Blood Extravasation Surrounding Each Optic Nerve.

5

AUTOPSY REPORT (Cont'd.)

- *Blunt Force Craniocerebral Injury (Cont'd.):
  - *Retinal Blood Extravasation.
  - *Blood Extravasation on Left Nerve Roots of C1 & C2 Vertebrae.
  - *Subdural Spinal Cord Blood Extravasation.
- *Evidence of Hypoxic-Ischemic Encephalopathy:
  - *Diffuse Gyral Flattening & Sulcal Narrowing.
  - *Cerebral Tonsillar Herniation.

6

MEDICAL EXAMINER CONCLUSION

"Based Upon The History And The Autopsy Findings, It Is My Opinion That ... 14-Month Old White Male Died As A Result Of Blunt Force Craniocerebral Injury."

7

FINAL MEDICAL EXAMINER OPINION:

MANNER OF DEATH:

"HOMICIDE"

8

DATE THAT FINAL, WRITTEN, MEDICAL EXAMINER RULING OF "HOMICIDE" WAS ISSUED:

***Two Days Post-Death.**

***Upon Completion of Autopsy.**

9

BASES FOR MEDICAL EXAMINER RULING THAT MANNER OF DEATH WAS HOMICIDE

*These Severe Closed Head Injuries, Especially Involving Markedly Depressed Occipital Bone Fragments Driven Into Brain, Could Not Have Been Sustained by a Fall From Ground Level; at Least a Two-Story, if Not a Three-Story, Fall Would Have Been Required.

*This 14 Month-Old Boy Must Have Been: (1) Slammed Down Violently Into the Floor; or (2) Thrown or Slammed at High Speed Against a Wall; or (3) Been Struck Violently with a Rolling Pin That Had Been Covered with a Towel; (4) Etc.

10

FORENSIC INFORMATION NOT CONSIDERED BY MEDICAL EXAMINER WHEN HOMICIDE RULING WAS ISSUED

*Witness Statements Describing Complex Accident Scenario.
*Police Investigation.
*Interviews of Two 3 Year-Old Accident Scene Witnesses.
*Accident Scene Inspection Findings.
*All Medical Records Generated Post-Injury.
*Biomechanical Engineering Analysis Evaluating Potential Validity of Witnessed Accident Scenario Details.

11

CONSEQUENCES OF MEDICAL EXAMINER RULING THAT MANNER OF DEATH WAS HOMICIDE

*Adult Female Who Was Caring for 14 Month-Old Boy Was Charged with Capital Murder and Injury to a Child (Serious Bodily Injury), Punishable by a Mandatory 30-Year Jail Sentence if Convicted.
*Accused Child Murderer Was, for All Practical Purposes, Assumed Guilty Until Proven Innocent.
*Professional and Personal Life of Accused Child Murderer Was Ruined.

12

FOLLOW-UP MEDICAL EXAMINER HANDLING OF DEATH CASE FILE

Book Co-Authored by Medical Examiner, That Was Published Prior to the Murder Trial, Utilized Autopsy Photographs Taken of This 14-Month-Old Boy, Citing These Photographs as Examples of Pediatric Scalp and Cranial Injuries Found in a Homicide Victim.

13

State of Texas Funds Hiring of Biomechanical Engineering Consultant to Court-Appointed Lawyer Defending Accused Child Murderer.

By Law, the State of Texas Cannot Convict and Jail Any Accused Murderer Absent the Defendant Having Had a Reasonable Opportunity to Explore Development of a Sound Defense.

14

BIOMECHANICAL ENGINEERING ANALYSIS PERFORMED:

***Reviewed & Analyzed Witness Statements & Police Fatality Investigation Report.**

***Inspected Accident Scene.**

***Interviewed Accused Child Murderer.**

***Formulated Witnessed Accident Scenario.**

15

BIOMECHANICAL ENGINEERING ANALYSIS PERFORMED (Cont'd.)

***Reviewed Pediatric Pre-Accident Medical Records for Three Boys Involved in Collision:**

(1) 3 Year-Old Boy: Wt. = 40 lbs.; Ht. = 36"
(2) 3 Year-Old Boy: Wt. = 40 lbs.; Ht. = 36"
(3) 14 Month-Old Boy Closed Head Injury Victim:
- Ht. = 29 inches
  (4th Percentile for 14 Month-Old Boys)
- Wt. = 21 lbs.
  (12th Percentile for 14 Month-Old Boys)

16

BIOMECHANICAL ENGINEERING ANALYSIS PERFORMED (Cont'd.)

***Reviewed All Post-Accident Medical Records.**
***Reviewed Relevant Trauma Medical & Biomechanical Engineering Literature.**
***Performed Injury Mechanism Analysis:**
- ***Fracture Pattern Analysis.**
- ***Single Impact vs. Multiple Impacts?**
- ***Comminuted Skull Fracture Sustained?**
- ***Depressed Skull Fracture Sustained?**

17

18

19

22

BIOMECHANICAL ENGINEERING ANALYSIS PERFORMED (Cont'd.)

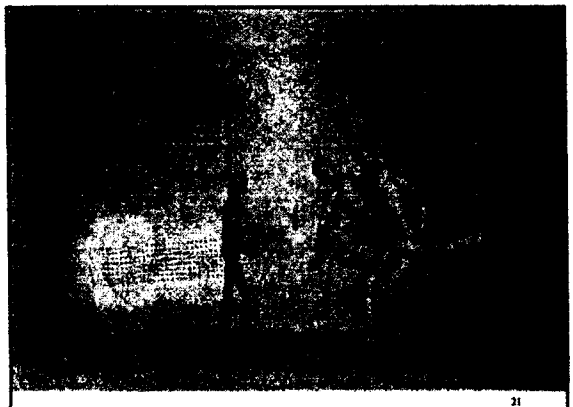
- *Reviewed All Post-Accident Medical Records.
- *Reviewed Relevant Trauma Medical & Biomechanical Engineering Literature.
- *Performed Injury Mechanism Analysis:
  - *Fracture Pattern Analysis.
  - *Single Impact vs. Multiple Impacts?
  - *Comminuted Skull Fracture Sustained?
  - *Depressed Skull Fracture Sustained?
- *Determined if Witnessed Head Impact Scenario Could Have Been Responsible for Severe Closed Head Injuries Sustained.

20

BIOMECHANICAL ENGINEERING RECONSTRUCTION OF WITNESSED ACCIDENT SCENARIO

- *Adult Blunt Head Impact Test Results: Head Kinetic Energy to Fracture

23



21

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MECHANICS OF SKULL FRACTURE

W. R. LISSNER, E. S. GURDJIAN, M. D., and J. E. WEBSTER, M. D.
Wayne University and Grace Hospital, Detroit, Michigan

It is a well known fact that head injury is a frequent cause of death. Investigations made by Crash Injury Research of Cornell University Medical College show that in survivable airplane crashes head injuries are primarily responsible for death. Head injuries also figure prominently in automobile accidents. The economy can definitely contribute to a reduction in the severity of accidental head injury by changes in automobile structural design.

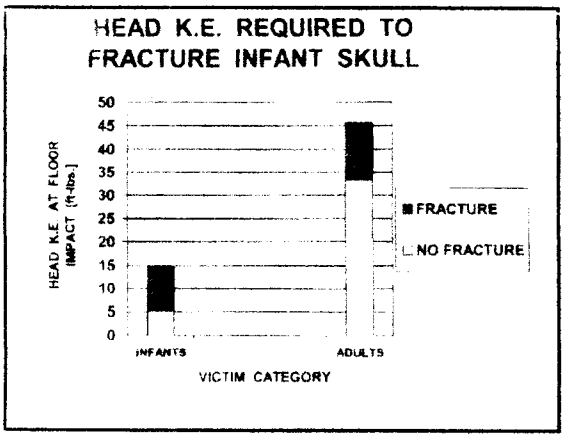
Let us briefly consider a few automobile accident statistics. Bodily injuries occurred in a little over 90% of the 45,000 automobile accidents in Detroit during the year 1947, according to the figures furnished by the Accident Prevention Bureau of the City of Detroit. Head, face and cranio-cerebral injury occurred to approximately 47% of the injured people. The type and severity of the injury received was a function of the position or seat occupied in the car. Where the driver had other passengers with him, accidental injury to the driver alone

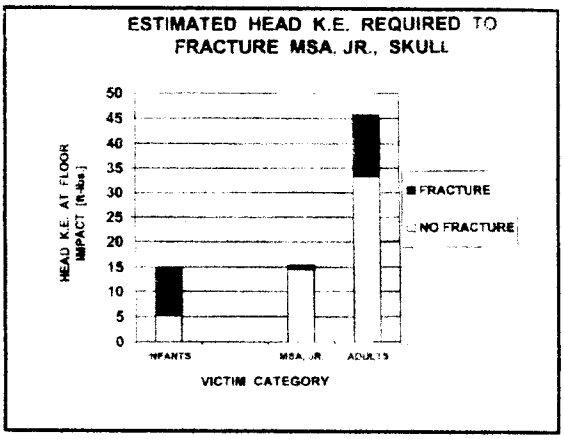
injuries were most frequently suffered by the passengers sitting next to the driver. Deep injuries were more common in such seat passengers when compared to those in the front seat.

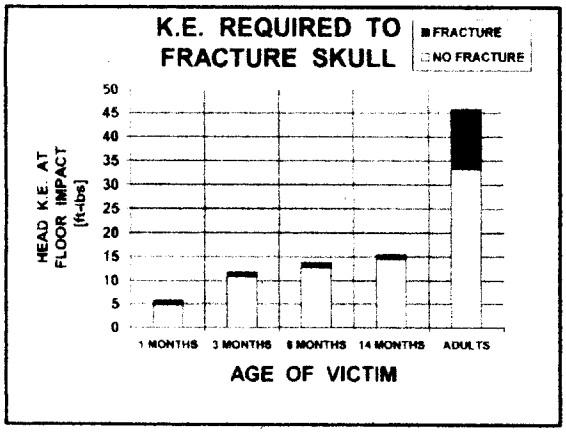
Statistics furnished by the Michigan State Police for the year 1947 show that in rural accidents on the highways, head injuries to passengers occurred twice as frequently as to drivers while 67% of all the persons injured received head injuries. It appears that in rural accidents, where speeds are greater than in the city, head injury is more prevalent.

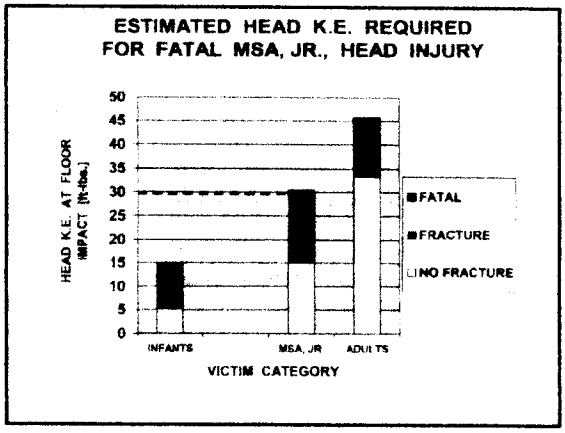
This brief summary of accident statistics reveals several important factors. One is that the driver gains considerable protection if he can brace himself by holding onto the steering wheel, thus preventing his head being thrown forward into the windshield or instrument panel. This is particularly true in the lower velocity accidents, but it should be pointed out that at high speeds this same device becomes a lethal weapon since the wheel breaks

24









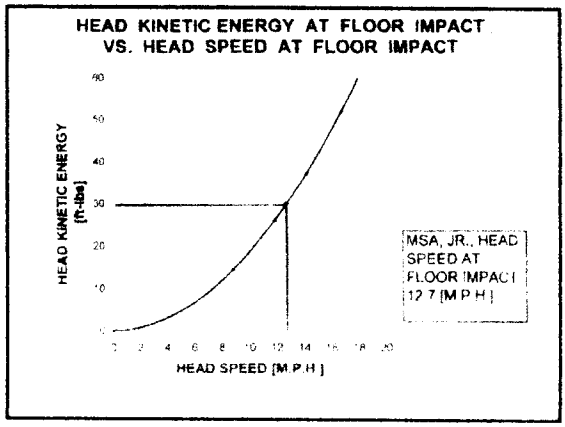
BIOMECHANICAL ENGINEERING RECONSTRUCTION OF WITNESSED ACCIDENT SCENARIO

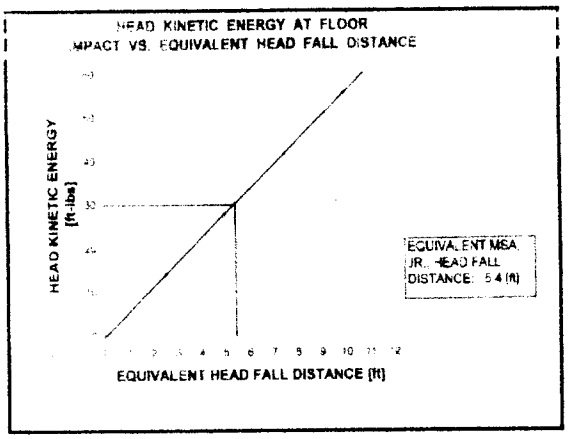
*Adult Blunt Head Impact Test Results: Head Kinetic Energy to Fracture

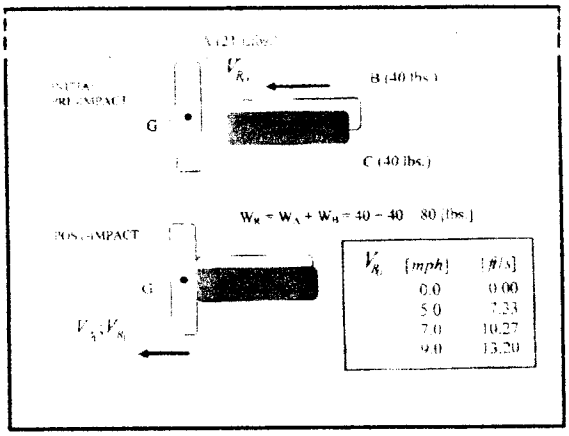
*Infant Blunt Head Impact Test Results: Head Kinetic Energy to Fracture

*Calculated Head Weight of 14 Month-Old Victim

*Estimated 14 Month-Old Victim Head Kinetic Energy Required for Blunt Impact to Cause Severe Occipital Skull Fractures Sustained







BIOMECHANICAL ENGINEERING RECONSTRUCTION OF WITNESSED ACCIDENT SCENARIO (Cont'd.)

*Experimentally Determined Speeds at Which 3 Year-Old Children Can Achieve Over Short Distances.

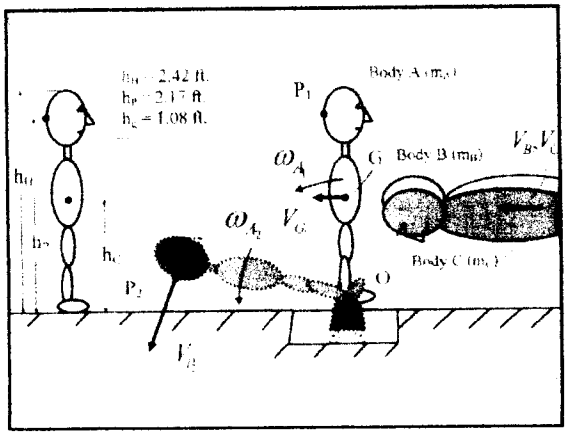
*Modeled Variations in (1) Body Pitch-Over Rearward and (2) Head Slam Down Kinematics Induced in 21-lb., 14-Month Victim in Response to a Variety of Collisions of the Two, Running 40-lb., 3 Year-Old Boys into the Standing 14 Month-Old Victim.

CONSERVATION OF LINEAR MOMENTUM

$$\boxed{\sum m_i V_{i_O} = \sum m_i V_i \quad (i = A, R)}$$

$$m_A \overbrace{V_{A_O}}^{0} + m_R V_{R_O} = (m_A + m_R) V_A$$

$$V_G = V_A = \frac{m_R V_{R_O}}{m_A + m_R} = \frac{(80/32.2) V_{R_O}}{(21+80)/32.2} = 0.792 V_{R_O} \left[ft/s\right]$$



CALCULATION OF INITIAL ANGULAR VELOCITY (ω_{A_2}) OF STANDING CHILD WHEN CHILD BEGINS TO PIVOT REARWARD ABOUT FEET

$$\omega_A h_G = V_{G_2}, \text{ or } \omega_A = \frac{V_G}{h_G}$$

$$\omega_A = \frac{0.792\, V_{R_O}}{1.084} = 0.731\, V_{R_O}, \text{ or}$$

$$\left(\omega_A \left[radians/s\right]\right)^2 = (0.731\, V_{R_O})^2 = 0.534\, (V_{R_O})^2$$

CALCULATION OF HEAD K.E. AT FLOOR IMPACT REQUIRED TO FRACTURE INFANT SKULLS

REF: W. WEBER, BIOMECHANICAL FRAGILITY OF SKULL FRACTURES IN INFANTS, Z. RECHTSMED (1995) 94: 93-101.

METHODS:
Infants (Ages 0-8.2 Months), Aligned Horizontally, Were Dropped 82-cm (2.69-ft.); Infant Heads Impacted:

A. Stone Floor
B. Carpeted Floor
C. Foam-Backed Linoleum Floor

RESULTS:
Skull Fractures Were Sustained by 100 % of Infants.

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ESTIMATION OF MSA, JR., HEAD WEIGHT

- MSA, JR.: Total Weight: 21 lbs
- CRABI 12-Month-Old Child ATD:
  - Total Weight: 22.00 lbs.
  - Head Weight: 5.81 lbs.
  - Head Weight / Total Weight = 5.81 / 22.00 = 0.264
- ESTIMATED MSA, JR., HEAD WEIGHT:
  - Estimated Head Wt. = 0.264 x Total Weight
    = 0.264 x 21 lbs.

MSA, JR., HEAD WEIGHT = 5.54 [lbs.]

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CALCULATION OF HEAD K.E. AT FLOOR IMPACT REQUIRED TO FRACTURE INFANT SKULLS (Con't.)

METHODS:
Infant Head Falls From 2.69 ft.:

CALCULATION OF TERMINAL HEAD SPEED:

$$V_{P_2} = \sqrt{2ah_p} = \sqrt{2(32.2)2.69}$$

$$\boxed{V_{P_2} = 13.2\,[ft/s]}$$

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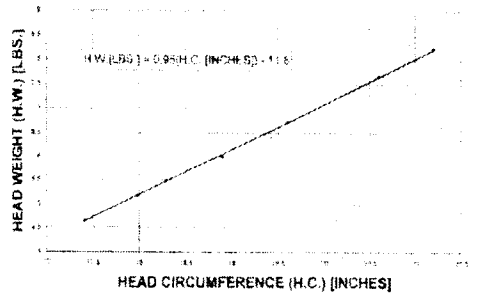
HEAD WEIGHT VS. HEAD CIRCUMFERENCE



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CALCULATION OF HEAD K.E. AT FLOOR IMPACT REQUIRED TO FRACTURE INFANT SKULLS (Con't.)

METHODS:
Infant Head Falls From 2.69 ft.:

CACULATION OF 14-MONTH-OLD VICTIM'S HEAD KINETIC ENERGY (K.E.):

$$K.E.\,[ft\text{-}lbs.] = \frac{1}{2} m\,[slugs] \times (V_{P_2}\,[ft/s])^2$$

$$m = \text{Head Mass}\,[slugs] = \frac{\text{Head Weight}\,[lbs.]}{32.2\,[ft/s^2]}$$

WEIGHT OF 14-MONTH-OLD MSA, JR., HEAD = ?

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CALCULATION OF 14-MO.-OLD HEAD K.E.:

$$K.E.\,[ft\text{-}lbs.] = \frac{1}{2} m\,[slugs] \times (V_{P_2}\,[ft/s])^2$$

$$m = \frac{W_{Head}\,[lbs.]}{32.2\,[ft/s^2]}$$

$$K.E. = \frac{1}{2} \times \frac{5.54\,[lbs.]}{32.2\,[ft/s^2]} \times (13.2\,[ft/s])^2 = 14.9\,[ft\text{-}lbs.]$$

SUMMARY RESULTS CALCULATED FOR FRACTURE OF 14-MONTH-OLD INFANT SKULL:

- 2.69-Foot Head Drop Achieves
- 13.2 [ft/s] Head Impact Speed Associated With
- 14.9 [ft-lbs] of Head Kinetic Energy At Floor Impact.

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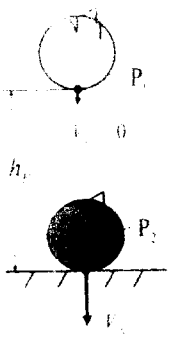
TERMINAL HEAD IMPACT SPEED

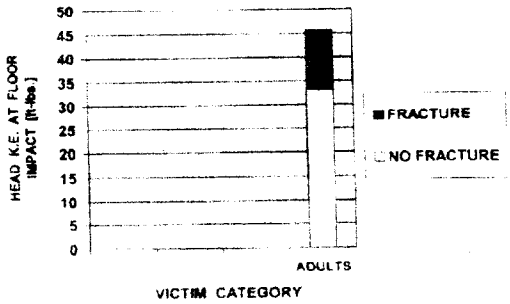


$$(V_{P_2})^2 = 2ah_p$$

Where:

- V_{P_2} = Head Speed $[ft/s]$
- h_p = Fall Height $[ft]$
- a = Acceleration Due to Gravity $[ft/s^2]$

HEAD K.E. REQUIRED TO FRACTURE OCCIPUT OF ADULT SKULL



KINETIC ENERGY *K.E.* OF HEAD AT FLOOR IMPACT:

$$K.E. = \frac{1}{2}m(V_G) = W(h_G)$$

Where:

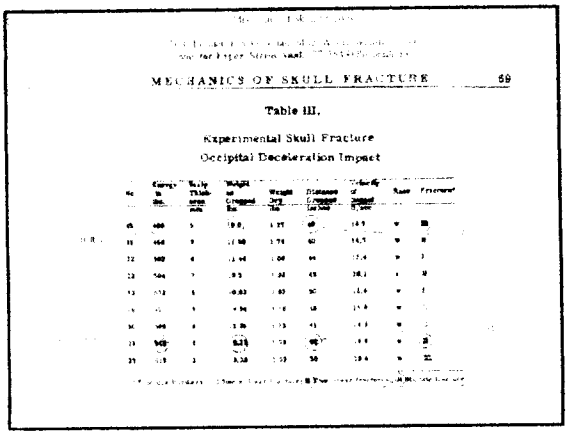
- $K.E.$ = Kinetic Energy of Rigid Body $[ft \cdot lbs]$
- m = Mass of Body $[slugs]$

  Where Body Mass $(slugs) = \left[\frac{W}{32.2\ [ft/s^2]}\right]$
- W = Weight of Body $[lbs]$
- G = Mass Center of Body
- V_G = Terminal Speed of Mass Center of Body $[ft/s]$
- h_G = Height of Mass Center of Body $[ft]$

BIOMECHANICAL ENGINEERING RECONSTRUCTION OF WITNESSED ACCIDENT SCENARIO

*Adult Blunt Head Impact Test Results: Head Kinetic Energy to Fracture

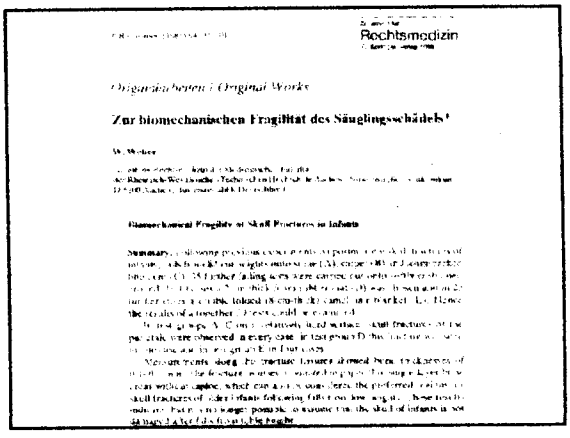
*Infant Blunt Head Impact Test Results: Head Kinetic Energy to Fracture



MECHANICS OF SKULL FRACTURE 69

Table III.

Experimental Skull Fracture
Occipital Deceleration Impact



Rechtsmedizin

Originalarbeiten / Original Works

Zur biomechanischen Fragilität des Säuglingsschädels[1]

W. Weber

Biomechanical Fragility of Skull Fractures in Infants

PRINCIPLE OF WORK & ENERGY: EQUATION OF MOTION

$$T_1 + \sum U_{1-2} = T_2$$

Where:

T_1 = Initial Translational & Rotational Kinetic Energy

$\sum U_{1-2}$ = Work Done By All External Forces & Couples

T_2 = Final Translational & Rotational Kinetic Energy

PRINCIPLE OF WORK & ENERGY (Cont'd.)

$$T_1 + \sum U_{1-2} = T_2, \text{ or } T_2 = T_1 + \sum U_{1-2}$$

$$T_2 = \frac{1}{2}(1.270)(\omega_{A_2})^2 = 0.635(\omega_{A_2})^2$$

$$0.635(\omega_{A_2})^2 = 0.635[(0.534)(V_{B_2})^2] + 22.76, \text{ or}$$

PRINCIPLE OF WORK & ENERGY (Cont'd.)

$$T_1 + \sum U_{1-2} = T_2$$

$$T_1 = \frac{1}{2} m_A (V_{G1})^2 + \frac{1}{2} I_G \omega_1^2 = \frac{1}{2} I_B \omega_1^2 = T_1$$

By Parallel Axis Theorem

Where:

1 = Initial Position of Body A; 2 = Final Position of Body A

$$T_2 = \frac{1}{2} I_G \omega_2^2$$

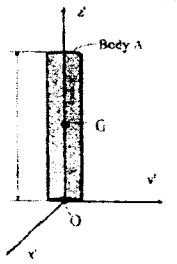
$$\sum U_{1-2} = W_A h_G = (21\ [lbs])(1.08\ [ft]) = 22.76\ [ft\text{-}lbs]$$

CALCULATION OF TERMINAL HEAD VELOCITY AT FLOOR IMPACT:

$$V_{B_2} = h_p \omega_{A_2} = 2.167 \omega_{A_2}$$

CALCULATION OF HEAD KINETIC ENERGY AT FLOOR IMPACT:

$$K.E._{(M.S.A.\ Jr.,\ Head)} = \frac{1}{2} m_A (V_{B_2})^2 = \frac{1}{2}\left(\frac{5.54}{32.2}\right)(V_{B_2})^2, \text{ or:}$$



$$I_{G'G'} = I_{A_y} = \frac{1}{3} m_A l^2$$

$$l = 2.417\ ft.$$

$$m_A = \frac{21[lbs.]}{32.2[ft/s^2]} = 0.652\ [slugs]$$

$$I_{A_y} = \frac{1}{3}(0.652)(2.417)^2 = 1.270\ [slugs]$$

MASS MOMENT OF INERTIA OF BODY A

BIOMECHANICAL ENGINEERING RECONSTRUCTION OF WITNESSED ACCIDENT SCENARIO (Cont'd.)

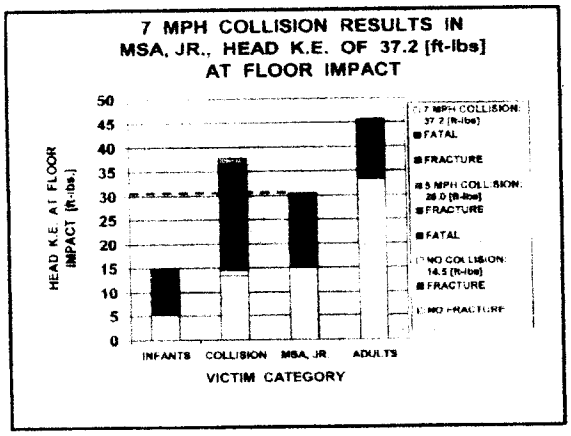
BIOMECHANICAL ENGINEERING RESULTS

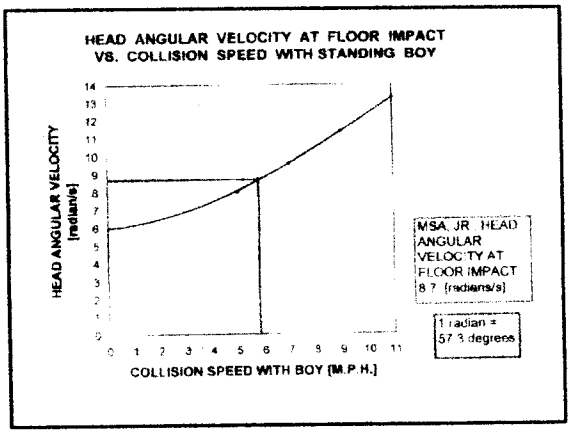
CENTERED HEAD SLAM DOWN KINEMATICS INDUCED BY COLLISION OF TWO 3-YEAR-OLD BOYS INTO STANDING 14-MONTH-OLD

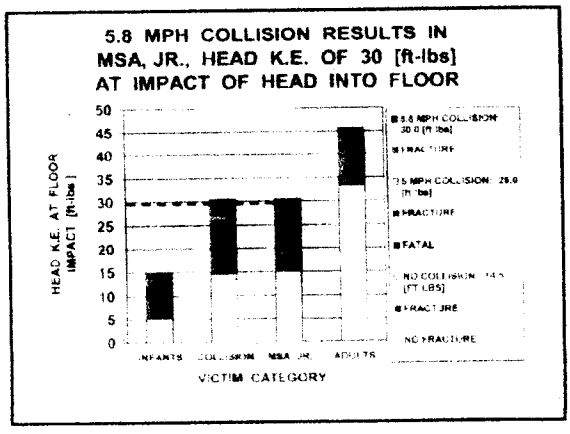
Impact Speed		Head Angular Velocity at Floor Impact	Head Speed at Floor Impact		Head Kinetic Energy at Floor Impact
V_x		ω_z	V_R		$K.E._{(MSA\ Jr.\ Head)}$
[ft/s]	[mph]	[rad/s]	[ft/s]	[mph]	[ft-lbs]
0.0	0.0	5.99	12.98	8.8	14.5
3.67	2.5	6.56	14.21	9.69	17.4
7.33	5.0	8.03	17.4	11.9	26.1
10.27	7.0	9.60	20.8	14.2	37.2
13.2	9.0	11.35	24.6	16.8	52.9
16.13	11.0	13.22	28.7	19.6	70.8
22.00	15.0	17.15	37.2	25.4	118.8

HEAD IMPACT BIOMECHANICS RESULTS: BLUNT, WORST-CASE HEAD IMPACTS ON RIGID FLOORS

Victim: Skull Region (Reference)	Age [months]	Head Weight [lbs]	Collision Speed [mph]	Drop Height Actual [ft]	Drop Height Equivalent [ft]	Terminal Head Speed [mph]	Head Kinetic Energy [ft-lbs]
Infants: Parietal (Weber)	1	1.9		2.7		9.0	5.2
	3	4.2		2.7		9.0	11.5
	8	4.9		2.7		9.0	13.2
	14 (MSA, JR.)	5.5			2.7	9.0	14.9
MSA, JR.: Occipital (Lenox)	14	5.5	0.0		2.6	8.8	14.5
	14	5.5	5.8		5.4	12.7	30.0
Adults: Occipital (Lissner)	Adult	10.0		3.5		10.0	23.1
	Adult	8.3		3.5		10.0	19.2







BIOMECHANICAL ENGINEERING CONCLUSION NO. 1:

Does Witnessed Accident Scenario Account for Severe Closed Head Injuries Sustained?

"BIOMECHANICAL ENGINEERING"
CONCLUSION NO. 2:

What Is the Probability That This
Accident Witness Fabricated
An Accident Scenario This Credible?

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OUTCOME OF FALL 2003
MURDER TRIAL

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SPECIFIC RECOMMENDATIONS

*Measure and Record Head Circumference for Pediatric Head-Impact-Induced Victim Autopsied.
*Thoroughly Characterize the Pediatric Skull at Skull Fracture Sites:
  *Diagram All Skull Fractures.
  *Measure and Record Skull Thicknesses Along Fracture Lines.
  *Document Local Fissures, Ossification Defects, Regions with Single Layer Without Diploe, and Discontinuities in the Skull Along Fracture Lines.
  *Make a Best Attempt to Characterize Degree of Flexibility vs. Rigidity.

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GENERAL RECOMMENDATION

When the Quest for Accurately Determining Injury Causation Involves Both Complex Medical and Biomechanical Engineering Issues, Forensic Pathologists Should Seek Support From Skilled, Trusted, Biomechanical Engineering AAFS Colleagues Prior to Issuing Final, Written Manner-of-Death Opinions.

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FATAL PEDIATRIC HEAD IMPACT BIOMECHANICS:
HOMICIDE VS. ACCIDENT

by
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Fatal Pediatric Head Impact Biomechanics: Homicide vs. Accident

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Attendees will develop skill in determining the head impact accident scenario and injury mechanisms responsible for fatal pediatric head injuries. In addition, attendees will develop skill in determining injury causation in possible homicide cases involving complex, interdisciplinary medical and biomechanical engineering concerns.

A 14-month male in good health sustained a severe closed head injury at a babysitter's house, and he died in the hospital few hours later. Head CT Scan performed prior to his death demonstrated occipital fractures with no significant skull bone depression, diffuse cerebral edema, and tentorial subarachnoid hemorrhage with no midline shift. An autopsy was performed 27 hours post death. Autopsy findings are provided below, prior to addressing accident witness statements and reconstruction of the accident versus homocide scenario responsible for the death of this child.

AUTOPSY FINDINGS REPORTED:

1. Blunt Force Craniocerebral Injury:
   a. No lacerations, abrasions or contusions seen on skin of posterior scalp.
   b. A 15 x 11 cm area of subscalpular {sic} and periosteal blood extravasation in occipital and posterior parietal regions.
   c. Extensive displaced fractures of occipital bones extending into the posterior aspect of both parietal bones.
   d. Film of epidural blood extravasation over skull fractures.
   e. An estimated 10 ml of liquid and partially clotted subdural blood extravasation, predominately over vertices of cerebral hemispheres, but also over base of skull.
   f. Moderate diffuse subarachnoid blood extravasation over entire brain with increased concentrations in left para sagittal/sagittal cortex and left temporal lobe.
   g. Apparent tear of falx cerebri anteriorly.
   h. A 2 x 1.5 cm contusion, right cerebellar hemisphere.
   i. A 1 cm contusion, right parieto-occipital lobe.
   j. Blood extravasation surrounding each optic nerve.
   k. Retinal blood extravasation.
   l. Blood extravasation on the left nerve roots of C1 and C2 vertebrae.
   m. Subdural spinal cord blood extravasation.

2. Evidence of hypoxic-ischemic encephalopathy:
   a. Diffuse gyral flattening and sulcal narrowing.
   b. Cerebral tonsillar herniation.
   c. Cerebral edema and early neuronal degeneration on histology.

3. Small, scattered, circular areas of erythema with central dried punctures resembling insect bites on skin.

WITNESS STATEMENT: The babysitter, the only adult witness to this accident, provided accident scenario descriptions (a) during the 911 call post-accident, (b) to the EMS crew, (c) to the emergency room

and hospital personnel, and (d) to investigating police officers; all of the accident scenario statements provided by the babysitter remained consistent. Namely, the 14-month-old boy was standing at rest, having just picked up a popular toy from a toy box, and he was facing two older children who were playing across the room. Suddenly, these two older children ran together fast towards the 14-month-old boy. As these two older boys approached this 14-month-old boy, still running fast, these older boys became entangled and they tripped and fell toward the 14-month-old boy. The 14-month-old boy was, in effect, gang-tackled by the two older boys, causing the 14-month-old boy to rotate backwards at a high rate of speed, pivoting about his feet, resulting in the back of his head violently impacting the bare, hardwood floor.

IMPACT INJURY BIOMECHANICS:

1. Analysis of all of the injuries sustained, and of the possible injury mechanisms responsible for each injury, led to the conclusion that one, single, violent, blunt blow, sustained by the back of the head of the 14-month-old boy, induced all of the injuries sustained. This injury biomechanics analysis included study of the pattern and extent of the skull fractures sustained and consideration of how deformation and fracturing of the skull increased the intracranial pressure sufficient to have induced hemorrhages in the region of the optic nerves and retinae.

2. Dynamic and impact biomechanics analyses were then performed to study (a) the kinematic consequences of collisions of the two older boys into the 14-month-old boy, along with (b) the magnitudes of the collision-induced increases in head-to-floor slam down velocities. These engineering analyses demonstrated that the collision of the two older boys into the 14-month-old boy standing at rest could have increased the 14-month-old boy's head-to-floor slam down velocity to a level more than capable of producing producing the severe skull fractures and fatal brain injuries sustained. In addition, these analyses demonstrated how unlikely it would have been for simple fall, starting at rest from a standing height and not involving a collision, to have caused these catastrophic head injuries.

RECOMMENDATIONS: In an interdisciplinary case such as this one, whether or not the death of this 14-month child was caused by homicide would be difficult for most medical examiners to judge absent feedback and support from a team member skilled in biomechanical engineering. When the quest for accurately determining injury causation involves consideration of complex medical and biomechanical engineering issues, forensic pathologists should seek support from skilled biomechanical engineering colleagues.

KEY WORDS: Head Impact Injury Biomechanics; Skull Fracture Mechanics; Occupant Kinematics; Head Impact and Skull Fracture Dynamics; Pediatric Head Injury Causation; Accident vs. Homicide Scenario Reconstruction; Interdisciplinary Medical-Engineering Team Work; Improving the Accuracy of Fatal Head Injury Causation Determination.