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# Abusive Head Trauma in Infants and Children

A Medical, Legal, and  
Forensic Reference



G.W. Medical Publishing, Inc.  
St. Louis

# Abusive Head Trauma in Infants and Children

A Medical, Legal, and  
Forensic Reference

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## FOREWORD

In 1860, a French Pathologist, Professor Auguste Ambroise Tardieu, described child abuse as “... a horrendous problem that would unsettle the soul of a moral philosopher.” In his paper titled *Étude médico-légale sur les sévices et mauvais traitements exercés sur des enfants* (Forensic study on cruelty and the ill-treatment of children), Tardieu describes “visible lesions to the brain, especially in very young infants submitted to such abuse. I have discovered effusions of blood on the surface of the brain, manifestly the result of blows to the head ...”<sup>1</sup>

More than 100 years later, Norman Guthkelch, the first pediatric neurosurgeon in England, published an article in the *British Medical Journal* reporting a series of infants with subdural hemorrhages, some of which were recurrent hemorrhages, whose caregivers described violently shaking their children.<sup>2</sup> This was the first clear reference in the world’s medical literature to shaking as a means of inducing head injury in infants and small children.

Guthkelch’s description of how he arrived at his hypothesis about the dangers of shaking is an example of sheer genius. By the early 1970s, he had operated on hundreds of children with subdural hematomas. He noted that many had no evidence of external trauma to the head, and some of the subdural hematomas were recurrent. While visiting the United States, he talked with Dr. William German, the Chair of Neurosurgery at Yale Medical School. German told Guthkelch about how, when riding a roller coaster at an amusement park, his head had been severely jolted and whipped around but had not impacted with any surface. After this incident, German developed a headache. He diagnosed his own subdural hematoma and went to the hospital for treatment.

This caused Guthkelch to think about the children with subdural hematomas that he had treated. He then worked with a gifted social worker who interviewed several families and obtained a history of shaking the babies without impact (Phone conversation with Jenny, September 2002).

This discovery led to the adoption of the term “shaken baby syndrome” to describe the triad of signs associated with abusive infant head trauma—unexplained encephalopathy, subdural hemorrhages, and retinal hemorrhages. The existence of shaken baby syndrome has been widely debated, despite the large number of cases where caretakers admit to shaking their babies out of anger and frustration.<sup>3-5</sup>

Sometimes it is difficult to tell if a child’s head has been shaken, impacted, or crushed; whether the blood supply to the brain was purposefully occluded; or if another event may have caused a healthy, happy child to become suddenly ill with serious head trauma. The editors of this book have recognized this difficulty and adopted the term “abusive head trauma.” This term conveys the understanding that the previously healthy child suffered an inflicted injury, but the mechanism of injury—of which shaking is merely one—is not presumed.

This book breaks new ground in many ways. First, it is comprehensive in its approach. Every aspect of abusive head trauma is covered, from neuroscience to prosecution. It is truly multidisciplinary, involving health professionals, law enforcement officers, legal prosecutors, social welfare experts, mental health professionals, and rehabilitation specialists.

Another exciting aspect of this book is that a new generation of experts is writing exciting chapters. The list of authors demonstrates that the field is expanding and vigorous. Many new people have acquired expertise in diagnosing and treating abusive head trauma. It is refreshing to see a child abuse text that highlights the work of new experts. Although the ancestry of this book can be traced to the work of John Caffey, C. Henry Kempe, Ray E. Helfer, Norman Guthkelch, and other legends in the field, it is clear that the field is in competent hands with the current generation.

The subject of abusive head trauma is approached with a critical eye on literature and extensive clinical experience, providing the readers with balanced sources of data. Finally, the case-based approach makes this text an excellent resource for teachers of medicine and related disciplines as well as for “life-long learners” who want to sharpen their diagnostic acumen and medical skills.

The field of child abuse medicine has come a long way in a short time. This book is yet another landmark on our road to understanding the infant brain and its unique vulnerabilities. I thank the editors and authors for documenting our progress thus far.

**Carole Jenny, MD, MBA**

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## FOREWORD

Every day, newspaper articles, magazine stories, and television news accounts recount events of courtroom proceedings dealing with allegations that an adult has shaken an infant, resulting in the child's death or permanent and devastating brain injury. The stories are often similar in origin, telling of an otherwise law-abiding adult accused of committing a violent and seemingly senseless act against a helpless infant. Why would this happen? How could it happen? What really did happen? Typically these stories take on a controversial slant, highlighting the testimony of conflicting expert witnesses who are at the center of the legal conflict. Such news accounts often sensationalize events and create false controversies in an effort to promote a more dramatic story line.

Today's courtrooms have become the battleground for lawyers and experts who challenge the core science of medical research and theory on abusive head trauma (AHT). It is a battle fought before jurors and judges who have little knowledge of the scientific and medical issues that they are supposed to determine. Amidst this chaotic battle sits the judicial system and its search for truth and justice; however, the end result in many instances is confusion, deception, and a loss of integrity in both the science and the law—a sad and tragic epilogue in the wake of the even more significant loss or destruction of a small and precious human life.

For those involved in responding to child maltreatment, these stories occur far too frequently. Few professionals exposed to these scenarios question the reality that children are the daily victims of violent acts perpetrated by those who are supposed to love and protect them the most. For professionals, it is not a question of understanding and believing that these situations exist, but rather of getting others to understand these same truths and to explain why these truths should be accepted; this is no easy task. Denial is endemic to most perpetrators of these crimes, and the child victim cannot articulate what has occurred. Conclusive forensic evidence is rarely recovered from the crime scene. The decision regarding what has occurred is based largely on circumstantial evidence premised in large measure on medical findings and interpretation of their significance. It is no wonder that those accused of such crimes aggressively seek to challenge medical findings or offer alternative theories of causation.

The last two decades have witnessed an unprecedented growth in the state of medical research and knowledge regarding AHT. This increased knowledge base has brought with it improvements in the recognition and diagnosis of such trauma by medical professionals, concomitant increases in referrals of these findings to other investigating and prosecuting agencies, and more frequent legal filings through both the juvenile and criminal courts. Although most of these advancements in medical knowledge have reflected a consistent strain of thought within the medical fields, fringe elements have voiced alternative concepts, often with limited, if any, rigorous scientific support. These fringe concepts, however, have found a voice within the courtroom setting with amazing alacrity.

Courts sympathetic to the rights of the accused to present a defense, regardless of its validity, have been very reluctant to exclude fringe theories or to reign in the experts who voice them. Moreover, attorneys representing the accused have recently attempted to turn the tables and exclude the admission of expert testimony diagnosing AHT, unjustifiably asserting that there is no evidence-based scientific support for such testimony and that biomechanical data refutes "anecdotal" medical studies supporting these assertions. These attorneys are consistently supported in their challenges by a small group of experts who espouse these fringe theories. Internet sites devoted to challenging allegations of AHT, and conferences geared toward promoting these alternative theories, provide a ready market for these efforts that have culminated in repeated Frye and Daubert challenges in courts across the United

States, and in lengthy legal proceedings challenging convictions in the United Kingdom. While most of these challenges have not been successful, the efforts in combating them consume enormous professional and judicial resources. The search for truth and justice is seldom easy, nor is it one made without enormous personal and professional sacrifice by those committed to its pursuit.

So where do we find the truth? Where do we look for answers, for guidance, for perspective? How do we ensure that the pursuit of truth and justice on behalf of children and their families follows a path toward enlightenment and understanding and does not become sidetracked on a path of adversarial misdirection? How do we overcome the hidden agendas that permeate the law and that increasingly find their way into scientific research and literature? How do we discern competent scientific research and literature from that which is written in an effort to promote an agenda for courtroom testimony? How do we stop the misuse of scientific research and literature in the court process in an effort to distort the truth or to achieve a particular adversarial goal? How do we ensure the integrity and competence of professional responses and adherence to high ethical standards in these cases? These are some of the questions this book attempts to address.

Answers to these dilemmas will not come from a single source or from one group of professionals. If there is one thing we have learned from the trials, tribulations, and controversies of the past, it is that a multidisciplinary, coordinated response to these cases is the most effective method for coordinating information, promoting knowledge, improving professional practice, and arriving at the truth. The multidisciplinary nature of *Abusive Head Trauma in Infants and Children: A Medical, Legal, and Forensic Reference* reflects the importance of this principle and the value of this approach.

The educational value of this text is to be found not only in alerting professionals to the current issues and controversies that we all face, but also as a compilation of current professional thought against which novel and controversial theories can be tested and judged. While each chapter focuses on a unique professional perspective relative to the topic of AHT, each author recognizes the necessity for integration of their perspectives and subject matter expertise between the various professional disciplines. Readers will be encouraged to elevate their own practice to the standards outlined by these experts, and perhaps as importantly, they will be motivated to seek additional knowledge from professionals both within and without their fields of practice. Some may be inspired to pursue new and needed areas of additional scientific research. All should be challenged to develop best practices for themselves and their communities. No lesser standards can hope to withstand the rigors of the current and future challenges that are meted out in the crucible of the courtroom.

**Brian Holmgren**

Assistant District Attorney General  
Davidson County District Attorney Generals Office  
Nashville, Tennessee

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## FOREWORD

From 2000 to 2004, I was charged with the responsibility of advising police officers in the United Kingdom on how to investigate cases of child abuse. In doing so, I gained unique insight into how the many professionals involved in investigating and treating these cases actually carry out their work. I have been lucky to work with truly committed doctors, nurses, forensic pathologists, lawyers, and social service workers in countries such as Sweden, the United States, Canada, Bermuda, Germany, Estonia, and the United Kingdom. It has been my privilege to work with and learn from many of the professionals who have given their time to this book.

Every year, in countries all over the world, children are injured or killed as a result of abusive head trauma. During the last few years, the nomenclature for describing these injuries has changed from Caffey's "whiplash shaken infant syndrome" of the 1970s, to the "shaken baby syndrome" of the 1990s. The title of this reference work, *Abusive Head Trauma in Infants and Children: A Medical, Legal, and Forensic Reference*, more accurately reflects the true nature of how these children are injured and killed.

When I researched abusive head trauma (AHT) on behalf of the Home Office from 2000 to 2003, I was surprised to find a lack of reference works on this extremely important issue in the hundreds of published research works in medical and scholarly journals. That gap is now being addressed, and these new publications are written for both professionals and the public. This book is the first illustrated clinical and photographic reference on AHT, and it will be invaluable to all disciplines involved in child abuse cases. Only by working in a truly multidisciplinary environment can we hope to understand these cases and build strategies to treat, investigate, and prevent them.

This book does exactly that by addressing the epidemiology of AHT and moving on to discuss and illustrate the neurological and biomechanical issues involved in child abuse cases. Although the nonprofessional may never be able to unravel the intricacies of neuromedicine, the signs and results illustrated here will help police officers and lawyers understand what they are dealing with and how to present evidence in cases. Also, the presence of retinal hemorrhages has become a marker for these types of injuries in recent years, and here, in the chapters on eye examination, the ophthalmological aspects of AHT are explained.

Of course, professionals involved in the examination, treatment, and investigation of suspected AHT cases should not jump to the conclusion that an injury is the result of abuse. For this reason, the conditions that may sometimes mimic abusive injury are discussed in detail so that professionals are fully aware of any disputes surrounding diagnosis.

Children recovering from AHT need to be cared for by many people, not least of course parents. In addition, outpatient nurses and the social work professionals are often unsung heroes in their support of parents. This reference work includes chapters that colleagues in these fields will find informative while educating other professionals about their difficulties and successes.

Sadly, for police officers and lawyers, cases of abusive head trauma are more easily investigated when a child has died. Investigators will find the forensic and pathologic evidence needed to prove these cases is presented clearly in the chapters on forensic investigation and pathologic case studies.

Many of these cases actually do not go to court. For those that do, one might ask exactly how a jury of 12 "good men and women true" can understand the intricacies of brain pathology they will encounter in these cases. Chapters covering the use of technology in court cases to present evidence as simply as possible to jurors illustrate solutions to those problems. This same technology can also be used to train professionals in the arena.

The final chapters of this invaluable and educational work illustrate individual cases of AHT in child abuse. What they cannot do is show the grief and despair encountered by parents who have lost a child to AHT or soothe a young victim. The professionals who have contributed to this book have encountered that grief and despair many times, and it is one of the driving factors as to why they have given their time and energy to helping with this book in order to educate colleagues and public alike.

The dedication shown by all professionals working in this arena is clear. Thank you for your efforts, on behalf of injured and abused children everywhere, in bringing this book to fruition.

**Philip L. Wheeler**

Detective Chief Inspector  
Central Operations  
New Scotland Yard  
London, England



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## PREFACE

The need for a comprehensive reference on abusive head trauma (AHT) in infants and children has been increasing since the last decade. As more communities work to develop effective methods for recognizing and treating victims, investigating cases, protecting victims from further harm, prosecuting offenders, and pursuing education and prevention efforts, there has been a growing interest in educating and training the professionals involved in all phases of the community's response to this problem. The time has come to synthesize what we know, what questions remain, and what scientific studies still need to be done. It is time to share information in an organized, comprehensive, and useful manner among professionals working in the field in order to provide improved recognition, treatment, investigation, prosecution, education, and prevention of this deadly form of abuse.

This text is designed to serve as a reference for medical, investigative, legal, social service, and prevention professionals. All of these disciplines are affected by AHT in children and all have made notable progress in handling the results of child maltreatment in general. Prevention efforts have also been cultivated, focusing specifically on avoiding the development of patterns of child abuse within the family. The goal of educating all professionals is to help children and families with the corollary of improving society's concern and care for the most helpless of its citizens.

The chapters offered here attempt to put the problem in perspective with respect to current attitudes and practices. In addition, notable differences between accidental brain injury and AHT are discussed in terms of the mechanisms of injury and the other signs to observe. Special considerations for the areas of nursing, radiology, neuroradiology, neurosurgery, and ophthalmology are addressed in specific chapters. Disorders that mimic AHT and fall into the differential diagnosis are carefully explained. As with other types of child maltreatment, the occurrence of associated injuries can help in making an accurate diagnosis, so the specific findings that distinguish AHT from other causes of injury are discussed in detail.

Clinical and investigative topics are covered in instructive detail and expanded upon with the addition of chapters devoted to photographic content. These chapters contain case studies and examples representing the many forms and sequelae of AHT, as well as the medical and investigative tools and techniques employed by professionals treating and protecting victims of AHT.

Specialists serving in social service, forensic, and prosecutorial roles will find chapters covering the contributions they make to resolving cases of AHT. The latest courtroom aids are explained to help present an accurate and visually compelling case. The roles of individuals who come into contact with children suffering from AHT are detailed in order to provide the background needed to deal with cases expeditiously. Each chapter emphasizes caring for the child and family as well as identifying the problem and the perpetrator. The chapter on neurodevelopmental outcomes offers follow-up information that is useful for planning how to care for a child who has been subjected to AHT.

It is well-known that shaking a child or infant is dangerous, so education alone seems insufficient. The challenges facing prevention efforts include informing caregivers of the dangers of inflicting head trauma on children and providing affirmative ways to handle the stresses of childcare. In addition, prevention efforts must offer caregivers incentives to consider those alternatives when they feel they have reached the limit of their resources.

Finally, a chapter presenting a hypothetical case illustrates the problem, the course of investigation, treatment concerns, and the medical and legal outcomes; thus, readers are given a broad perspective and the information pertinent to their area of expertise.

We have sought to offer a balanced approach to the problem of AHT while exploring current efforts and recommendations to address the concerns of professionals. It is hoped that this publication will become a reliable reference for professionals in the medical, investigative, legal, social service, and prevention areas.

**Lori Frasier, MD**

**Kay Rauth-Farley, MD**

**Randell Alexander, MD**

**Robert N. Parrish, JD**

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## REVIEWS

*Combining current knowledge on head trauma from several professional fields is an outstanding feature of this book; it will support clinicians, pathologists, and other medical personnel working with professionals in other disciplines as they diagnose and investigate cases of both abusive and unintentional head trauma in children. The authors are recognized experts who have referenced their discussions with care. Child abuse specialists and any physician interested in pediatric head trauma should own this text.*

Robert W. Block, MD, FAAP  
Professor and Daniel C. Plunket Chair  
Department of Pediatrics  
Oklahoma University

*Abusive head trauma is a very difficult, complex and controversial subject, and much of the literature on it is relatively inaccessible. This much needed and highly original book is the first time that paediatricians have had a comprehensive source that covers, in detail, all aspects of one of the most difficult clinical and medico-legal problems in childhood available to them. All pediatricians and paediatric subspecialists will need access to this timely illustration of how and why child abuse has become a subspecialty in the USA.*

Tim David PhD, MD, FRCP, FRCPC  
Professor of Child Health and Paediatrics  
University of Manchester, UK

*Although controversy on the nomenclature and mechanics of abusive head trauma continue, it remains a major cause of death and morbidity in infants. The text's authors of this text have developed a helpful guide for physicians, both those familiar and unfamiliar with the problem. Dr. Boos provides a thoughtful and cogent discussion of the evaluation for possible abusive head trauma. Dr. Sirotnak's chapter provides an extensive, well referenced, look at unusual, but important, differential diagnoses.*

Kenneth W. Feldman, MD  
Pediatrics  
Children's Hospital and Regional Center  
Seattle, Washington

*The chapters on investigation are valuable resources for law enforcement investigators and prosecutors dealing with cases of suspected AHT. There are many practical recommendations made in this text that will contribute to thorough, quality investigations. The case examples used throughout provide an excellent way to understand the issues and challenges that are routinely encountered in the investigation of these types of child abuse incidents. This publication should be part of every child abuse investigator's library.*

Lt Bill Walsh  
Dallas Police Department  
Dallas, Texas

*The book itself is a clear reflection of the partnerships necessary to accurately identify and address the most serious inflicted injuries to infants and young children. The contributors definitively illustrate that "multidisciplinary" must be much more than a catchword. Knowledge, cooperation and collaboration are essential to effectively protect children.*

Gus H. Kolilis  
Chief, State Technical Assistance Team  
Jefferson City, Missouri

*I read the chapter on prosecution on the eve of a child homicide trial and found that the factors in the Appendix described my case to a tee. It succinctly summed up the evidence a prosecutor needs to identify who abused the child and why. By conveying the answers to the questions to the jury, the prosecutor can overcome one of the biggest hurdles in a child abuse case: convincing the jury that parents can and have intentionally hurt their child. Every attorney, whether experienced or novice, should utilize this Appendix on every child case they have.*

Jeannette R. Gallagher  
Deputy County Attorney  
Maricopa County Attorney's Office  
Phoenix, Arizona

*Abusive Head Trauma in Infants and Children brings together in one volume the most complete treatment ever of the medical and legal issues involved in what are perhaps the most challenging prosecutions in our nation's courtrooms. Prosecutors and investigators will find it to be an essential guide to bringing the strongest possible case against the abusers of our children.*

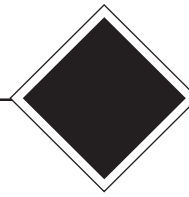
Paul Logli  
President of the National District  
Attorneys Association,  
2005-2006  
Winnebago County State's Attorney  
Rockford, Illinois

*The comprehensiveness of this text is a testament of its quality. It identifies guidelines regarding critical information that needs to be communicated among health care professionals, child protection agencies, and law enforcement officials. Abusive head trauma is analyzed in terms of both investigative procedures and prevention efforts. Such a systemic approach to investigation and prevention is necessary if we are to protect our nation's children.*

Dale Fitch, PhD  
Assistant Professor  
School of Social Work  
University of Michigan

*This is a book on an important topic of considerable current interest to medical and nonmedical professionals working in child abuse. The chapters are well researched and particularly well written. The use of case examples is exceptional. This is an excellent guide for professional reference and for teaching new professionals to our field.*

Jon R. Conte, PhD  
School of Social Work  
University of Washington  
Seattle, Washington



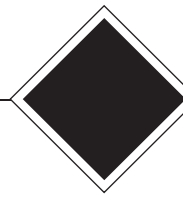
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# CURRENT PERSPECTIVES ON ABUSIVE HEAD TRAUMA

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It is widely accepted that shaking a young child or infant is dangerous, yet education alone seems to be insufficient in preventing incidences of abusive head trauma (AHT). The main goal for professionals, caregivers, and parents alike is the elimination of child maltreatment. The rate for reports of maltreatment in 2000—12.2 per thousand—was the second lowest over the past decade; however, these are real children suffering physical and emotional pain. To prevent further occurrences of child maltreatment, caregivers must be given affirmative ways to handle the stresses of caring for children and provided incentives to consider those alternatives when faced with stressful situations.

AHT is a problem best addressed by a multidisciplinary team, including medical, investigative, legal, social service, and prevention professionals. This team approach has been formed over the course of the field's history, from the first recognition of maltreatment in children through the development of its current level of knowledge and expertise.

## HISTORY

Physical abuse by a caregiver has been recognized as a cause of traumatic injury in infants and children for nearly half a century. In 1961, the term *battered child syndrome* was coined by Dr. C. Henry Kempe as the title of the first multidisciplinary conference on the newly recognized problem of child abuse.<sup>1</sup> This conference is credited with eliciting a great outcry on behalf of abused children and garnering much-needed support for further study of the problem. In 1962, the results of this conference were published in the *Journal of the American Medical Association (JAMA)*,<sup>2</sup> and in 1968 the first edition of the text *The Battered Child* was published with Drs. Ray Helfer and Henry Kempe as editors. This landmark text contained contributions from many of Helfer and Kempe's colleagues, not only in pediatrics but also in radiology, mental health, law, and social services. The latest edition,<sup>1</sup> published in 1997, continues to present a multidisciplinary picture of the field of child maltreatment.

The term *child maltreatment* has replaced the original *battered child syndrome* term as a less offensive and all-encompassing way of describing the variety of injuries and illnesses in children caused by their caregivers. Thousands of children each year are seriously or permanently injured or killed by their caregivers. Many types of abusive injury have been described and studied since the 1960s, including skin surface injuries (ie, bruises, lacerations, and burns), bony trauma (ie, fractures), abdominal trauma, genital injuries, and head injuries, which are most frequently lethal.

Any type of abusive injury should be regarded as serious and worthy of attention and study; however, abusive head trauma is the primary cause of death from abuse in infants and young children.<sup>3,4</sup> In 2000 a total of 1200 children in the United States

died from abuse or neglect.<sup>5</sup> Statistics on these deaths are collected through the National Child Abuse and Neglect Data System, but may underestimate the actual problem because of a lack of national definitions as well as nonuniform child fatality investigation and autopsy methods throughout the United States. Most of these child abuse fatalities in infants and children younger than 2 years result from AHT.

The entire multidisciplinary field of child maltreatment now exists due to the efforts of pioneering professionals, including thousands of professionals from the fields of law enforcement, medicine, law, social services, mental health, education, rehabilitation, prevention, and child advocacy. Over the last 4 decades, this field of study and service, which has been called by various names—*child abuse*, *forensic pediatrics*, and *child maltreatment*—has evolved into specialized subfields. This text focuses on that of abusive head injuries in infants and children, but injuries of many types are produced by maltreatment.

In 1946 pediatrician and radiologist Dr. John Caffey first questioned the association of bony injuries with head injuries in infants. He reported on 6 infants who suffered long-bone fractures and subdural hematomas.<sup>4</sup> In none of his 6 cases was a history given to reasonably account for the presence of these injuries. One of the infants in Caffey's 6 cases was noted to be "clearly unwanted by both parents," causing the doctor to raise the question of possible intentional infliction of injury on the child. Caffey concluded in his report that the subdural hematomas and the long-bone fractures were caused by the same traumatic forces. He was the first to report such an association in medical literature. The presence of unrecognized traumatic injury in infants also caught the attention of Dr. Frederic Silverman, who in 1953 reported finding unsuspected fractures on routine presurgical radiographs in infants,<sup>6</sup> reinforcing not only the prior radiographic findings of Caffey but also the lack of a credible history given by caregivers to account for the injuries.

Woolley and Evans<sup>7</sup> authored a paper describing 9 years of injury data from the Children's Hospital of Michigan. They found that many children had skeletal injuries associated with trauma, but no history of a traumatic event was obtained from caregivers. Some of these children also had associated subdural hematomas. An unknown syndrome was postulated to describe these "nontraumatic findings." In summarizing the study the authors stated, "It is difficult to avoid the overall conclusion that skeletal lesions having the appearance of fractures—regardless of history of injury or the presence or absence of intracranial bleeding—are due to undesirable vectors of force." Public acknowledgement of maltreatment in children as a problem<sup>8</sup> nudged the medical profession into paying closer attention to the possibility of child abuse as a cause of traumatic injury, even in the absence of a clear history of trauma.

Twenty-six years after Caffey's first report, following the important contributions of researchers such as Guthkelch<sup>9</sup> and Ommaya,<sup>10-12</sup> Caffey's often-cited article, "On the Theory and Practice of Shaking Infants: Its Potential Residual Effects of Permanent Brain Damage and Mental Retardation"<sup>13</sup> appeared in the *American Journal of Diseases in Children*. Just 1 year previously, Guthkelch's article on the relationship of subdural hematomas found in infants to the mechanism of whiplash injuries was published in the *British Medical Journal*.<sup>9</sup> By that time Caffey was convinced that the cause of these head injuries in infants was manual shaking by their caregiver. He recognized that the history given by these caregivers was falsified and theorized that they did so out of fear of recrimination for causing the injuries. In addition, Caffey noted the frequent presence of retinal hemorrhages and the absence of external injuries in some cases. The outcomes for his group of patients included permanent brain damage, mental retardation, and death. In 1974 Caffey<sup>14</sup> used the term *whiplash shaken infant syndrome* to describe this constellation of intracranial injuries, long-bone fractures, and frequently found retinal hemorrhages. The term *shaken baby syndrome* (SBS) came into general usage in the 1980s and remains a well-recognized means of describing this deadly constellation of findings.

# EPIDEMIOLOGY OF TRAUMATIC BRAIN INJURY: RECOGNIZING UNINTENTIONAL HEAD INJURIES IN CHILDREN

M. Denise Dowd, MD, MPH

## MAGNITUDE OF THE PROBLEM

Each year in the United States approximately 100 of every 100 000 children younger than 6 years suffer from traumatic brain injuries resulting in death or hospitalization.<sup>1</sup> Eighty-two percent of all head injuries are considered mild (Glasgow Coma Scale [GCS] >12), 14% are moderate (GCS 8-12) to severe (GCS <8), and 5% are fatal. Children have the highest rate of minor head injuries compared to other age-groups. Each year 400 000 children younger than 5 years are treated for minor head injuries in emergency departments and outpatient clinics.<sup>2</sup> Outcomes of unintentional head injury vary from complete recovery to severe impairment and depend on the severity of initial injury mechanisms and *secondary brain injuries*, or brain damage that results from swelling after the injury. An estimated 30 000 or more children sustain permanent disabilities as a result of brain injury every year.<sup>3</sup> Although head injuries remain at levels demanding greater prevention measures, recent data indicate that head injury hospitalization and deaths among children have declined significantly in the United States since the early 1980s.<sup>4</sup> This is a tribute to the success of injury prevention measures such as child safety seats and bicycle helmets. The decrease is also partially explained by a tendency toward less hospitalization in recent years.

For children aged 5 years and younger, the leading mechanisms and annual rates of head injuries are falls (50.6 per 100 000 children), motor vehicle crashes (25.9 per 100 000 children), and abuse (12.8 per 100 000 children).<sup>1</sup> Mechanisms of head injury vary with developmental vulnerabilities that change rapidly during the first 5 years of life. For infants younger than 1 year, serious head injuries are most commonly caused by abuse, whereas the majority of head-injured children older than 1 year are injured by unintentional means. Severe accidental head injuries in infants are rare, as indicated by a study that found, excluding uncomplicated skull fractures, 95% of serious intracranial injuries and 64% of all head injuries in infants are the result of abuse.<sup>5</sup>

As with the majority of childhood traumas, accidental head injuries are more common in males and occur when children are most active—the spring and summer months and weekends. Certain medical disorders, including hydrocephalus with a shunt and coagulation disorders such as hemophilia and vitamin K deficiency, increase the risk for intracranial injuries with a smaller degree of force.

## COMMON MECHANISMS OF HEAD INJURY

Mechanisms predict the resulting types of head injuries. General categories of head injury mechanisms include direct contact to the head, acceleration or deceleration of the brain within the skull, and hypoxia-ischemia. Events leading to injury may involve a combination of these mechanisms. Most severe unintentional head injuries are accompanied by dramatic and notable histories of injury. Many abusive head injury patients are brought to medical attention with histories of accidental injury; thus, it is important to understand the typical ways in which childhood unintentional head injuries occur and the types of physical findings to expect. Several of the more common causes of unintentional head injury are specifically described.

### FALLS

#### Falls Down Stairs

Though parents often are frightened when skull fractures occur, falls down stairs, excluding those in walkers, rarely lead to serious intracranial injuries. Falls down stairs include an initial fall followed by a series of several small falls, with physical damage occurring as the result of the cumulative effect of kinetic energy generated in several impacts. A study of 363 cases of stair falls by Joffe and Ludwig<sup>6</sup> found that 28% of the children sustained skull fractures and no patient suffered intracranial injuries. Skull fracture occurrence increased to 40% when children fell while in the arms of caregivers. Chiaviello et al<sup>7</sup> found that 3 of 69 children who fell down stairs sustained intracranial injuries, 1 with a subdural hematoma and 2 with cerebral contusions. Two of these more seriously injured patients were being carried in their caregivers' arms. No correlation between severity of injury and number of stairs involved in the fall was noted in either study.

#### *Falls in Walkers*

When children fall down stairs in infant walkers, the potential for serious injury increases significantly. The Consumer Product Safety Commission estimates that 25 000 children are treated for infant walker-related injuries in emergency departments in the United States each year and that about 80% of them involve falls down stairs. The vast majority (95%) are younger than 15 months, and one fourth of them sustain injuries classified as "more severe," which includes head injuries and fractures. One child per year dies in the United States because of a walker-related head injury.<sup>8</sup> Two studies found that 10% to 15% of children sustained skull fractures and 1% to 8% had intracranial bleeding, including subdural hematomas.<sup>9,10</sup> Risks for skull fracture varied depending upon the number of steps fallen down and whether infants struck a concrete floor.<sup>10</sup> Pediatric injury prevention experts and medical organizations such as the American Academy of Pediatrics recommend that infant walker manufacturing and sales be banned<sup>11</sup>; nonetheless, use of walkers is still relatively common. Alternative nonmobile infant seating options such as "exersaucers" have become increasingly popular, but safety comparison information on these items is not available.

#### Falls From Shopping Carts

Falls from shopping carts are an important cause of pediatric head trauma to consider. In 1996, 16 000 children were treated for falls from shopping carts, 66% of whom sustained head injuries such as concussions or skull fractures.<sup>12</sup> Fortunately, severe intracranial injuries in these falls are rare. Smith et al<sup>13</sup> found that about 26% of cart-related falls occur when shopping carts tip over. About half of children falling from carts fall from the seat and the other half fall from the basket.<sup>13</sup>

#### Short Vertical Falls

Short vertical falls from heights lower than 4 feet (eg, out of bed, from a highchair, out of the arms of a caregiver) are common. These falls included those from inappropriately placed car seats and "bouncy chairs." Caregivers underestimate the

# UNINTENTIONAL HEAD INJURIES: CASE STUDIES

Todd C. Grey, MD

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The patterns of injury seen in accidental lethal head trauma are striking. The typical findings in a case of immediately or rapidly fatal accidental head injury in which the child is pronounced dead at the scene or within a short time of arriving at the hospital have an array of cutaneous, skeletal, and intracranial findings. While the extent of injury in the various structural layers of the head may at times be discrepant, there is always something in the pattern and extent of injury that is indicative of a significant amount of force being delivered to the head. What is even more striking is the clear correlation between the severity of injury and the mechanism of injury provided in the history. The injuries present in the patient are reasonable given the explanation provided for these injuries, which is in sharp contrast to the often trivial mechanisms offered as an explanation for a child's injuries in cases of abusive trauma. The cases in this chapter are graphic in their presentation but serve to emphasize the dramatic and distinct nature of the injuries. It is also notable that tremendous forces are involved when accidental fatal head trauma occurs in the case of motor vehicle collisions, a horse falling on a child, or an adult falling down stairs and landing on a child.

## MOTOR VEHICLES

### PASSENGER FATALITY

#### Case Study 3-1

This 11-year-old boy was riding in the car with his mother when she fell asleep while driving. The car left the roadway and rolled approximately 100 m. The mother was wearing her seat belt and sustained minor injuries. The boy had undone his seat belt; in addition to injuries to the torso and extremities, he suffered extensive head trauma.

**Figure 3-1-a.** Abrasion and contusion of the right frontotemporal region.

**Figure 3-1-b.** Extensive subgaleal contusion.

**Figures 3-1-c and d.** Complex fracturing of the vault and base of the skull.

**Figure 3-1-e.** Thin subdural hematoma with subarachnoid hemorrhage over the convexities and cerebral edema.



Figure 3-1-a

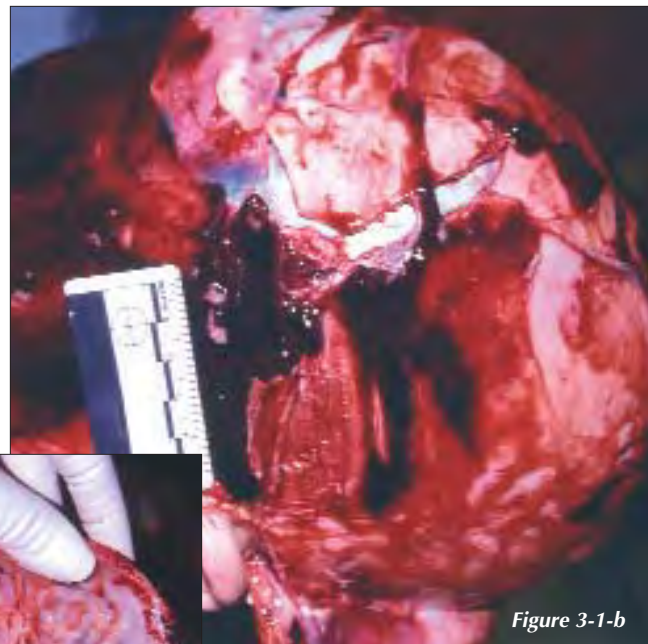


Figure 3-1-b



Figure 3-1-c

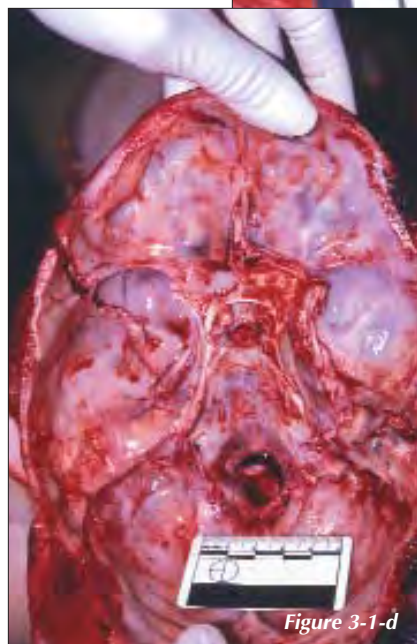


Figure 3-1-d

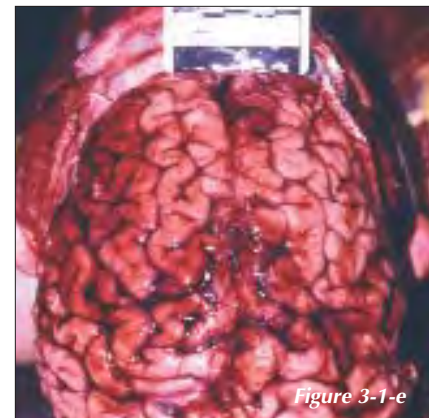
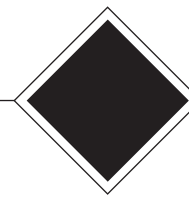


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