

Abusive Head Trauma: Historical and Current Perspectives of a Complex Diagnosis

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ABSTRACT

Abusive Head Trauma (AHT) results in more child fatalities than any other form of physical abuse and is associated with significant risk of morbidity for survivors. The diagnosis of AHT is made like any other complex medical condition and is based on a constellation of findings within the context of a reported history provided by the patient's caregiver(s). A standardized process with careful consideration of a differential diagnosis and utilization of a multidisciplinary team is essential. This article explores the history of the diagnosis of AHT, reviews the scientific basis for potential mechanisms, references the recommended medical evaluation, describes common findings, and the importance of early and accurate diagnosis.

KEYWORDS: abusive head trauma, shaken baby syndrome, diagnosis, history, physical abuse

INTRODUCTION

Abusive head trauma (AHT) refers to any inflicted head, spine, and/or brain injury to an infant or young child.¹ The incidence of AHT is about 33–38 cases per 100,000 infant less than one year of age.² AHT results in more child fatalities than any other type of physical abuse and is associated with significant risk of morbidity for survivors.³ When AHT is missed or not diagnosed, children may return to a potentially unsafe environment, placing them at risk of repeated injury or death.⁴ Importantly, AHT is a diagnosis made by a multidisciplinary team based on history, physical examination, imaging, and laboratory studies. The courtroom, however, has inappropriately become the forum for speculative theories that cannot be reconciled with generally accepted medical literature. The purpose of this article is to provide an overview of the history and scientific basis and to describe the common findings for AHT.

Anatomically, infants are vulnerable to the rotational forces associated with AHT. They have a large head-to-body ratio and relatively “soft” brain comprised of mostly water, immature glial cells, and unmyelinated axons. Infant neck muscles are weak and have cervical ligamentous laxity. Perhaps what makes infants most vulnerable is that they express their needs by crying; infant crying has been identified as the most common event that leads to

caregiver frustration, loss of control and subsequent injury.⁵⁻⁷

Terms used to describe this form of head injury have evolved as scientific data have advanced. In 1946, Dr. John Caffey first described six children with chronic subdural hematomas and long bone fractures.⁸ Subsequently in 1962, Dr. Henry Kempe identified “The Battered Child Syndrome” when there was a discrepancy between clinical findings and historical information for hospitalized infants.⁹ In 1971, Dr. Norman Guthkelch made the connection between infants with subdural hematomas and a history of having been shaken by their caregivers. Notably during this time there was not stigma associated with shaking an infant and therefore caregivers readily reported this act to medical providers.¹⁰ The terminology of Shaken Baby Syndrome emerged out of the 1970s and was questioned in 1987 by Dr. Christine Duhaime after studying the biomechanics using model simulation and data based on injury thresholds established in primates.¹¹ Using the term Shaken Baby Syndrome persisted until 2009 when the American Academy of Pediatrics issued a statement recommending the medical use of the term Abusive Head Trauma (AHT) instead. AHT identifies that shaking alone is not inclusive of the range of mechanisms to explain inflicted head injury and, is not a rejection of the dangers of shaking an infant thereby recognizing that this is type of head injury is a form of child abuse. Additionally, a prescribed syndrome approach to diagnosis is not appropriate.¹²

A prospective randomized case-control study can never be ethically completed to understand the biomechanics of AHT. Therefore, our knowledge base relies on extrapolated data from animal studies, comparative studies, simulation modeling as well as admissions and confessions by people who have caused injury to infants.

Biomechanics of head injury

Some of the earliest work to inform the biomechanics of head injury used primate studies that were done by Ayub Ommaya and colleagues in the 1960s. For example, in 1968 researchers secured sedated rhesus monkeys into a fiberglass chair on a sled apparatus with either a collared or uncollared neck. Either a single or multiple propulsion(s) was/were applied to the sled and then researchers evaluated grossly which conditions resulted in concussion and/or subdural hematoma.¹³ Direct, gross examination of the brain occurred

because it wasn't until 1971 that computed tomography (CT) scans were in existence. These data helped to establish what kind of mechanisms resulted in different injuries and injury thresholds. It is critical to recognize that these injuries and thresholds were established in monkeys and *not* in humans nor human infants. While animal data are important, a large limitation to this research is that human infants have different brain compositions, necks, and do not experience the same mechanisms as a monkey on a sled apparatus.

Simulation modeling

Information from simulation modeling has also contributed to our understanding of the biomechanics of AHT. In 1987 Dr. Christine Duhaime and colleagues published a study that utilized clinical, pathology and model simulation data to help elucidate the biomechanics of the entity referred to at that time as Shaken Baby Syndrome. For the simulation component of the study, a primitive model (stuffed head with hinged neck) that had accelerometers placed on its "head" were used to measure the force required to reach certain injury thresholds that resulted in concussion, SDH, and axonal injury. They found that shaking alone did not meet extrapolated injury thresholds – remembering that previously established thresholds were based on the primate data. Despite this, they concluded that "Shaken baby syndrome at least in its most severe acute form is not usually caused by shaking alone. Although shaking may in fact be part of the process, it is more likely that, such infants suffer blunt force impact." This conclusion led to the claim that persists as a serious controversy, that, "It is biomechanically impossible to cause massive brain injuries including subdural hematomas in children through shaking alone."¹¹

More recent simulation modeling has provided additional information about mechanisms. Using a high biofidelic model, that more closely mimicked the head to body proportions of a human infant and importantly had an articulated neck as compared to the hinged neck of the Duhaime model, the researchers demonstrated high levels of angular acceleration on accelerometers placed on the model undergoing vigorous shaking. Additionally, this study offers visual data from high speed videography that identifies the model's "head" experiencing a wide arc of rotation during a 3–4 second episode of being shaken by an adult study volunteer.¹⁴

Comparative studies

Comparative studies have furthermore aided in understanding the biomechanics of AHT. In 2007, Hymel et al published a multicentered prospective study comparing 30 noninflicted head-injured infants to 11 inflicted head-injured infants. They demonstrated significant differences between the two cohorts with the inflicted head-injured infants having: greater depth of injury on neuroimaging, more frequent presentation with acute cardiorespiratory compromise and lower initial Glasgow Coma scores, more frequent and

prolonged impairments of consciousness, more frequently demonstrated bilateral, hypoxic-brain injury and had worse injury and outcome scores. While the mechanisms differ between infants who suffered injury from motor vehicle crashes, this and other comparative studies contribute to our conceptualization of the harmful effects of AHT.^{15,16}

In addition to the anecdotal experience of medical providers and clinicians having caregivers admit to hurting their infant children, a growing body of literature includes caregivers describing how they injured their infants by shaking both with and without head impact. For example, a study published by Adamsbaum et al in 2013 describes caregiver admissions in France, where plea bargains are not a component of the legal process and thus there is no criminal benefit to admitting to injuring a child, lending some credibility to their validity. The researchers compared the written statements of 29 confession cases with 83 non-confession cases and demonstrated several similarities between the confession statements. The similarities between the confession cases include caregiver frustration particularly with a crying infant, recognition that what they did was dangerous, and that the infant became symptomatic immediately.⁵ Criticism exists that confession data lacks validity; however, several studies now published on this topic have added to the consistency and similarity of information provided to medical providers, and confessions inform our understanding of the biomechanics, and context of AHT.^{6,7} From extrapolated data, we understand to date that AHT is caused by rotational forces applied to the infant brain which can include acceleration, deceleration with or without impact, occurs outside of normal caregiving, including accidental impacts, short falls or playful activities, and the person who causes or witnesses the abusive event recognizes that it is dangerous for the baby.^{5,17,18}

DIAGNOSIS OF AHT

The diagnosis of AHT is based on a constellation of findings within the context of a reported history provided by the patient's caregiver(s). Subdural hematomas (SDHs), with concomitant brain injury, and retinal hemorrhages (RHs) are hallmarks of AHT; however, many infants will have spinal, cutaneous and skeletal injuries, additionally.¹⁹ This diagnosis is made like other complex medical conditions by obtaining a detailed history of present illness, past medical and family history, review of systems; completing a physical examination; and ordering pertinent laboratory studies and radiologic imaging. Based on this standardized process, subsequent consideration of a differential diagnosis is essential.^{20,21} Significantly, the diagnosis of AHT is not made based upon any single component and is specifically never reliant on the patient's social history or a single physical finding. Additionally, the diagnosis is not based upon a predetermined set of findings (e.g., subdural hematoma,

encephalopathy and retinal hemorrhages) often described as “The Triad” by defense claims within a legal setting and inappropriately applied in the clinical setting. Despite “The Triad” being used to discredit the diagnosis of AHT, it is critical to understand the specific relevance of SDH and retinal hemorrhages (RH) in the diagnosis of AHT.

Subdural hematomas (SDH)

Subdural hematomas (SDH) are a common neuroimaging finding in general and are the most common finding in the diagnosis of abusive head trauma.¹⁸ As with any other physical finding, the Identification of a SDH in an infant must be put into context to determine etiology. For example, a small SDH found underlying a skull fracture in the context of a well appearing infant who presents with a history of a fall from caregiver’s arms, likely does not warrant pursuing further work-up. In contrast, mixed density bifrontal SDHs or interhemispheric SDH found in an infant who presents with seizures or respiratory compromise who presents with the same fall history warrants further work-up given that the findings are inconsistent with the history or proposed mechanism of injury. In a 2011 systematic review which described neuroimaging signs that distinguish abusive from accidental head trauma, Kemp and colleagues found that interhemispheric SDHs were 9.5 times more likely in the abused infants. Similarly, for infants presenting with intracranial findings, a systematic review comparing *clinical* signs that distinguish abusive from accidental head trauma found that retina hemorrhages were 3.5 times more likely seen in the abused infants and apnea was 17.1 times more likely.^{22,23}

Retinal hemorrhages

Retinal hemorrhages are found in approximately 80% of patients diagnosed with abusive head trauma. Like SDH, retinal hemorrhages are identified in other medical conditions as well as other traumas and have been described and compared with retinal hemorrhages from abusive head trauma in the scientific literature.²⁴⁻²⁷ The retinal hemorrhages specifically associated with abusive head trauma are extensive, found in multiple layers, and extend from the posterior pole out to the periphery of the retina (the ora serrata). Pediatric ophthalmologists are part of the clinical multidisciplinary team making the diagnosis of AHT. Detailed documentation and assessment of retinal findings is reliant on dilated indirect fundoscopic exam with scleral depression to visualize the entire retina and after consideration of clinical presentation, history, laboratory studies, and physical and neuroimaging findings.²⁸

Assessment recommendations

When there is suspicion for AHT, a thorough undressed physical examination is essential in identifying any cutaneous injuries as approximately 50% of children with abusive

head trauma will have cutaneous injuries.²⁹ Neurologic assessment is particularly important including examination of the anterior fontanel, measuring head circumference, and comparing to previous measurements. Minor injuries in children are common and not usually the result of abuse or neglect. However, when an injury occurs in a non-mobile infant it is important to recognize that even a small bruise should expand the clinician’s differential diagnosis to include inflicted injury and possible physical abuse, and prompt further work-up. Additionally, early recognition of injuries especially in young infants provides an opportunity for intervention and protection for vulnerable children as 28% of infants diagnosed with AHT had a previous minor “sentinel” injury seen by a medical provider before the diagnosis of AHT was made. The most common sentinel injuries seen infants with AHT were bruises and intraoral injury.³⁰ The American Academy of Pediatrics has clearly outlined detailed physical evaluation, laboratory, and radiologic recommendations for children when there is clinical suspicion of child physical abuse and in specifically abusive head trauma.²⁰

CONCLUSIONS

Abusive Head Trauma is a diagnosis made by a multidisciplinary team based on history, physical examination, imaging, and laboratory studies. The number and quality of published peer-reviewed research studies regarding AHT have increased dramatically over the years. However, some non-pediatric medical professionals and others have erroneously opined that AHT is an unproven diagnosis and are directly challenging widely held theories regarding the mechanism of AHT.³¹⁻³³ Professional medical societies use consensus statements or white papers, to communicate general physician and medical acceptance on a particular topic. A consensus statement on Abusive Head Trauma published in 2018 was written and then endorsed by representatives from multiple subspecialties from 15 major national and international professional societies spanning seven countries.³⁴ It was created specifically to reduce confusion on the topic and to distinguish genuine evidence-based opinions of the relevant medical community from legal arguments or etiological speculations. The referenced confusion on this topic often highlighted by the media and promulgated within the courtroom has the potential to disseminate inaccurate information that could result in parents not trusting nor seeking medical care due to the potential of child abuse being over-diagnosed. Dangerously, the message that shaking an infant cannot cause serious injury will create the additional risk of encouraging dangerous or even life-threatening caregiver behavior.

A uniform, unbiased, and non-judgmental approach is required when making the diagnosis of AHT. This entails utilization of a multidisciplinary team that can be comprised

of child abuse pediatricians, ophthalmologists, radiologists and other providers depending on the case (e.g., ICU teams, genetics, hematology). Standard medical diagnostic processes within the context of an extensive peer-reviewed literature and in conjunction with the clinical expertise of thousands of physicians, leads to the conclusion that children can sustain head and brain injuries caused by those entrusted to care for them.

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