



Evaluation of the Hypothesis That Choking/ALTE May Mimic Abusive Head Trauma

Jennifer B. Hansen, MD; Terra Frazier, DO; Mary Moffatt, MD; Timothy Zinkus, MD; James D. Anderst, MD, MS

From the Department of Pediatrics (Drs Hansen, Frazier, Moffatt, and Anderst), and Department of Radiology (Dr Zinkus), Children's Mercy Hospital, Kansas City, Mo

Conflict of Interest: Drs Hansen, Frazier, Moffatt, and Anderst are child abuse pediatricians and provide medical care for children when there is concern for abuse and offer expert testimony in those cases. Dr Anderst provides expert consultation to public defenders, prosecutors, and other attorneys in criminal and juvenile courts. Dr Zinkus has no conflicts of interest to disclose.

Address correspondence to James D. Anderst, MD, MS, Department of Pediatrics, Children's Mercy Hospital, 2401 Gillham Rd, Kansas City, MO 64108 (e-mail: jdanderst@cmh.edu).

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ABSTRACT

OBJECTIVE: Apparent life-threatening events (ALTEs), often accompanied by choking, have been hypothesized to cause subdural hemorrhages (SDH), retinal hemorrhages, and brain injury. If the choking/ALTE hypothesis were true, children who present with ALTE and SDH would have fewer extracranial injuries suspicious for abuse than those with SDH and no ALTE. We aimed to compare the prevalence of suspicious extracranial injuries in children who have ALTE-associated SDH to those with non-ALTE SDH.

METHODS: We performed a 5-year retrospective case-control study of children <2 years of age with SDH evaluated by the Child Abuse Pediatrics program at a children's hospital. Subjects were classified as ALTE-associated SDH and non-ALTE SDH on the basis of ALTE definitions as proposed by the authors of the choking/ALTE hypothesis. The 2 groups were compared for the prevalence of suspicious extracranial injuries.

RESULTS: Of 170 study subjects, 64 had an ALTE-associated SDH and 106 had non-ALTE SDH. ALTE-associated SDH

subjects were nearly 5 times more likely to have at least one suspicious extracranial injury (odds ratio [OR] 4.8, 95% confidence interval [CI] 1.9–12.1) and were more likely to have individual types of suspicious extracranial injuries, including retinoschisis (OR 4.1, 95% CI 1.6–10.2), high-specificity bruising (OR 2.6, 95% CI 1.3–4.9), and internal abdominal injury (3.5, 95% CI 1.2–9.9). Subjects with ALTE-associated SDH were also significantly more likely to die or have persistent neurologic impairment. All 10 subjects with a dysphagic-choking type ALTE had at least 1 suspicious extracranial injury.

CONCLUSIONS: ALTEs are not supported as causative mechanisms for findings concerning abusive head trauma.

KEYWORDS: abusive head trauma; child abuse; child maltreatment; physical abuse; shaken baby syndrome

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WHAT'S NEW

This is the first scientific evaluation of the hypothesis that choking/apparent life threatening events (ALTE) may mimic abusive head trauma in the population of interest. The results of this study are the opposite of those predicted by the choking/ALTE hypothesis: ALTEs are not supported as causative mechanisms for findings concerning abusive head trauma.

ABUSIVE HEAD TRAUMA (AHT) is the leading cause of traumatic death in infancy and is associated with overall poor prognosis in survivors.¹ The diagnosis of AHT is often challenging because of overlapping findings resulting from noninflicted trauma, abusive trauma, and possible medical causes for the physical findings. Additionally,

there is no reference standard diagnostic test and frequently no clear history regarding trauma.¹ The diagnosis of AHT has significant implications. An incorrect diagnosis of abuse could have considerable negative effects on the family. Likewise, incorrectly attributing an abusive injury to an accidental or natural cause places a child at great risk of recurrence of abuse.^{2,3}

Subdural hemorrhage (SDH) is a frequent finding in AHT.^{1,4–6} Most SDHs in young children are the result of trauma, and the single greatest cause of symptomatic brain injury with SDH in this population is AHT.^{5,6} SDH is thought to result from acceleration–deceleration of the head, resulting in tearing of bridging veins or bleeding from small intradural veins.^{7–9} Traumatic bleeding from either source is thought to require significant force.^{10,11} However, in children who present with SDH and no history of significant trauma, a differential diagnosis must be explored.

Differential diagnoses for AHT should include medical conditions that have been shown to cause findings that are similar to those seen in AHT, such as bleeding disorders, vascular malformations, and other medical conditions.^{12,13} Some authors have presented the hypothesis that SDH, retinal hemorrhages (RH), and brain injury, specifically hypoxic-ischemic encephalopathy, may result from an apparent life-threatening event (ALTE) due to a dysphagic-choking episode (the choking/ALTE AHT-mimic hypothesis).¹⁴ The choking/ALTE AHT-mimic hypothesis (henceforth called the “choking/ALTE hypothesis”) suggests that choking causes paroxysmal coughing, which leads to significant increases in intrathoracic pressure, which is transmitted to intracranial vasculature. This elevated pressure is hypothesized to cause distention and damage to the intracranial vessels, resulting in SDH, subarachnoid hemorrhage, and RH. Additionally, hypoxia caused by the initial choking event is hypothesized to lead to further brain swelling and injury. This theory has been further developed to propose that hypoxia may cause damage to the endothelium of intradural blood vessels which results in oozing from the vessels and subsequent SDH formation.^{15,16} The proponents of the choking/ALTE hypothesis suggest that this process is frequently the cause of findings that are incorrectly diagnosed as AHT and use this theory in legal proceedings.¹⁷ Infants and children with AHT are commonly found to have other extracranial injuries suspicious for abuse, such as bruising, retinosis, fractures, or intra-abdominal injury.^{18–24} The choking/ALTE hypothesis does not include an explanation for these other injuries.

Many disorders can cause an ALTE in childhood, including child abuse, gastroesophageal reflux, and infections, among others.²⁵ “Brief resolved unexplained event” (BRUE) is the newly recommended terminology for these events.²⁵ However, under the new terminology, children who have ongoing symptoms or other findings of illness after a thorough history and physical examination are excluded from the BRUE definition. ALTE (or BRUE) is not a diagnosis or an underlying condition.²⁵ Much like a fever, ALTE is a symptom of some other disease condition. However, in the medicolegal setting, ALTE is presented as a distinct pathologic process which is theorized to result in SDH and RH.^{14,17} Despite its use in legal proceedings, the choking/ALTE hypothesis has not been scientifically evaluated. If the choking/ALTE hypothesis is true, then children who present with SDH after an ALTE would be less likely to have other injuries suspicious for abuse than those with SDH and no history of an ALTE.

The primary objective of this study was to compare the prevalence of extracranial injuries suspicious for abuse in children who were diagnosed with SDH and who presented with a history (as provided by a caregiver) of an ALTE, as defined by Barnes et al¹⁴ (ALTE-associated SDH, cases), to children diagnosed with SDH and who presented without a history of ALTE (non-ALTE SDH, controls). The secondary objective was to compare clinical outcomes between the 2 groups.

In evaluating the choking/ALTE hypothesis, the null hypothesis is that there is no difference between the occurrence of extracranial injuries suspicious for abuse in children with ALTE-associated SDH and non-ALTE-associated SDH. Data that indicate no difference between children with ALTE-associated SDH and non-ALTE SDH in prevalence of suspicious extracranial injuries would fail to support the choking/ALTE hypothesis. Similarly, data that indicate a higher prevalence of suspicious extracranial injuries for abuse in subjects with ALTE-associated SDH would be the opposite of what would be expected if the choking/ALTE hypothesis were true.

METHODS

STUDY DESIGN AND POPULATION

We performed a retrospective case-control study of children younger than 2 years of age who presented to the authors' institution with SDH and were evaluated by the hospital Child Abuse Pediatrics (CAP) team between June 2008 and December 2013. SDH was chosen as the index finding for inclusion in the study because it is commonly seen in AHT but is also present in cases theorized to occur via the choking/ALTE hypothesis. In order to study the association of caregiver-reported ALTE with suspicious extracranial injuries, ALTE must be present in one group (cases) and not present in the other group (controls). An age of younger than 2 years was chosen as an inclusion criterion to encompass children at the highest risk of AHT and who were most likely to have the choking/ALTE hypothesis used to explain their findings.²⁶ To account for known mimics of child abuse or causes of SDH, children were excluded if there was a history of a pre-existing abnormality of the brain, infection of the central nervous system, known prior intracranial hemorrhage, prior central nervous system surgery or shunt placement, extreme prematurity (<28 weeks' gestational age at birth), bone fragility syndrome, known bleeding disorder or vascular abnormality, or another condition that predisposed subjects to intracranial hemorrhage, bruising, fractures, or findings that may mimic abdominal trauma, or if any of these were discovered during the medical evaluation (inclusive of the CAP team evaluation) related to the SDH. Additionally, children with a small isolated SDH immediately underlying a skull fracture were excluded, as these findings generally result from contact forces, are often from accidental injury, and are not part of the choking/ALTE hypothesis.²⁷ The study was approved by the institutional review board of Children's Mercy Hospital.

DATA COLLECTION

Demographic information, medical and clinical history, physical examination and radiologic findings, and neurologic outcomes were obtained through chart review. The purpose of this study was to test the choking/ALTE hypothesis in isolation, irrespective of the diagnosis of abuse. Thus, the ultimate diagnosis regarding abuse made by the CAP team was not collected and did not affect determination of whether injuries suspicious for abuse were present.

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