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Research Aticle

Clinical Features of Children with Abusive Head Injury and Apparent Life-Threatening Events upon Presentation to a Children's Hospital

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Abstract

Background: The symptoms of child abuse and ALTE are similar. Diagnosing child abuse in those who present with an ALTE may be difficult since the symptoms are similar, and bruising is not always seen in those abused. Approximately only 50% of infants who have bruising are found to be abused. There is limited literature showing bruises to the face or blood in the nose or mouth are distinguishing features of those abused infants who initially present to the Emergency Department (ED) for ALTE.

Objective: To determine if bruises or contusions to the face or body in infants occur more often in those who present to the ED as an ALTE but found to have Abusive Head Injury (AHI) versus those who present as ALTE and not found to have AHI. A secondary aim was to determine if blood in the mouth and/or nose was present in those with ALTE but found to have AHI.

Methods: Retrospective case-control study of infants <12 months of age with ALTE who were admitted to a children's hospital for whom head CT or MRI were performed. Cases were patients who's ALTE was deemed to result from physical abuse as determined by court or confession by perpetrator. The control group was those with a discharge diagnosis of ALTE with the etiology not known. We estimated odds ratios and 95% confidence intervals to determine whether there was an association between physical abuse and bruises to the face or body or blood in the nose or mouth, were present more often in those found to be AHI.

Results: There were 49 patients in the study: 20 AHI and 29 non-AHI. All infants in both groups had apnea as a presenting symptom. There were no differences in race or gender between groups. No patients in the non-AHI group had retinal hemorrhages. There was not a significant difference in CPR performed prior to arriving to the ED between groups. Intubation was performed with higher frequency in the AHI patients than non-AHI patients (62% vs 0%, p=0.002 by Fisher's Exact Test). All nine patients requiring intubation were in the AHI group and had intracranial bleeds. Bruises were present with higher frequency in the abused than non-abused group (31% vs 0%, P=0.017 by Fisher's Exact Test). All bruises were found on patients' bodies and none on their faces. There were 2 patients with blood from the nose but those were in the non-AHI group and had received CPR.

Conclusions: Infants with ALTE who have AHI are more likely to present with bruising to the body, retinal hemorrhages, and intracranial bleeds than infants who have AHI. Blood in the nose does not identify those with AHI. The performance of CPR does not differentiate between groups but the need for intubation was associated with AHI.

Keywords: AHI; ALTE; BRUE; Child abuse, Shaken baby syndrome, Nonaccidental trauma

Background

Apparent Life-Threatening Event (ALTE) is characterized by some combination of apnea, color change, (cyanotic or pallid), marked change in muscle tone (limpness), choking or gagging which appears to be frightening to the observer in infants less than 1 year of age [1]. Brief resolved unexplained event (BRUE), should be applied only when the infant is asymptomatic on presentation. In patients who have sustained an abusive head injury (AHI) or ALTE can present with symptoms of BRUE but do not always have resolved symptoms when they present to the hospital. For this reason, we will use the term ALTE instead of BRUE in this paper.

The symptoms of ALTE and AHI are very similar but because AHI can be life-threatening it is important to be able to discriminate between the two diagnoses. The clinical features of BRUE and ALTE are: 1) Cyanosis or pallor 2) Absent, decreased or irregular breathing 3) Marked change in tone and 4) Altered mental status. The symptoms that both ALTE and AHI patients can present with are: apnea, marked change in muscle tone and color change [2]. In a study by Vellody and colleagues 3 of 4 pts that presented with ALTE were found to be victims of AHI. Three of the patients had apnea, and 1 was without apnea but was limp, pale and unresponsive [3].

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Diagnosing child abuse in those who present with an ALTE may be difficult, since noticeable signs of trauma such as bruising or contusions are only evident in approximately 50% of infants who are found to be abused [4]. From previous literature, bruises to the face have distinguished those abused infants who initially presented to the Emergency Department (ED) for an ALTE [3,5]. The presence of blood in the nose or mouth immediately following the ALTE have been found in those with AHI [6-8].

There is a low incidence of infants who initially present to a medical facility as an ALTE found to have AHI. The incidence of ALTE patients found to be abused victims ranges from .5%-3% [3,9-11]. Despite the low incidence of AHI in infants presenting with an ALTE, the consequences of AHI are often very serious. Twelve percent to 30% of children with AHI die [12,13] and 60% to 70% of the survivors have significant neurological disability [12-14]. For this reason, it is important to recognize and diagnose AHI in the healthcare setting. A landmark study from Jenny and colleagues demonstrated how important it is to recognize AHI early since it can lead to significant morbidity and mortality. Of 173 abused children with AHI, fifty-four (31.2%) had been seen by physicians after AHI and the diagnosis was not recognized. AHI was more likely to be unrecognized in very young children. Fifteen children (27.8%) were reinjured after the missed diagnosis. Twenty-two (40.7%) experienced medical complications related to the missed diagnosis. Four of 5 deaths in the group with unrecognized AHT might have been prevented by earlier recognition of abuse [15].

Objectives

To determine if bruises or contusions to the face or body in infants occur more often in those who present to the ED as an ALTE but found to have AHI versus those who present as ALTE and not found to have AHI. A secondary aim was to determine if blood in the mouth and/or nose was present in those with ALTE but found to have AHI.

Methods

This was a retrospective case-control series of infants who presented to an Academic Pediatric Emergency Department (ED). Infants <12 months of age with ALTE who were admitted to a children's hospital were included. A total of 740 patient with ALTE were screened (343 with AHI and 397 non- AHI). All patients had a head CT performed and/or ophthalmologic exam. The AHI group were patients whose ALTE was deemed to result from (AHI) as determined by court or confession by perpetrator and had an intracranial bleed. Intracranial bleed was defined as a subdural hematomas (SDH), subarachnoid hemorrhage (SAH), cortical hemorrhage, or contusion. The control group were those with a discharge diagnosis of ALTE with a negative CT (non-AHI). We estimated odds ratios and 95% confidence intervals to determine whether there was an association between AHI and bruises to the face/head and blood from the nose or mouth. This study was approved by the medical school's Institutional Review Board.

Results

There were 49 patients in the study: 20 AHI and 29 non-AHI. All infants in both groups had apnea as a presenting symptom. All those in the AHI group had intracranial bleeds or retinal hemorrhages. Comparing the groups, there were no differences in race (p=0.4640) or gender (p=0.29). The median age was 4.9 months in the abused group and 1.8 months in the non-abused group (p=0.005).

Bruises on the face/head (p=.2662 CI .4091-infinity) did not significantly differ in the two groups because none of the infants in both groups had bruises on the face. There were two patients with blood in their nose and they were in the non-AHI group. Those two patients did have bystander CPR performed prior to coming to ED. There were four non-AHI patients and two AHI patients where parents performed CPR before arriving in the ED (p=.2771 CI .455-30.9). Despite there being no difference in the need for CPR in both groups there was a significant number of patients in the AHI group who required ventilation (9) versus (0) in the non-AHI group. There was a significant difference in the AHI group versus non-AHI group in reference to bruising on the body, not including the face/head (p=.0049 CI 1.035-1.717) (5% *vs.* 0%) (Table 1).

Signs & Symptoms	Non-AHI	AHI	P value and 95% CI
Apnea	29	20	
Bruising on body	0	5	P=.004 (CI .035-1.717)
Bruising on face/head	0	0	
Nasal or oropharynx blood	3	0	P=.266 (CI .4091-infinity)
CPR	4	2	P=.277 (CI .455-30.9)
Ventilated	1	9	P=<.001 (CI .001-.402)

Table 1: Signs and Symptoms.

There also was a significant difference in those with an abnormal CT finding, with there being more in the AHI group versus the non-AHI group (20 versus 5) (p<.001, CI .0023-.157). The CT findings in the AHI group were consistent what has been reported in AHI victims, 13 had subdural hematomas (SDH), 4 subarachnoid hemorrhage (SAH), 1 with cortical hemorrhage, and one with a contusion. Two patients had an SDH associated with cerebral edema. Also, retinal hemorrhages were only found in those with AHI. CT abnormalities and retinal hemorrhages were more frequent in abused than non-abused patients (90% *vs*. 14% and 85% *vs*. 0% respectively). All nine intubations were performed in patients with intracranial bleeds in the AHI group. Of those with AHI, there were 12 patients with a bone fractures, skull or long bone fractures. There were four non-AHI patients who had abnormal brain CTs, but none of those were with intracranial bleeds, but instead hypoxic ischemia, an arachnoid cyst, and hemosiderin staining (Table 2). None of the patients in both the AHI and non-AHI group died.

ALTE patients' presentation	Age	CT findings
Apnea, cyanosis, no CPR	4 days	Hypoxic Ischemia & Edema
Apnea, cyanosis CPR for 2-15 minutes	5 months	Hypoxic Ischemia
Apnea, cyanosis, no CPR	16 days	Hemosiderrin staining
Apnea, cyanosis, no CPR	1 month	Germinal matrix hemorrhage
Apnea, no CPR	1 month	Arachnoid cyst

Table 2: Non-AHI patients with abnormal CT findings.

Discussion

Our study showed that all ALTE patients, those with or without AHI, presented with apnea. Bruises were more common in those with AHI but not located on the face/head but instead on other parts of the body. None of the patients, AHI and non-AHI, had bruises to the face/head in our study. Blood from the nose or mouth was not found in

those with AHI but in the non-AHI group. Interestingly all those with bystander CPR performed prior to coming to the ED had blood from the nose or mouth. Maybe this was from the trauma of CPR. This was unlike the limited studies of AHI where infants had bruising to the face/head [3,5] and blood from the nose or mouth [6-8]. Our study brings more evidence that it is concerning for possible abuse when patients present with symptoms of ALTE or BRUE, and bruises to the body in nonambulatory children [16,17]. It is important that health care professionals recognize bruises in nonambulatory children such as those less than 12 months of age as signs of physical abuse.

From previous literature, the symptoms of apnea is common in ALTE patients with and without AHI. A recent study described the clinical features of 81 children under 16 months of age who were judged by criminal and family courts to have been killed by their parents. Seventy-five had a history of unusual or unexplained events, most commonly apnea, cyanosis, appearing dazed, or twitching [2]. In a prospective consecutive case series of 243 infants younger than 12 months admitted to a medical center for evaluation of an ALTE, six subjects (2.5%) were diagnosed as having AHI [18]. All of the patients evaluated for ALTE had the symptom of apnea.

Previous studies have found bruising associated with child abuse. The most common sites of bruising in those found to be abused were below the knees, facial head, while rare sites included the ears, neck, genitalia, and hands, in any child. Bruises to the buttocks and front trunk in early mobile and pre-mobile children were more common in those abused [17,18]. Bruising in infants is uncommon because of their lack of independent mobility. The likelihood of having a non-inflicted bruise in a child who is not independently mobile has been estimated to be <1% [19]. In a retrospective review of AHI fatalities, Ingham and colleagues [20] reported 16% of infants who died of AHI had one or more bruises, yet this study didn't indicate if the bruises were specifically on the head or face [20]. In a study of 627 patients, 9 (1.4%) were determined by the Division of Child and Family Services to have experienced AHI. Of the 9, the 5 patients who were diagnosed in the ED with AHI were reported to have abnormal physical examination findings including bruising (n = 2). The location of the bruises was not mentioned in this study [21]. In our study, bruises were significantly more frequent in those with AHI versus those without AHI, but there were not on the face but on the body. Since our population included only infants <12 months of age, bruising, in general, should have been low if due to accidental injury since they were nonambulatory, so any bruising was suspicious for abuse.

Bruises specific to the face and head have been shown to be specific for AHI, but there are few studies specific to this finding [3,14]. In a study aimed at identifying key elements in the history and physical exam in 108 infants presenting with an ALTE, every patient in this study had physical exam findings that raised suspicion of of abuse (2/4 with skin findings and 3/4 with neurological findings). The two patients with skin findings, 1 had a contusion of the face and upper extremities, and the other patient with facial bruises [2]. In a study of missed AHI, 56 % had facial or scalp injury. Facial and/or scalp injury was one of four variables that predicted the diagnosis of AHI in those with missed AHI. If none of the 4 factors, in their study, were present, the probability that a physician would make the correct diagnosis of AHI would be less than 1 in 5 [16].

Recent studies that validated a prediction model which included the symptoms of apnea and bruising to the face were used to identify those children with AHI. A prospective, multicenter, observational, cross-sectional study tested a prediction model for AHI. Two hundred ninety-one acutely head-injured children <3 years of age admitted to Pediatric Intensive Care Units (PICU) at 14 participating sites were studied. Application of this model demonstrated a sensitivity of .96, specificity of .46, positive predictive value of .55, negative predictive value of .93, positive likelihood ratio of 1.67, and negative likelihood ratio of 0.09. This revealed that the AHI prediction model identified 98% of study patients who were ultimately diagnosed with AHI. They concluded four readily available variables (acute respiratory compromise before admission; bruising of the torso, ears, or neck; bilateral or interhemispheric subdural hemorrhages or collections; and any skull fractures other than an isolated, unilateral, nondiastatic, linear, parietal fracture) identify AHT with high sensitivity in young, acutely head-injured children admitted to the PICU [22]. In another validation study by the same group, consecutive children aged <36 months admitted with an intracranial injury, confirmed as abusive or nonabusive were studied [22]. Details of 6 influential features were recorded (retinal hemorrhage, rib, and long -bone fractures, apnea, seizures, and head or neck bruising). Their results showed when ≥three features were present in a child <36 months old with intracranial injury, the estimated probability of AHT was >81.5% (95% CI, 63.3-91.8). The sensitivity of the tool was 72.3% (95% CI, 60.4-81.7), the specificity was 85.7% (95% CI, 78.8-90.7), area under the curve 0.88 (95% CI, 0.823-0.926) [26]. Both of these validation studies included bruising and apnea as predictors of AHI like our study, but they included children greater than 12 months of age, examining children <3 years. This unlike our study where we examined children less than 12 months of age. By definition, ALTE/BRUE occurs in those < 12 months of age so it is not clear if these same predictors could be applied to an ALTE group.

Blood from the mouth or nose due to pulmonary edema has been seen in abusive suffocation alone and head injury [2]. There have been limited reports of Neurogenic Pulmonary Edema (NPE) following AHI in infants. NPE caused by central nervous system (CNS) injury is a phenomenon that has been well documented for almost a century. In 1918, Moutier [24] described a case of pulmonary edema after a gunshot wound to the head, and in 1939, Weisman [25] described pulmonary edema coexisting with traumatic brain injury. Despite NPE being described in the medical literature, there have only been two previous reports in children with AHI. One case of NPE was in a young child with inflicted head injury [7]. The second case was reported in 2001. This was a case of a 7½-month-old boy with no previous history of trauma or seizures who developed seizure activity and stopped breathing. A head CT revealed bilateral subdural hematomas. Ophthalmologic examination showed bilateral diffuse retinal hemorrhages [8].

In our study blood from the mouth or nose was not found in those with AHI, but rather only those in the non-AHI group, so this goes against the observation that pulmonary edema can be associated with intracranial injury. Blood from the mouth or nose has been more commonly seen in those infants with sudden infant death syndrome (SIDS), reported to be up to 50% [26]. The association of SIDS and AHI is felt to be rare [27,28]. Our ALTE patients with blood from the nose and mouth did not have SIDS since none of them died. Perhaps they were near SIDS. Patient with near SIDS do have findings on head CT with hypoxic ischemia encephalopathy. So, this

does pose a question if our non-AHI patients had near SIDs. Even if they did die, unfortunately, there are no pathognomonic autopsy findings on lung exam for intra-alveolar hemorrhage for suffocation versus SIDS [29].

Blood from the nose or mouth can be found with abusive suffocation without concomitant AHI. Perhaps our non-AHI patients had been abusively suffocated since the patients without AHI had blood from their nose or mouth. Unfortunately, the finding of blood in the nose or mouth in young infants has not been helpful in making a diagnosis of intentional suffocation [5,29]. Samuels and colleagues found that up to 18% of infants who presented with ALTEs who required cardiopulmonary resuscitation were due to intentional suffocation by a caregiver which was videotaped [30,31]. In our study, the two patients who had bloody secretions in their nose or mouth did require CPR by a parent but didn't have findings of AHI per physical exam, CT scan or retinal exam. This is concerning for intentional suffocation but the diagnosis of intentional suffocation is difficult to make unless caregivers provide a history of intentional suffocation or are observed.

The CT findings in our patients with AHI was consistent with the literature. Intracranial injuries found in AHI are usually subdural, epidural hematomas and subcortical abnormalities. Historically, SDH if more common, up to 68% [32,33]. The majority of our patients with AHI had SD hemorrhages. Only one patient of the 5 in the non-AHI group had a hemorrhage which was germinal matrix hemorrhage. This type of hemorrhage is not consistent with AHI but seen in prematurity. This patient did not have other findings of abuse. The CT of head findings for those in the ALTE group without AHI, per previous studies have been found to be cerebral edema due to prolonged apnea or other findings consistent with prematurity have been found [3]. This was consistent in our study, with three of the non-AHI group having hypoxic ischemia and one of those with associated cerebral edema.

Since it is critical that a physician distinguish AHI in those presenting with ALTE due to its significant mortality and morbidity, our study has profound implications. Even though our study did not show that bruises to the face/head or blood from the nose or mouth were significantly more common in AHI, any study that helps to determine if these signs can differentiate an ALTE patient with AHI is useful, since there is a paucity of literature. There have been only 2 cases that found blood from the nose or mouth associated with AHI. There are few studies with small numbers of patients examining facial/ head bruising in those ALTE patients with AHI. Strengths of our study include the large size of ALTE patients with and without AHI (20 AHI and 29 non-AHI). Other studies detecting AHI in ALTE patients included fewer patients than our study. Guenther's study found nine patients under age 12 months who presented as ALTE who had AHI [25].Vellody and colleagues studied 108 patients, 1 year or younger, who were admitted for an ALTE. Only 4 patients were found to have AHI. In a prospective study of 243 infants younger than 12 months admitted for ALTE only 5 patients were found to have AHI [3]. In a prospective study by Altman of 243 infants less than 12 months of age admitted to a hospital for ALTE were studied. Six patients were diagnosed with AHI. One of the three had a face bruising and the other two had scalp bruising. The other three that were found to have AHI had retinal hemorrhages [17]. In a study by Bankowsky where ALTE and outcomes were studied, only 2 were AHI victims with CT findings consistent for AHI. They found no clinical features that were predictive of child abuse [34]. The two prediction model studies for AHI by Corely did have larger sample sizes but they included those older than 12 months of age (up to 35 months of age), so this was not specific for those with ALTE as in our study.

Another strength of our study was the inclusion of a required CT of head and/or ophthalmological exam by and ophthalmologist for all those who presented with ALTE. Per a systematic review of 14 studies, apnea and retinal hemorrhages were the most predictive of AHI so it is important to include these two predictors when trying to distinguish ALTE from AHI [35]. Not all of the patients in the non- AHT and AHI group in Bonkowky's, Guenther's, Vellody's, or Altman's study had a head CT or MRI exam performed so some of those in the non-AHI group could have potentially had AHI.

Limitations to our study were its retrospective nature, which may not have included all the documentation of signs and symptoms and physical exam. We did capture all of the radiologic and ophthalmic findings since the reports were on the electronic medical record. Another limitation was that it was conducted at one pediatric hospital. This could have potentially introduced bias.

Conclusion

Infants presenting with ALTE are difficult to differentiate from those who have AHI upon presentation to a hospital. Bruises of the head and face and blood from the nose or mouth did not distinguish the two groups whereas bruises to the body did distinguish the patients with AHI.

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