Abusive Head Trauma in Children Presenting with an Apparent Life-Threatening Event

Elisabeth Guenther, MD, MPH, Annie Powers, MD, PhD, Rajendu Srivastava, MD, FRCP, MPH, and Joshua L. Bonkowsky, MD, PhD

Objective To identify rates of abusive head trauma and associated clinical risk factors in patients with an apparent life-threatening event (ALTE).

Study design Retrospective study of infants, 0 to 12 months, admitted for an apparent life-threatening event (ALTE; 1999–2003). Patients with abusive head trauma were identified at presentation or on follow-up; statistical analysis identified characteristics associated with abusive head trauma.

Results Of 627 patients with ALTE, 48% were male. Nine (1.4%) were diagnosed with abusive head trauma, of whom 5 were diagnosed in the emergency department. All cases detected in the emergency department had physical examination findings indicative of abusive head trauma. Patient age, male sex, or ethnicity were not significantly different between those with and without abusive head trauma. More children with abusive head trauma had a documented 911 call (56% vs 22%, $P = .029$), vomiting (56% vs 19%, $P = .018$), or irritability (22% vs 3%, $P = .033$). Multivariate analysis revealed odds ratio for abusive head trauma were 4.9 with a 911 call ($P = .037$), 5.3 with vomiting ($P = .024$), and 11.9 with irritability ($P = .0197$).

Conclusions Abusive head trauma is in the differential for infants with an ALTE, although almost half of the cases are missed by current emergency department management. Vomiting, irritability, or a call to 911 are significantly associated with heightened risk for abusive head trauma. *(J Pediatr 2010;157:821-5)*.

nfants presenting to the emergency department after an apparent life-threatening event (ALTE) pose a diagnostic challenge for health care providers. An ALTE was defined by a National Institutes of Health consensus statement as "an episode that is frightening to the observer and that is characterized by some combination of apnea (central or occasionally obstructive), color change (usually cyanotic or pallid), marked change in muscle tone, choking or gagging. In some cases, the observer fears that the infant has died."[1] Documented diagnoses after ALTE presentations include gastroesophageal reflux, seizure, cardiac abnormalities, inborn errors of metabolism, lower respiratory tract infection, and nonaccidental trauma, as well as numerous others.[2-4] Bonkowsky et al[2] found that 11% of well-appearing patients presenting with an ALTE were found to have substantiated abuse in follow-up of the cohort, including physical or sexual abuse, domestic violence exposure, or a sibling with child abuse. However, previous studies report that as many as 54%[1] of infants presenting with an ALTE episode appear perfectly well on initial clinical examination, and 23% to 39%[4] of these infants are discharged without a diagnosis. Some ALTE cases lacking definitive discharge diagnoses therefore could be patients in whom nonaccidental trauma was not detected.[2,5] The potential consequences of any missed diagnoses of abuse[6] warrants the inclusion of nonaccidental trauma in the differential diagnosis of any patient presenting with an ALTE, although to date there are no clear guidelines regarding a recommended, evidence-based diagnostic work-up for child abuse at the time of presentation to the emergency department (ED) with an ALTE.

The objective of our study was to identify the occurrence of abusive head trauma in patients with ALTE and to determine the clinical characteristics associated with abusive head trauma. We hypothesized that certain characteristics concerning for abusive head trauma may be identified on initial evaluation in the ED, with the hope that recognition of these risk factors by the ED health care provider will result in improved diagnostic testing and fewer missed cases of abusive head trauma.

Methods

We reviewed the medical records of all infants less than 12 months of age who presented to the ED for evaluation of an ALTE between January 1, 1999, and December 31, 2003. The study was performed at a children's hospital that serves as both the sole tertiary pediatric center for an estimated pediatric pop-

| ALTE | Apparent life-threatening event |
| ED | Emergency department |

ulation of >1 million children[2,7] and is part of a 21-hospital not-for-profit health care system. Because ALTE is not used as a billing diagnosis, all records of children younger than 12 months of age were searched for keywords ALTE, altered mental status, apnea, breath-holding spell, choking, gastroesophageal reflux disease, hypotonia, lethargy, other convulsions, other neurology diagnosis, other respiratory diagnosis, pallor, seizures, sleep apnea, stiff, syncope, and unresponsiveness. Of 1148 patients identified through these criteria, 7 charts could not be located.[2] All 1141 charts were reviewed to determine whether a patient met inclusion and exclusion criteria listed below (Figure 1).

Patients were included if they were 12 months of age or younger and had a clinical history of an ALTE defined as a sudden event consisting of one or more of the following that was concerning to the caregiver: (1) breathing irregularity (including apnea, choking, gagging); (2) color change (including cyanosis and pallor); (3) altered muscle tone (including hypotonia, hypertonia); (4) abnormal movements (including clonus); (5) altered mental status (including unresponsiveness).[2]

Exclusion criteria included seizure associated with fever and age greater than 6 months, known seizure disorder, known history of intracranial or central nervous system disease (including shunt placement, hydrocephalus, or brain structural abnormalities), bronchiolitis or pneumonia diagnosed in the ED, abnormalities found on lumbar puncture consistent with infection, and known ingestion or medication overdose. Known genetic syndromes or metabolic disease with central nervous system involvement, known severe gastroesophageal reflux disease that was on treatment, known heart disease, and known lung disease requiring chronic home oxygen therapy (including bronchopulmonary dysplasia) were also excluded.

For those patients admitted more than once for an ALTE, data from the first admission only was included for analysis. The study was approved by the Institutional Review Boards of the University of Utah and the Utah Department of Human Services.

Data Collection

Data abstracted from the charts included date of presentation, sex, race, whether parents called 911, whether "rescue breaths" were given by the parents, history of prior similar event(s), past medical history, history of prematurity, physical examination findings, the caretaker at the time of the ALTE, story discrepancy noted in the history provided by the parents, and a history of vomiting or irritability. Finally, we abstracted information on diagnostic management in the ED or hospital including any central nervous system imaging (head ultrasonography, computed tomography, or magnetic resonance imaging) and the result(s), skeletal survey and results, consults by ophthalmology and results, consults by the hospital child protection team, involvement of the State of Utah Division of Child and Family Services, and discharge diagnosis.
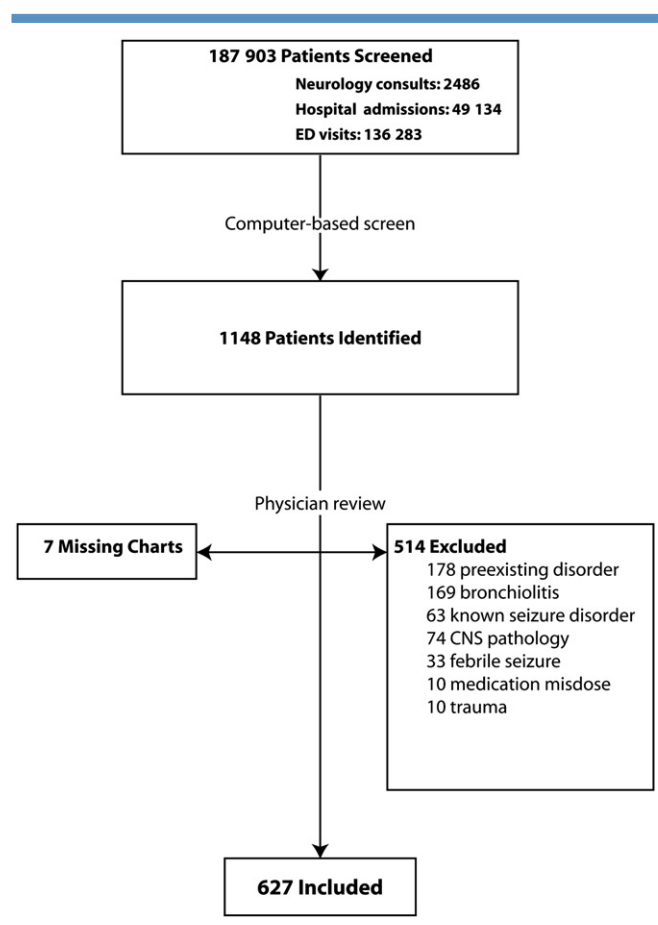
Figure 1. Patient enrollment. Flow diagram for enrollment of the ALTE cohort. A computer-based ICD-9 and keyword search was performed on a total of 187 903 patients during the study time period, including pediatric neurology in-patient consults, hospital admissions, and ED visits. A total of 1148 unique patients were identified, for whom 7 charts could not be located. A total of 514 patients were excluded. The final ALTE cohort for analysis consisted of 627 patients. (See Methods for complete details.)

Main Outcome Measures

All patients in the ALTE cohort were reviewed for diagnosis of abusive head trauma, both at the time of admission, as well as in follow-up (through December 31, 2003). Abusive head trauma was identified with the computerized medical record and also by cross-referencing the ALTE cohort to the Utah Division of Child and Family Services. Child abuse is defined by the State of Utah Division of Child and Family Services in conjunction with the Utah Code (Utah Code Ann.76-5-109) as "actual or threatened non-accidental physical or mental harm, negligent treatment, sexual exploitation, or sexual abuse."[8] All cases included in the analysis were substantiated in a formal process by the state Division of Child and Family Services.[8]

Statistical Analysis

Descriptive statistics were used to characterize the study cohort. The χ^2 tests were performed to calculate odds ratios; the

Fisher exact test was used to calculate *P* values. Unadjusted bivariable analysis (contingency analysis) and multiple variable regression models to determine odds ratios were performed. To obtain the regression model, a model containing the predictor variables (added in forward, stepwise fashion) age, sex, preterm history, 911 call, seizure history, vomiting and history of irritability was performed. SAS software (SAS Institute, Inc., Cary, North Carolina) version 9.1.3 was used for analyses.

Results

From a total of 187 903 patients, there were 1148 patients with an ALTE, of whom 627 met inclusion criteria (**Figure 1**). Of the total patients, 301 (48%) were male, and the mean age was 2.8 months with a median age of 1 month. There were 104 (16.5%) patients born prematurely (gestational age less than 37 weeks), and most were white (**Table I**).

Of the total 627 patients, 9 (1.4%) were determined by the Division of Child and Family Services to have experienced abusive head trauma (**Table II**). Of the 9, the 5 patients who were diagnosed in the ED with abusive head trauma were reported to have abnormal physical examination findings including bruising (n = 2), bilateral retinal hemorrhages (n = 3), or a bulging anterior fontanel (n = 2). The diagnosis of abusive head trauma was not made in 4 patients until either their hospitalization or a subsequent presentation and readmission.

Of the 4 patients in whom the diagnosis of abusive head trauma was not initially made, all were noted to have unremarkable physical examination results. Two of the children were observed in the hospital without neuroimaging studies but were then noted to have subdural hemorrhages on ED visits immediately after hospital discharge, and a retrospective review of a chest x-ray film of 1 of the children revealed evidence of rib fractures. Similarly, a third child was discharged to home from the ED having presented with apnea,

Table I. Selected demographic, hospitalization, and follow-up characteristics of infants with an ALTE

Characteristic	Number (n = 627)	Percentage
Sex		
Male	301	48%
Female	326	52%
Age		
Mean	2.8 months	
Median	1 month	
Race		
Caucasian	347	78%
Hispanic	63	14%
Pacific-Islander	6	1.3%
Black	4	0.9%
Native American	3	0.6%
Asian	2	0.4%
Unknown	19	4.2%
Premature (<37 weeks)	104	16.5%

Table II. Characteristics of abusive head trauma in the ALTE cohort

| Outcome	Number	Percentage
Abusive Head Trauma	9	1.4%
Diagnosed in emergency department	5	0.8%
Diagnosed in first hospitalization	2	0.3%
Diagnosed at second presentation	2	0.3%
Abnormal head CT scan result computed tomography scan result	9 (of 9)	
Abnormal skeletal survey	1 (of 7)	
Abnormal fundoscopic exam	7 (of 7)	
Suggestive physical exam	5 (of 7)	

Total number of patients was 627.

vomiting, and lethargy, without neuroimaging but was found within 48 hours to have subdural hemorrhages. The fourth child underwent head computed tomography, the result of which was initially read as normal, but then was transferred to a tertiary care center with persistent seizures where the head computed tomography scan was noted to show subdural hemorrhages.

When compared with all patients with ALTE and adjusted for patient age, sex, and preterm history, the odds that a patient with ALTE had an abusive head trauma diagnosis were 27 times greater if pertinent physical examination findings were reported ($P < .0001$). Similar to physical examination findings, documented story discrepancy was a high marker for abusive head trauma. When adjusted for patient age, sex, and preterm history, patients were 149 times more likely to be diagnosed with abusive head injury if story discrepancy was reported ($P = .0002$).

When physical findings consistent with abusive head injury and story discrepancy were removed from the analysis, an unadjusted bivariate model showed no significant differences between patients with ALTE who had abusive head injury or not for patient age (4 vs 2.8 months, $P = .32$), male sex (67% vs 48%, $P = .27$), history of prematurity (30% vs. 20%, $P = .40$), reported ethnicity ($P = .20$), seizures (44% vs 18%, $P = .068$), or reported rescue breaths (11% vs 8%, $P = .54$). However, more children with abusive head injury had a documented 911 call (56% vs 22%, $P = .029$), had a history of vomiting (56% vs 19%, $P = .018$), or irritability (22% vs 3%, $P = .033$) (**Figure 2**).

Similarly, once suggestive physical examination findings for abusive head trauma and discrepancy with history were removed from the model, a multiple variable regression model containing the predictor variables (added in forward, stepwise fashion) age, sex, preterm history, 911 call, history of prior ALTE, seizure history, vomiting, and history of irritability revealed the odds a patient with ALTE had an abusive head trauma diagnosis were as follow: 4.93 times greater if a 911 call is reported or documented ($P = .037$), 2.39 times greater with a history of prior ALTE event ($P = .45$), 9.4 times if reporting seizures ($P = .011$), 5.30 times if vomiting ($P = .024$), and 11.89 times if irritable ($P = .020$). Although data were collected on the child's primary caretaker at the time of the ALTE, following adjustment for patient age, sex, and
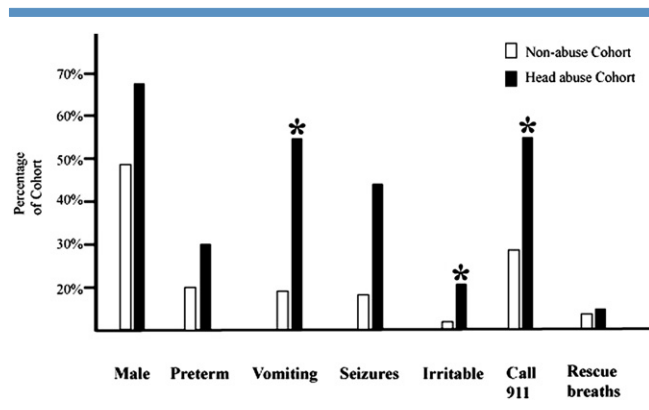
Figure 2. Percentages of clinical characteristics predicting abusive head trauma. Percentages (*y-axis*) were calculated for the percentage of infants with ALTE who had abusive head trauma (*solid bars*), compared with the nonabuse ALTE cohort (*clear bars*), comparing different clinical risk factors (*x-axis*), by use of bivariate analysis. *Asterisk* indicates *P* < .05.

preterm history, the model containing the caretaker variable was too unstable to interpret.

Discussion

Our study shows that abusive head trauma is a significant diagnosis in the ALTE patient, making up more than 1% of cases, yet in cases without physical examination findings the diagnosis is often missed in the ED setting. Although the differential diagnosis for ALTE remains extensive and diverse,[2-4] abusive head trauma has consistently been included in this differential.[2,9,10] In our study, however, almost one-half of patients with abusive head trauma were not diagnosed in the ED setting despite the fact that this study was performed at a tertiary children's hospital staffed by physicians with pediatrics certifications. In cases in which pertinent physical examination findings were documented, the diagnosis was consistently made. This may be due to the nature of the physical examination findings, such as bruising in the premobile infant[11] and retinal hemorrhages, both of which are highly suggestive for abusive head trauma in infants.[12,13] It is also likely that, once abusive head trauma is considered, there is better documentation of possible discrepancies in the history. It is the cases in which there are no documented physical examination findings that the diagnosis appears to have been missed.

It is difficult to ascertain from this study whether there were pertinent findings that were missed and therefore not documented, or whether there is a group of patients in whom there are no appreciable findings on physical examination despite abusive head trauma resulting in intracranial hemorrhage. Previous literature supports the unique challenge of making the diagnosis of abusive head trauma both in the ED[14,15] and inpatient settings.[16] This may stem from many reasons including a lack of comfort with recognition

of abusive head trauma[14,17] and the legal repercussions of diagnosing abuse.[18] Furthermore, as in our study, Loiselle et al[16] found that children diagnosed as inpatients with physical abuse were less likely to have physical findings. It appears that the difficulty in making this diagnosis transcends the presenting chief complaint and makes the recognition of clinical predictors that much more significant.

Importantly, we found that in those patients in whom no suggestive physical examination findings were appreciated, either in the ED or the inpatient settings, there are several clear historical clinical predictors in the child with ALTE for the increased risk for abusive head trauma. These included a history of vomiting, irritability, seizures, or a call by the caretaker to emergency medical services (911 call). Because the overall rate of either positive ED diagnostic evaluations or significant medical interventions during ED evaluation of infants after an ALTE is low, limited ED diagnostic evaluation and a period of observation has been recommended.[19] The findings of our study, however, support previously published recommendations that occult head trauma caused by physical child abuse should be considered in all well-appearing patients presenting with ALTE.[2,9] Thus the ED health care provider should consider brain neuroimaging or ophthalmologic consultation in the evaluation of patients with ALTE with nonsuggestive initial presentations[20,21] so as not to miss abusive head injury. This possibly could result in catastrophic outcomes for the child if missed.[6,22-24] Furthermore, recent recommendations from the American Academy of Pediatrics encourage pediatricians to develop skills in the recognition of signs and symptoms of abusive head injury, and "consult with pediatric subspecialists when necessary."[25] Finally, future research will need to explore a cost/benefit analysis of obtaining these studies in high-risk subgroups of patients presenting with ALTE.

There were several limitations to this study. First, despite the extensive size of our ALTE cohort, the overall number of abusive head trauma cases was limited, and both the small numbers of abusive head trauma cases and random variations might have had statistically significant effects on our conclusions. Second, the data were collected retrospectively. Third, it is possible that there may have been migration of children out of the state during the study period, which may have resulted in underascertainment of subsequent abusive head trauma cases. Fourth, we excluded some patients with known prior medical history (such as a history of seizures) who could still have been at risk for abusive head trauma. Finally, the single setting may impact generalizability of our findings.

Strengths of this study include the large size of the ALTE cohort, our inclusion of both well- and ill-appearing infants presenting to the ED with the diagnosis of ALTE, our ability to access state records for extended follow-up, and the availability of reliable data on these cases.

We conclude that the infant presenting to the ED with a history of ALTE is at risk for abusive head trauma even in the absence of exam or history findings. Almost half of all

infants with abusive head trauma presenting as ALTE are missed by current ED management. The presence of vomiting, irritability, seizures, or a call to 911 are significantly associated with heightened risk for abusive head trauma. ■

References

1. NIH Consensus Development Conference on Infantile Apnea and Home Monitoring. Pediatrics 1986;79:292-9.

2. Bonkowsky JL, Guenther E, Filloux FM, Srivastava R. Death, Child Abuse, and Adverse Neurological Outcome of Infants After an Apparent Life-Threatening Event. Pediatrics 2008;122:125-31.

3. McGovern MC, Smith MB. Causes of apparent life threatening events in infants: a systematic review. Arch Dis Child 2004;89:1043-8.

4. Al-Kindy HA, Gelinas JF, Hatzakis G, Cote A. Risk Factors for Extreme Events in Infants Hospitalized for Apparent Life-threatening Events. J Pediatr 2009;154:332-7.

5. Davies F, Gupta R. Apparent life threatening events in infants presenting to an emergency department. Emerg Med J 2002;19:11-6.

6. Oral R, Yagmur F, Nashelsky M, Turkmen M, Kirby P. Fatal abusive head trauma cases: consequence of medical staff missing milder forms of physical abuse. Pediatr Emerg Care 2008;24:816-21.

7. Norlin C, Osborn LM. Organizational responses to managed care: issues for academic health centers and implications for pediatric programs. Pediatrics 1998;101:805-11. ; discussion 11–12.

8. DCFS Practice Guidelines. 2006 [cited 2007 September 27]; pdf]. Available from: http://www.hspolicy.utah.gov/dcfs/

9. Altman RL, Brand DA, Forman S, Kutscher ML, Lowenthal DB, Franke KA, et al. Abusive head injury as a cause of apparent life-threatening events in infancy. Arch Pediatr Adolesc Med 2003;157:1011-5.

10. Waseem M, Pinkert H. Apparent life-threatening event or child abuse? Pediatr Emerg Care 2006;22:245-6.

11. Feldman KW. The bruised premobile infant: should you evaluate further? Pediatr Emerg Care 2009;25:37-9.

12. Kos L, Shwayder T. Cutaneous manifestations of child abuse. Pediatr Dermatol 2006;23:311-20.

13. Kivlin JD. Manifestations of the shaken baby syndrome. Curr Opin Ophthalmol 2001;12:158-63.

14. Guenther E, Olsen C, Keenan H, Newberry C, Dean JM, Olson LM. Randomized prospective study to evaluate child abuse documentation in the emergency department. Acad Emerg Med 2009;16:249-57.

15. Woodman J, Pitt M, Wentz R, Taylor B, Hodes D, Gilbert RE. Performance of screening tests for child physical abuse in accident and emergency departments. Health Technol Assess 2008;12. iii, xi-xiii 1–95.

16. Loiselle JM, Westle RE. Inpatient reports of suspected child abuse or neglect (SCAN): a question of missed opportunities in the acute care setting. Pediatr Emerg Care 1999;15:90-4.

17. Christian CW. Professional education in child abuse and neglect. Pediatrics 2008;122(Suppl 1):S13-7.

18. Newton AW, Vandeven AM. Update on child maltreatment. Curr Opin Pediatr 2009;21:252-61.

19. De Piero AD TS, Chamberlain JM. ED evaluation of infants after an apparent life-threatening event. Am J Emerg Med 2004;22:83-86

20. Brand DA, Altman RL, Purtill K, Edwards KS. Yield of diagnostic testing in infants who have had an apparent life-threatening event. Pediatrics 2005;115:885-93.

21. Vellody K, Freeto JP, Gage SL, Collins N, Gershan WM. Clues that aid in the diagnosis of nonaccidental trauma presenting as an apparent life-threatening event. Clin Pediatr 2008;47:912-8.

22. Morris MW SS, Cressman J, Ancheta J. Evaluation of infants with subdural hematoma who lack external evidence of abuse. Pediatrics 2000;105:549-553.

23. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. JAMA 1999;281:621-6.

24. Altman RL, Forman S, Brand DA. Ophthalmologic findings in infants after an apparent life-threatening event. Eur J Ophthalmol 2007;17:648-53.

25. Christian CW, Block R. Abusive head trauma in infants and children. Pediatrics 2009;123:1409-11.