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Base deficit correlates with mortality in pediatric abusive head trauma

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Abstract

Background/purpose: Children suffering from abusive head trauma (AHT) have worse outcomes compared to non-AHT, but the reasons for this are unclear. We hypothesized that delayed medical care associated with AHT causes prolonged pre-hospital hypotension and hypoxia as measured by admission base deficit (BD), and that this would correlate with outcome.

Methods: We performed a 10-year retrospective chart review of children admitted for AHT at two academic level-I trauma centers. Statistics were performed using Student's t test, chi-square analysis, and multivariate logistic regression, and considered significant at $p < 0.05$.

Results: Four-hundred twelve children with AHT were identified, and admission BD was drawn for 148/412 (36%) children, including 104 survivors and 44 non-survivors. Non-survivors had significantly higher BD compared to survivors (12.6 ± 1.6 versus 5.3 ± 0.6, $p < 0.001$). Non-survivors were more likely to be intubated pre-hospital and get cardiopulmonary resuscitation (CPR) ($p < 0.001$). Mortality increased with rising BD, according to CPR status. There was no difference in patterns of brain injury between survivors and non-survivors ($p > 0.05$).

Conclusions: BD correlates with mortality in children suffering severe AHT. Non-survivors are also more likely to be intubated pre-hospital and require CPR, with no difference in pattern of brain injury, suggesting that secondary injury is a major determinant of outcome in severe AHT.

Abusive head trauma (AHT), shaken baby or shaken infant syndrome, inflicted traumatic brain injury, and non-accidental head injury all refer to intentional head injury of infants and young children [1]. In 2009, the American Academy of Pediatrics adopted AHT as the official term for this type of injury to streamline discussion on the topic and to prevent practitioners from excluding patients from this group who were not shaken [2]. The prevalence of AHT is difficult to determine owing to lack of recognition and misdiagnosis

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as unintentional head trauma, but is estimated to be 17:100,000 person-years [3]. In children <24 months of age, it has been suggested that more than 50% of traumatic brain injuries requiring hospitalization are secondary to AHT [3]. These children tend to be younger, have distinctive patterns of injury, worse functional outcomes, and higher mortality compared with patients suffering from non-AHT [3–7]. The reason for the differences in mortality and functional outcome in children with AHT compared to non-AHT remains elusive and cannot be explained solely by differences in injury severity score (ISS), intracranial pressure (ICP), or Glasgow Coma Scale (GCS) [4,6].

Base deficit (BD) is a rapidly and widely available serum laboratory marker of systemic acidosis that increases with hypoxemia and/or shock. In the trauma setting, BD correlates with blood transfusion requirement, risk of multi-organ failure, and mortality in adult patients, including adults with traumatic brain injury (TBI) [8–10]. Similarly, in pediatric trauma patients, BD correlates with blood transfusion requirement, duration of mechanical ventilation, infectious complications, and mortality [11,12]. Differences between AHT and non-AHT are not always easy to discern; it seems, however, that children suffering AHT are more apt to suffer delays in definitive care. For example, children with non-AHT are more likely to arrive at an ED while asymptomatic and with a witnessed injury, whereas children with AHT more often are brought to the ED because of symptoms without any given history of trauma [4]. In adults suffering TBI, hypotension and hypoxia are independently associated with worse functional outcomes and higher mortality [10,13,14]. For children with TBI, even brief episodes of hypoxia and hypotension increase mortality markedly [15–18]. In the setting of severe AHT, delays in seeking emergent medical care can result in prolonged periods of hypoxia and hypotension, which in turn can lead to increased anaerobic metabolism, elevated serum lactic acidosis, and greater BD. We hypothesized that children with fatal AHT would have increased serum BD, and that higher levels of BD would correlate with worse functional outcomes in survivors.

1. Methods

A retrospective chart review was performed of children ages 0–24 months who were admitted for AHT at two academic level-I trauma centers from January 2002–January 2012. The Child Protection Teams at both institutions determined presence of AHT. Medical records were evaluated for patient demographics, injuries, laboratory studies, and treatment information, including initial BD drawn within three hours of arrival, as well as the first recorded GCS on the day of presentation. We also examined need for cardiopulmonary resuscitation (CPR) and intubation within the first 24 hours. Continuous numerical data are reported as mean ± standard error of the mean, and comparisons were made by Student's t test. Categorical data comparisons were made by Pearson's chi-square analysis with a single degree of freedom. Data were further analyzed by using multivariate logistic regression to determine which variables were independently predictive of death. Functional outcome scores for survivors were calculated using the King's Outcome Scale for Childhood Head Injury (KOSCHI) [19]. All statistical tests were considered to be significant at a two-sided $p < 0.05$, and were reported as <0.001 when values were lower. Analyses were performed using SAS, version 9.3 (Cary, NC).

2. Results

A 10-year retrospective chart review revealed 412 children diagnosed with AHT, of which 359 survived to discharge, and 54 died (13% mortality). An admission BD was drawn for 148/412 (36%) children, including 104 of the survivors and 44 of the non-survivors. Further analysis in this study was limited to this group of 148 patients.

2.1. Demographics

Age, gender, and ethnicity were compared between survivors and non-survivors (Table 1). The average age was

Table 1 Demographic, intervention, injury, and laboratory comparison between survivors and non-survivors of abusive head trauma

	Survivors	Non-survivors	p-value
Age (days)	204	248	0.26
Gender			
Male	68%	32%	0.48
Female	74%	26%	0.48
Ethnicity			
Caucasian	68%	32%	0.54
African American	86%	14%	0.36
Hispanic	71%	29%	0.93
Other/Unknown	71%	29%	0.86
CPR	15%	66%	**<0.001**
Intubated	81%	100%	
Pre-hospital	8%	32%	**<0.001**
Initial GCS	7.8	3.9	**<0.001**
Max AIS Head	4.4	4.9	**<0.001**
Injury Severity Score	22.5	31.1	**<0.001**
Retinal hemorrhage	76%	95%	**0.02**
Hematocrit	29.9%	29.5%	0.68
Base deficit (mEq/L)	5.3	12.6	**<0.001**

Demographic, intervention, injury, and laboratory comparison between survivors and non-survivors of pediatric abusive head trauma with an admission base deficit. Values represent either the mean, or percentage of children in that subset. p-values are derived from Student's t test for numerical data or chi-square analysis for categorical data. Bold p-values meet the threshold for statistical significance.