



Consistent screening of admitted infants with head injuries reveals high rate of nonaccidental trauma ^{☆,☆☆,★}



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ABSTRACT

Purpose: Implementation of a nonaccidental trauma (NAT) screening guideline for the evaluation of infants admitted with an unwitnessed head injury has eliminated screening disparities. This study sought to determine the overall NAT rate and key predictive factors using this guideline.

Methods: All infants screened via the guideline from 2008 to 2015 were retrospectively reviewed. The overall rate of NAT as determined by our child abuse team was determined. In addition, a logistic regression model was developed to evaluate potential predictors of increased risk of NAT.

Results: A total of 563 infants were screened with an overall rate of NAT of 25.6% (n = 144). NAT screening was consistent across race and insurance status. By univariate analysis, patients with government insurance or no insurance had a significantly higher rate of NAT, but race was not a factor. Also NAT victims had significantly higher ISS. Skeletal survey showed high positive predictive value of 94%. When regression modeling was performed, ISS, abnormal skeletal survey and having public or no insurance were significantly correlated with NAT, while race showed no correlation.

Conclusion: One quarter of infants admitted with a head injury not witnessed in a public situation were identified as the victims of NAT. The high rate of abuse among this population supports routine screening in order to avoid missing intentional injuries and preventing future injuries. Race is not a predictor of NAT, but insurance status, as a proxy for socioeconomic status, is correlated, and further investigation is needed.

Level of evidence: III

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Childhood abuse, or nonaccidental trauma (NAT), can range in harm from emotional damage to physical harm resulting in death. Physical abuse is the leading cause of infant death, accounting for 1580 fatalities in 2014 [1]. NAT victims in general have higher injury severity scores, rates of intensive care unit (ICU) stay, and mortality. Adding to the problem, there are often delays in the diagnosis of NAT [2].

Abusive head trauma (AHT) is the leading cause of severe brain injury and death in children less than 2 years old [3]. AHT is also associated with a significant increase in morbidity compared to nonabusive head trauma [4]. Unfortunately, since infants cannot provide their own history or report symptoms, healthcare providers must rely on observable

vague clinical symptoms and history obtained from caregivers which can be unreliable [5]. In addition, children suffering NAT may have complex injury patterns spanning multiple organ systems [6]. At times, AHT, minor or severe may be the initial presentation of NAT. Despite this, there remain significant variations of screening patterns among major U.S. hospitals, highlighting the need for a consensus protocol in screening [7]. Multiple studies have documented the potential benefits of a consensus screening protocol such as increased awareness among the health care providers, increased rate of appropriate, thorough screening, and increased detection of occult injuries [8–12]. As such, when screening is implemented correctly, it plays a crucial role in early detection of abusive injuries and ultimately in prevention of future more significant NAT.

Traditionally, minority and disadvantaged children have been evaluated for NAT at a significantly higher rate than other children [13]. At our hospital, a guideline was implemented which successfully eliminated this disparity among children admitted with an unwitnessed head injury [13]. Given our routine screening of all admitted children less than one year of age (12 months) with an unwitnessed head injury, we sought to determine the overall rate of NAT among this cohort. In addition, socioeconomic factors, demographics and injury characteristics were evaluated as potential predictors of NAT.

Abbreviations: NAT, nonaccidental trauma; CAT, Child Abuse Team; AA, African American; ISS, Injury Severity Score; AHT, abusive head trauma; SES, socioeconomic status.

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1. Methods

This retrospective study utilized information from our trauma registry as well as our child abuse team registry and was reviewed by our institutional review board (IRB) and deemed exempt. Our hospital is a free-standing 500-bed pediatric institution with a Level I trauma center responsible for 85% to 90% of pediatric admissions from a population base of 2,000,000 people. We have prospectively maintained a trauma registry of all injured patients admitted to the hospital over the past 10 years. We also have a multidisciplinary Child Abuse Team (CAT) comprised of fellowship-trained physicians in NAT, social workers, pastoral care and law enforcement. Since July 2003, CAT has kept a registry of NAT determination for inpatients they have evaluated.

Our trauma registry was queried for patients younger than 12 months admitted with a diagnosis of a head injury defined as a skull fracture (*International Classification of Diseases, Ninth Revision* (ICD-9) codes beginning with 800–804) or intracranial injury (ICD-9 codes beginning with 851–854) over the 7-year period from February 2008 through February 2015. This age was selected since these patients have minimal ambulation and lack sufficient verbal skills to express the cause of their injury, making it difficult to identify occult injuries. The data set was then limited to those patients with an unwitnessed head injury defined as a mechanism that could not be verified by witnesses outside of immediate family or caretakers. Data were extracted on demographics, injury severity scores (ISS), insurance status (private versus none or Medicaid), and performance and outcome of skeletal surveys. Insurance status was used as a surrogate marker for socioeconomic status (SES). Patients were dichotomized into groups of uninsured/government insurance or private insurance. Each patient's electronic medical record was reviewed by the researchers for accuracy and to collect missing data.

Per our guideline, all families were interviewed by social services and had a skeletal survey to help assess level of suspicion for NAT. Children with suspicious findings, such as occult fractures on skeletal surveys, were further evaluated by the CAT. The CAT initially rated the patients as “not concerning for abuse”, “possible abuse,” “probable abuse,” or “definite abuse” [14]. These determinations represent clinical diagnoses that were made based on history, physical exam, and radiologic findings as a part of the CAT consultation and reflect actual practice. For convenience of study, we converted the rating into a binary measure of NAT by defining “not concerning for abuse” and “possible abuse” as negative for NAT and “probable abuse” or “definite abuse” as positive for NAT.

Categorical and binary variables were summarized by frequency (%) and continuous variables summarized by median and range. All *p*-values were derived by utilizing the chi-square test with a *p* < 0.05 considered significant. Also, a multivariate logistic regression model was used to determine the influence of various factors (age, gender, ISS, presence of occult fracture on skeletal survey, race, and insurance status) on the odds of a positive determination of NAT.

2. Results

A total of 563 children less than 1-year-old were admitted to our hospital following an unwitnessed head injury over a 7-year period. Despite the recommendations of our guideline that a skeletal survey be performed on all of these children, only 394 (70%) of patients actually received a skeletal survey during their admission. This screening rate was consistent regardless of race or insurance status; among those with a low clinical suspicion as well as low level of social work concern, the most common reasons for not having a skeletal survey were clinician discretion/guideline noncompliance or rarely family refusal.

Those children with a concerning finding on their skeletal survey or a concern raised on their social work evaluation were referred to our multidisciplinary CAT. After multidisciplinary CAT evaluation, a total of 144 (25.6%) children were classified as being victims of NAT. Overall

rates of NAT according to demographic groups are shown in Table 1. By univariate analysis, patients who were either uninsured or insured by the government had a significantly higher rate of being victims of NAT (31% vs 17% for private insurance, *p* = 0.0009). Additionally, there were no significant differences according to race in rates of NAT (White = 26.1%, AA = 23.6%, Other 26.0%, *p* > 0.05). Children who were the victims of NAT had significantly higher median ISS (16.5 vs 8 for children negative for abuse, *p* < 0.05) and had a 9% vs 0% mortality rate overall. In addition, when ISS was dichotomized into those with severe injuries (ISS ≥ 15) and less severe injuries (ISS < 15), the children with severe injuries had higher rate of NAT (61.9%) compared to only 13.3% of those with less severe injuries (*p* < 0.00001).

Skeletal surveys revealed an occult fracture in 9.2% of the cases (*n* = 52) (Table 2). Among the 144 victims of NAT, skeletal surveys demonstrated an occult fracture 34% of the time. No occult fractures were identified in 43.1% of those suffering NAT and 22.9% never had a skeletal survey performed. Among those ultimately determined not to be victims of NAT, only 3 of the 394 children (0.8%) with a skeletal survey had an occult fracture identified. In these 3 cases either the injury identified was felt secondary to birth trauma, consistent with the described mechanism, or it was an artifact on further imaging. Positive predictive value was 94% and negative predictive value was 78%.

Logistic regression analysis of various predictive factors showed that higher ISS, positive skeletal survey, and no insurance or government insurance were associated with higher likelihood of NAT (*p* < 0.0001 for ISS and skeletal survey, *p* < 0.0047 for insurance status) (Table 3). Other factors such as age, race, and sex were not statistically significant.

3. Discussion

An estimated 1600 children die from NAT annually with a fatality rate as high as 22% among children with abusive head trauma [1,3]. Furthermore, failure to recognize the initial, or sentinel injury, has been shown to result in nearly 30% of the children suffering a second and often more significant injury [6]. Thus, it is crucial that the children at risk for possible NAT are carefully and consistently screened and evaluated.

This study demonstrated that 25.6% of admitted children less than 1-year-old with an unwitnessed head injury were victims of NAT. This rate is slightly higher than the reported 9.4% rate of NAT nationally in the data published by Department of Health and Human Services in 2014. However, that overall rate includes children of all ages. When limited to children less than 1-year-old, the rate is much higher at 24.4%, which is more consistent with our results [1]. In addition 40% of the victims of NAT had an ISS greater than 15 with an overall mortality rate of 9%. Although our findings confirm an association with NAT and overall injury severity, 40% of children who suffered NAT had an ISS less than 15. It is important to note that our study cohort is limited to children that required admission to the hospital, but it still emphasizes the importance of thorough screening in this high risk group. And based upon our results and in collaboration with our emergency department colleagues, more consistent screening has been implemented over the course of this study.

Routine skeletal survey in our cohort revealed occult fractures in 9.2% overall. Among the victims of NAT, 34% had occult fractures identified, resulting in a high positive predictive value of 94% and negative predictive value of 78%. This was further supported by our logistic regression model where positive skeletal survey was predictive of NAT. These findings are consistent with prior studies. Skeletal surveys are very useful and important screening tools especially for very young children (less than 1-year-old) who cannot articulate the history or their symptoms. Studies have shown a detection rate of occult fractures ranging from 11% to 33%, and the rate of detection significantly increases in children suspicious of abuse, such as head injury. A positive skeletal survey often serves as confirmatory finding for NAT which leads to more comprehensive evaluation [7–9,15]. Despite these findings, the utilization of skeletal surveys still varies greatly among hospitals in the

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