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Prematurity and neonatal comorbidities as risk factors for nonaccidental trauma

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ABSTRACT

Background: Parental, familial, and demographic risk factors for nonaccidental trauma (NAT) have been well-studied, but neonatal factors, such as comorbidities and prematurity have not. We assess the correlation of these factors with NAT.
Methods: A total of 234 cases of NAT and 287 cases of accidental trauma (AT) among children <1 year were identified in a trauma registry. Known risk factors for NAT, gestational age, and neonatal comorbidities were abstracted from medical records. Chi-square analysis and logistic regression evaluated the association of prematurity and comorbidities with NAT compared to AT with and without controlling for confounders.
Results: Children treated for NAT were younger than those treated for AT and were more likely to have younger parents with substance abuse issues. Prematurity, major comorbidities, and minor comorbidities were more common in those treated after NAT than after AT (24.8% vs 12.7%, $p = 0.0004$; 25.6% vs 7.2%, $p < 0.0001$, and 42.6% vs 29.3%, $p = 0.0014$, respectively). After model adjustments for other risk factors, major comorbidity remained a significant risk factor for NAT compared to AT, with an adjusted odds ratio of 4.37 ($p < 0.0001$).
Conclusions: Among other risk factors, neonatal factors predict a child's risk for abuse. We have an opportunity for targeted preventive interventions among this at-risk population.

The United States Department of Health and Human Services Children's Bureau reports that during the 2012 fiscal year there were approximately 686,000 childhood victims of abuse and neglect in the United States [1]. They report that those less than one year of age are at the greatest risk for such maltreatment, citing a victimization rate in this age cohort of 21.9 per 1000 [1]. Despite this astronomically large estimate, the number of children affected by abuse is likely underestimated given deficiencies in data collection and reporting [1–3].

Child abuse bestows significant long term medical and psychological morbidities upon its victims. Children presenting after nonaccidental trauma (NAT) of the head and abdomen are at higher risk of death and disability than children presenting after accidental trauma [4]. The Center for Disease Control reports 1,956 deaths attributable to cases of substantiated NAT from 2002 to 2005 in the United States [5]. Furthermore, such abuse has been linked to poor neurocognitive functioning and the development of a host of psychological, behavioral and social problems [4,6].

Given the substantial public health burden of NAT, prevention strategies are of paramount importance. Key to prevention is the identification of at-risk children. A recent review has explained abusive trauma as a consequence of a failure in the normal infant–caregiver interaction [7]. In this light, risk factors for NAT can be understood as variables that create barriers to the formation of this normal relationship. Classically, four major classes of risk factors, or barriers, have been explored, including demographic, familial, parental and child (victim) factors [8]. By far, the most widely studied classes include the first three. Implicated risk factors falling within these categories include low-income homes, young maternal age, intimate partner violence, single-parent homes and parental substance abuse [4,8–10].

Only a small number of studies have evaluated characteristics of the victim that might be linked to childhood abuse. Such studies have suggested that disabled children, low-birth weight children and children affected by pregnancy or birth complications are at increased risk of NAT compared to children unaffected by such conditions [1,8,11,12]. The lack of literature in this field represents an important void as infant factors are likely to play a large role in the development of an infant–caregiver relationship. Prematurity and neonatal comorbidities represent two important infant factors that have not been extensively studied in relation to the risk of NAT. As such, the primary goal of this study was to evaluate the association between the presence of prematurity and

Abbreviations: NAT, nonaccidental trauma; AT, accidental trauma.

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neonatal comorbidities and the presence of NAT in infants less than one year of age.

1. Methods

Institutional review board approval was obtained for retrospective review of children treated at Brenner Children's Hospital (BCH). BCH is a 160-bed pediatric hospital within the Wake Forest Baptist Health system. It has been accredited by the American College of Surgeons as a Level 1 Pediatric Trauma Center (PTC) since 2010. As an accredited PTC, an institutional trauma registry is maintained by a certified trauma registrar and support staff. Using this trauma registry, International Classification of Disease, Ninth Revision (ICD-9) external cause of injury codes (e-codes) 967.2–967.8 were utilized to identify children admitted after nonaccidentally-induced trauma from January 1994 through July 2013. Children greater than 1 year of age were excluded. A random cohort of children less than 1 year of age admitted after accidental trauma (AT) across the same time span was also selected from the registry to serve as a control.

Variables abstracted from the registry included patient age, race, ethnicity and date of presentation. Variables abstracted through chart review included known parental risk factors for NAT (maternal age, non-relatives in the home, intimate partner violence and parental substance abuse) as well as patient information, including gestational age and neonatal comorbidities. Prematurity was defined as gestational age of less than 37 weeks. Among premature infants, further subclassification delineated between those who were delivered very prematurely (<32 weeks) and those delivered extremely prematurely (<28 weeks). Comorbidities were also subdivided as follows. Major comorbidities included major congenital malformations, medical conditions (excluding trauma) that had previously required a neonatal intensive care unit (NICU) stay of greater than or equal to 7 days, and prematurity of less than 32 weeks (very and extremely premature infants). Minor comorbidities included asthma, gastroesophageal reflux disease (GERD), recurrent respiratory infections, inguinal hernias requiring surgical repair, colic and prematurity less than 37 weeks but greater than or equal to 32 weeks. Patients were categorized based upon their most severe comorbidity. A third category included children suffering from acute illness at the time of the trauma, including acute upper and lower respiratory infections and otitis media.

Chi-square analyses were used to compare the distributions of categorical variables and Student's t-tests were used to compare the means of continuous variables between NAT cases and AT controls. Logistic regression was employed to evaluate the odds of NAT relative to AT while controlling for the presence of selected confounders. Such confounders included maternal age, parental substance abuse, non-relatives in the home, patient age and race/ethnicity. All statistical analyses were performed utilizing SAS 9.3 (SAS Institute, Cary, NC) and JMP Pro 10.0.0 (SAS institute, Cary, NC). Significance was defined as *p*-values less than 0.05.

2. Results

A total of 234 children less than 1 year of age were treated for NAT during the specified time period. Two hundred eighty-seven children less than 1 year treated for AT during the same time period were randomly selected to serve as a control group. Baseline characteristics of the two groups are summarized in Table 1. In sum, children admitted for NAT were similar to children admitted for AT in terms of gender (63.7% male vs 60.6% male, $p = 0.476$, respectively) and race ($p = 0.893$). Likewise, the two groups of children did not differ in terms of the number of biologic parents living in the home, the number of prior maternal pregnancies or the percentage of deliveries performed by caesarian-section. However, NAT patients were significantly younger than their AT counterparts (4.3 ± 2.7 months vs. 5.6 ± 3.5 months, $p < 0.001$) and were more likely to be birthed by younger mothers (mean maternal age 22.7 ± 5.1 years vs 26.3 ± 7.0 years, $p < 0.001$). Similarly, children admitted for NAT were more likely to have nonrelatives living in their homes (16.4% vs 4.6%, $p < 0.001$) and were more likely to have parents with a history of substance abuse (45% vs 15%, $p < 0.001$).

Table 1
Baseline characteristics of NAT cases and AT controls.

	Nonaccidental trauma ($n = 234$)	Accidental trauma ($n = 287$)	*p*-Value
Patient age, mean ± SD, m	4.3 +/- 2.7	5.6 +/- 3.5	<0.001
Male gender, *n* (%)	149 (63.7)	174 (60.6)	0.476
Race			0.893
Black, *n* (%)	61 (26.1)	73 (25.4)	
Hispanic, *n* (%)	25 (10.7)	29 (10.1)	
White, *n* (%)	139 (59.4)	177 (61.7)	
Other, *n* (%)	9 (3.9)	8 (2.8)	
Maternal age, mean ± SD, y	22.7 ± 5.1	26.3 ± 7.0	<0.001
Born by C-section, *n* (%)	38 (32.5)	35 (30.7)	0.772
No. of prior pregnancies	2.1 ± 1.3	2.2 ± 2.2	0.895
Nonrelatives in home, *n* (%)	35 (16.4)	11 (4.6)	<0.001
No. biologic parents in home, *n* (%)			0.173
≤1	79 (35.1)	79 (29.4)	
2	146 (64.9)	190 (70.6)	
Parental substance abuse, *n* (%)	82 (45)	35 (15)	<0.001

The proportion of patients presenting after NAT who had been the products of premature delivery (<37 weeks) was 24.8%, while that of patients presenting after AT who had been premature was only 12.7% ($p = 0.0004$). Thus, mean gestational age of infants presenting after NAT was significantly lower than the mean gestational age of infants presenting after AT (38.0 ± 2.7 weeks vs 38.8 ± 3.1 weeks, respectively, $p = 0.004$). Eleven of 230 children (4.8%) admitted after NAT were considered very premature compared to 7 of 276 children (2.5%) admitted after AT but this difference was not statistically significant ($p = 0.174$). Similarly, only 3/230 (1.3%) and 4/275 (1.5%) of children admitted after NAT and AT respectively had been products of extreme prematurity ($p = 0.886$).

Logistic regression utilizing prematurity as the only predictor of NAT demonstrated that premature birth increased the odds of NAT by 128% (Odds ratio [OR] 2.28, 95% confidence interval [CI] 1.43–3.68). However, model adjustments to control for confounders (described in Section 1) revealed that the role of prematurity in predicting NAT trended toward but did not reach significance (OR 1.92, 95% CI: 0.97–3.78, $p = 0.061$). Similarly, use of gestational age in the logistic regression model as a continuous variable (rather than categorical classification indicating the presence or absence of prematurity) demonstrated that children of higher gestational age were protected against NAT (OR 0.90, 95% CI 0.83–0.97, $p = 0.0041$) but this effect did not remain significant after adjusting for confounders (OR 0.92, 95% CI 0.84–1.00, $p = 0.055$) (Table 2).

Major comorbidities were present in 58 of the 230 (25.6%) of children presenting after NAT but in only 20 of the 279 (7.2%) children presenting after AT ($p < 0.0001$). Prematurity of <32 weeks accounted for 18 of the 78 patients (23.1%) with major comorbidities and all such patients had at least one additional major comorbidity, such as necrotizing enterocolitis or respiratory distress syndrome. The most frequent major comorbidities in the remaining 60 patients without prematurity of <32 weeks included respiratory distress syndromes requiring intubation (9/60), respiratory distress syndromes requiring NICU stays ≥7 days without intubation (8/60), cardiac malformations including ventricular–septal defects and double-outlet right ventricle (4/60), hydrocephalus (3/60) and laryngomalacia (3/60). Other major comorbidities included jejunal atresia, pyloric stenosis, gastroschisis, holoprosencephaly, Wiskott Aldrich syndrome, and anoxic brain injury sustained at birth.