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Research Article

Indicators of Non-accidental Trauma in Patients Under 24 Months of Age

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Abstract

Objective: Child abuse, also known as Non-Accidental Trauma (NAT) is more prevalent in children under 24 months of age than any other pediatric age group. As this population of patients is unable to explain the origin of their injuries, it is critical to develop a framework of signifiers to help uncover the true cause of their trauma.

Methods: A retrospective chart review of 233 trauma patients was conducted. Each patient's electronic medical record was reviewed for demographic information, details of their injury, prior emergency department visits, and subsequent emergency department visits or medical conditions.

Results: 105 patients were classified as victims of NAT and 128 patients were identified as accidental trauma. Compared to the accidental group, the NAT patients had a significantly longer length of stay, were significantly younger, had a significantly lower weight percentile, had a significantly higher incidence of long bone, rib, skull, and healing fractures, and had a significantly higher incidence of prior CPS or abuse cases.

Conclusion: Emergency department medical staff should be cautious of trauma patients who present with any of thesevariables found to be associated with NAT. Identification of NAT on the first presentation by medical staff may prevent victims of NAT from facing subsequent abuse, fatality, or lifelong complications.

Keywords: Child abuse; Non accidental trauma; 24 months old

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Introduction

Children under 24 months of age have the highest incidence of physical abuse [1]. Although in some cases the presence of abuse is clear from the initial evaluation, these patients are often brought to medical providers' care by their own abusers, and being unable to ask for help or provide a history, uncovering the real cause of their injuries can be extremely challenging. Most often, the history reported by the abusive parent or guardian in Non-Accidental Trauma (NAT) cases is that of a minor fall or an unobserved injury [2]. Fortunately, upon further investigation, thephysical examor radiological findings are often inconsistent with the reported history, allowing clinicians to suspect abuse.

Several studies have identified subdural hematomas and retinal hemorrhages, to be highly suggestive of NAT [2-4]. Since abusive head trauma is the leading cause of fatal head injuries in children younger than 2 years, it is important to distinguish the accidents from abuse [5,6]. Although skeletal surveys are helpful in identifying further injuries in a suspected abuse case, these tools may lead to unnecessary exposure to radiation with sparse yield [7]. In addition, fractures are the second most frequent diagnosis in NAT cases and necessitate a method to distinguish themselves from their accidental counterparts [8].

Often, cases of NAT are recurrent incidents and can lead to fatalities if the abusive nature of the injuries is not initially recognized [9,10]. Although recurrence is common, little information is available regarding the outcomes of the patients who experienced severe NAT and survived.

The purpose of this study is to identify findings upon presentation to the emergency department that could help distinguish accidental from non-accidental injuries. Additionally, this study aims to identify prior and subsequent visits and determine whether they are associated with the initial NAT incident.

Methods

Participants

A retrospective chart review was conducted. All patients 24 months of age and younger that presented to the Children's Hospital of Michigan as a trauma evaluationbetween January 1st2015 to December 31st2016 were included. Patients were placed in the non-accidental trauma group if either a Report of Actual or Suspected Child Abuse or Neglect was filed (3200), and/or they were sent home with an alternate caregiver. These criteria were chosen as they have been used as an appropriate abuse indicator in other NAT literature when a conclusive diagnosis of non-accidental trauma is unattainable [11]. If neither of these conditions were met but a trauma evaluationoccurred, the child was characterized as an accidental trauma.

Data

Data was derived from the Electronic Medical Records (EMR) of each patient and the desired variables were manually extracted.

Demographic information, weight percentile, and height percentilewere recorded. Diagnoses were characterized by the number of acute fractures, the type of fracture (long bone, rib, skull, or other), the number of fractures in the healing stage, the presence of an intracranial hemorrhage or hematoma, and other traumatic findings, such as a laceration, amputation, or sexual abuse. Finally, the reason for injury, as stated by the accompanying parent, guardian, or adult, was noted. Each of these variables were then identified across three separate time periods: previous visits, including any injury-related visits to our institution prior to the trauma evaluation admission, the index visit, which was the trauma admission between January 1st 2015 and December 31st 2016, and any future injury-related visits to our institution following the index trauma admission. A breakdown of these three time periods can be seen in figure 1.

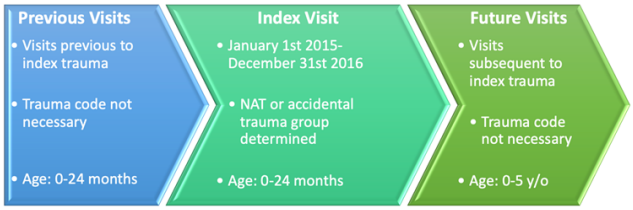

Figure 1: A breakdown of the three separate time periods is portrayed above.

Previous and subsequent visits were evaluatedin order to identify an indication that abuse may have occurred prior to the indexvisit. The variables extracted from this block of time included: the number of previous or subsequent emergency department visits, whether these visits were due to injury as opposed to sickness, whether Child Protective Services (CPS) were involved, and if there was any other social work or CPS involvement noted outside of our institution.

Statistical analysis

Demographic variables were presented with proportions and ratios for categorical variables and means/standard deviations for continuous variables. Persons Chi-square and Fisher's Exact test were performed for comparisons of proportional differences between study groups. A parametric independent sample t-test was performed to examine mean differences on continuous variables. Homogeneity of variance was checked and verified. A series of binary logistic regression models was performed which included variables found to be significant predictors from the univariate analyses of abuse burns. The final model was reported with odds and their 95% confidence intervals. SPSS Version 26.0 IBM Inc. was used to perform all statistical procedures.

Results

233 patients met the inclusion criteriawith 128 patients (54.9%) being classified as accidental trauma and 105 patients (45.1%) as NAT.Out of all the patients, 54.1% (n=126/233)were male and 45.9% (n=107/233) were female with no significant differences between sex in either group.Reported races included Black (45.5%, n=106/233), White (39.9%,n=93/233), Middle Eastern (5.2%,n=12/233), Hispanic (3%, n=7/233), Native American (0.4%, n=1/233) and unknown or not listed (6%, n=14/233). All demographic data can be referenced in table 1.

Categories	NAT N, (% within group)	Accidental N, (% within group)	Total N (% of all participants)
Sex			
Male	51 (48.57%)	75 (58.59%)	126 (54.08%)
Female	54 (51.43%)	53 (41.41%)	107 (45.92%)
Race			
Black	56 (53.33%)	50 (39.06%)	106 (45.49%)
White	36 (34.29%)	57 (44.53%)	93 (39.91%)
Unknown	5 (4.76%)	9 (7.03%)	14 (6.01%)
Middle Eastern	5 (4.76%)	7 (5.47%)	12 (5.15%)
Hispanic	2 (1.90%)	5 (3.91%)	7 (3.00%)
Native American	1 (0.95%)	0 (0.00%)	1 (0.43%)
Insurance Type			
Medicaid	85 (80.95%)	90 (70.31%)	175 (75.11%)
Commercial	14 (13.33%)	27 (21.09%)	41 (17.60%)
None	6 (5.71%)	11 (8.59%)	17 (7.30%)

Table 1: Demographic data for the non-accidental trauma (NAT) group and the accidental trauma group. The table shows the number of participants in each group and the percentages reflect the percent of patients within their group (NAT or Accidental).

Table 2 compares the characteristics of both groups. Compared to the accidental trauma group, the NAT group was younger (0.72± 0.57 years old vs. 1.14 ± 0.58 years old, p=0.001)had a longer length of stay (4.1 ± 09.27 days vs 1.11 ± 1.64 days, p=0.001), a lower weight percentile (45.80% ± 31.72% vs. 63.54%± 28.4%, p=0.001), a higher incidence of long bone fractures (0.62 ± 1.25 vs. 0.13± 0.34, p=0.001), skull fractures (0.41± 0.69 vs. 0.18± 0.42, p=0.002), rib fractures (0.4 ± 1.90 vs. 0± 0, p=0.017), healing fractures (0.49 ± 2.39 vs. 0± 0, p=0.022), and prior CPS involvement (0.28± 0.51 times vs. 0.14± 0.43 times, p=0.029). The NAT group also had a significantly higher incidence of low weight (under the 10th percentile) or Failure To Thrive (FTT) than that of the accidental trauma group (p=0.001).

	NAT Average	Accidental Trauma Average	P value
Age	0.72 ± 0.57	1.14± 0.58	0.001
Length of stay (days)	4.10± 9.27	1.11± 1.64	0.001
Weight percentile	45.80± 31.72	63.54± 28.40	0.001
Number of long bone fractures	0.62± 1.25	0.13± 0.34	0.001
Number of skull fractures	0.41± 0.69	0.18± 0.42	0.002
Number of rib bone fractures	0.40± 1.90	0± 0.00	0.017
Number of healing fractures	0.49± 2.39	0± 0.00	0.022
Number of prior CPS cases	0.28± 0.51	0.14± 0.43	0.029

Table 2: Mean averages and standard deviations for both the NAT group and the Accidental group across all significant variables found in the study. The significance level (*p<0.05) is shown in the last column.

Table 3 displays the variables resulting from the logistic regression. A longer length of stay was associated with a 1.47-fold increase in likelihood for NAT (95% CI: 1.10 to 1.97 fold, p=0.01). Additionally, a lowerweight percentile was associated with a 0.99-fold increase in likelihood for NAT (95% CI: 0.97 (97.0%) to 0.99 (99%), p=0.031).Regarding injury type, a higher mean number of long bone

fractures were associated with a 3.60-fold increase in likelihood of NAT (95% CI: 1.48 to 8.76 fold, p=0.005). Past abuse, injury, or CPS involvement was associated with a 3.65-fold increase in likelihood for NAT (95% CI: 1.20 to 11.09-fold, p=.023). Although not significantly different at p≤.05, the presence of an intracranial hemorrhage or hematoma was associated with a 2.51-foldincrease in likelihood for NAT (95% CI: 0.82 to 7.67-fold, p=0.11). Finally, if the reason identified for the visit was for decreased use of an extremity, pain, crying when touched, or visual evidence of injury, such as bruising, there was a 0.59-fold increase in the likelihood for NATover a fall or being dropped (95% CI: .015 to .236, p ≤.001).

				95% C.I. for EXP(B)	
	B	**Sig.**	**Exp (B)**	**Lower**	**Upper**
Reason for visit	-2.82	0.001	0.06	0.01	0.24
Past abuse, injury, or CPS involvement	1.29	0.023	3.65	1.2	11.09
Weight percentile	-0.02	0.031	0.99	0.97	1
Number of long bone fractures	1.28	0.005	3.6	1.48	8.76
Number of days admitted	0.38	0.01	1.47	1.1	1.97
Brain bleed present	0.92	0.107	2.51	0.82	7.67

Table 3: Variables from the logistic regression model are shown. The significance level (*p<0.05) is shown in the second column. All variables except the presence of a brain bleed were statistically significant.

Within 5 years of the initial trauma, 20% (n=21/105) of the NAT patients and 16.41% (n=21/128) of the accidental group had at least one diagnosis or complication resulting from the trauma. These included neurologic conditions (11.59%, n=27/233), cognitive delays (6.87%, n=16/233), and other medical diagnosis (7.3%, n=17/233). The breakdown of these future diagnoses can be seen in Table 4. Four patients died during their trauma admission and 100% of these patients were in the NAT group.

	NAT n, (% within group)	**Accidental n, (% within group)**	**Total N (% of total population)**
Neurologic Diagnoses	**16 (15.24%)**	**11 (8.59%)**	**27 (11.59%)**
Seizures	8 (7.62%)	5 (3.91%)	13 (5.83%)
Other CNS disorders	4 (3.81%)	2 (1.56%)	6 (2.58%)
Ophthalmic	0 (0%)	2 (1.56%)	2 (0.86%)
Gastrointestinal	2 (1.9%)	0 (0%)	2 (0.86%)
Sleep disorders	1 (0.95%)	3 (2.34%)	4 (1.72%)
Cognitive Delays	**8 (7.62%)**	**8 (6.25%)**	**16 (6.87%)**
Other medical diagnoses	**8 (7.62%)**	**9 (7.03%)**	**17 (7.3%)**
Hospital complications	2 (1.9%)	1 (0.78%)	3 (1.29%)
Ophthalmic complications	2 (1.9%)	2 (1.56%)	4 (1.72%)
Musculoskeletal conditions	1 (0.95%)	2 (1.56%)	3 (1.29%)
Lack of care indicators	1 (0.95%)	3 (2.34%)	4 (1.72%)
Drug dependence	0 (0%)	1 (0.78%)	1 (0.43)
Physical deformities	2 (1.9%)	0 (0%)	2 (0.86%)
Total	**32**	**28**	**104**

Table 4: Future medical diagnoses and complications as a result of the trauma visit are shown. The percentages reflect the percent of patients within their group (NAT or Accidental) that were diagnosed. Note that one patient may have been diagnosed with >1 condition, thus the bottom total row reflects the number of conditions reported within that group, not the number of patients.

Table 5 outlines all subsequent emergency department injury-related visits and CPS cases. Fifty-six out of all 233 patients (24.03%) experienced at least one incident of abuse, injury, and/or CPS case subsequent to the index trauma visit.Within the NAT group, 18.1% (n=19/105) of patients experienced at least one subsequent injury visit and 3.81% (n=4/105) experienced a future CPS case. Within the accidental trauma group, 25% (n=32/128) of patients experienced at least one subsequent injury visit and 3.12% (n=4/128) experienced a future CPS case.

	NAT n, (% within group)	**NAT (3200 filed and/ or discharged with alternate caregiver) (% within group)**	**Accidental n, (% within group)**	**NAT (3200 filed and/ or discharged with alternate caregiver) (% within group)**	**Total N (% of total population)**
Future Injury Visits					
1 future injury visit	19 (18.10%)	2 (1.90%)	32 (25.00%)	5 (3.91%)	50 (21.46%)
2 future injury visits	6 (5.71%)	1 (0.95%)	11 (8.59%)	1 (0.78%)	17 (7.30%)
3 future injury visits	2 (1.90%)	1 (0.95%)	5 (3.91%)	1 (0.78%)	7 (3.00%)
Future CPS Cases	4 (3.81%)		4 (3.12%)		8 (3.43%)
Total patients with future injury, abuse, and/or CPS cases	**23** **-21.90%**		**3 3 (25.78%)**		**5 6 (24.03%)**

Table 5: Future injuries, CPS cases, and whether a 3200 was filed or the patient went home with an alternate caregiver is shown. The second and third column reflect the patients whose subsequent injury visit was classified as NAT. It is possible for one patient to be listed in both the future injury visit row as well as the CPS cases row, thus, totals displayed at the bottom are reflective of the total amount of patients who met at least one of these criteria, not the number of occurrences.

Limitations

Our study is a single-institution, retrospective one. Although we are a level 1 pediatric trauma referral center, our study may be more reflective of an urban population, rather than that of the general population. Our study excluded patients older than two years of age, thus this information can only be applied to patients in that age group. The study also excluded patients whose trauma was minor, in which ourtrauma team was not involved. These patients may have been victims of NAT but were not captured in our trauma registry due to the lesser degree of their injury. Some patients may have also been taken to outside hospitals or clinics, thereby not permitting a complete analysis of prior and/or subsequent injuries. Finally, as a result of the difficulty to

concretely diagnose a patient with NAT due to the ambiguous nature of these injuries, the criteria for the NAT group was defined to include patients that were highly suspicious of NAT, but not confirmed. It is possible that some patients in the accidental trauma group may have in fact been victims of NAT, however if a Report of Actual or Suspected Child Abuse or Neglect (3200) was not filed, or if they were not sent home with an alternate caregiver, they were automatically placed in the accidental trauma group. Likewise, it is possible that some of the patients in the NAT group may have truly been victims of accidental injury. As this study includes patients from January 1st, 2015 to December 31st, 2016, the maximum age of the patients when examining their future outcomes was 4 to 5 years old. Future studies should follow up with the patients for 10+ years in order to fully assess any future abuse, behavioral issues, or medical conditions that arise over time.

Discussion

Our study was consistent with previous findings of a negative correlation between age and incidence of abuse, with the average age of the NAT group being 37% lower than that of the accidental group. As this finding has been consistent amongst other NAT studies [11-13] as well as national databases,1 an age of less than one year old should be cause of suspicion for the emergency department staff. Younger infants may experience higher rates of abuse as parents become frustrated with the infant's inability to communicate and increased crying that usually peaks between two and four months of age.

Scanning the EMR for any previous suspicious injuries, CPS cases, social work involvement, or abuse may also be helpful to identify NAT. As previous studies have listed recurrent NAT rates of up to 40% within 2 years of the initial trauma [9], recognizing a pattern of suspicious injuries may be the key to preventingabuse and potentially saving lives. Although recurrent NAT is common, abusive parents may alternate between hospitals and primary caregivers, thus making identification of previous visits difficult [14]. If a linkage network across hospital records in the general area is not possible, it may be beneficial to ask the parent or guardian to list any previous emergency department visits, social work involvement, or CPS cases. Although this information may not be voluntarily offered, many parents in our study released this information when explicitly asked by the social worker. Contacting the primary care physician may be appropriate when this information is refused or not reliable.

In cases of nonorganic FTT, in which no underlying medical condition is identified, the patient is not provided with enough nutrients and calories to grow [15,16]. By using weight percentiles as a tool to recognize neglect, medical providers can better identify a patient who is at risk for physical abuse. Additionally, using weight percentiles to identify malnutrition may also serve as a proactive measure to intervene.

Although some studies suggest that skeletal surveys may expose the patient to unnecessary radiation [7,17], when other signifiers of NAT are present, such as an age younger than 12 months, prior CPS or abusive history, a low weight percentile, bruising, lacerations and/or deceased use of the extremity, a skeletal survey may expose unrecognized or healing fractures, suggestive of unidentified or untreated injuries.

NAT often has a lasting effect on the patient's quality of lifein addition to consuming significant hospital resources. Out of all the patients in the NAT group, 1 in every 5 was left with either a long-term medical diagnosis or a severe chronic condition. The majority of these problems were neurological in nature, thus necessitating frequent follow up visits to treat seizures, hydrocephalus, and other conditions. In addition, some victimsof NAT developed cognitive delays, likely requiring assisted learning, specialized medical care, and in severe cases, in-home nursing care. As 81% of the patients in the NAT group listed their primary insurance as Medicaid, this financial burden falls on the taxpayer.

A larger percentage of future injury related visits and CPS cases were observed in the accidental trauma group than the NAT group. Of the 23 patients in the NAT group with subsequent injuries or CPS cases, 15 were not sent home with an alternate caregiver during their index trauma visit. Although being sent home with an alternate caregiver was one characteristic that classified a patient as NAT in our study, if they had a Report of Actual or Suspected Child Abuse or Neglect (3200) filed, they were included in the NAT group. Thus, it is possible that the NAT patients who were sent home with an alternate caregiver may have been saved from future incidents of abuse.It is important to note that the rest of the NAT patients with future injury or CPS cases, with the exception of one who was sent home with foster care, were sent home with a relative. In these situations, is possible that the abusive caregiver still has access to the patient, thereby allowing the abuse to continue. When selecting an alternate caregiver, the amount of contact the previous caregiver will have with the patient in the new environment should be considered to avoid further abuse. Unexpectedly, one in four patients in the accidental group had a future injury or CPS case. This large number may be explained by the difficulty indistinguishing NAT in this age group. It is possible that these patients may have truly been victims of NAT during the index trauma visit, yet due to the ambiguous nature of thesecases, was able to evade the suspicion of the medical personnel. For this reason, the variables found to be associated with NAT in this study should be used as a tool to assist medical professionals in determining patients that are at a higher risk for NAT.

Conclusion

When compared to patients admitted for accidental trauma, patients in the NAT group were younger, had a lower weight percentile, and had a higher incidence of previous CPS involvement. They also had a higher incidence of fractures and intracranial hemorrhages or hematomas. Their hospital length of stay was longer and had a higher incidence of chronic sequelae. Familiarity with these findings might help clinicians to identify potential NAT and initiate interventions to prevent recurrence.

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