Infant Head Injury in Falls and Nonaccidental Trauma
Does Injury Pattern Correlate With Mechanism?

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Objectives: Nonaccidental trauma (NAT) is most common and most lethal in infants. Falls are the most frequently given explanation for NAT, and head injuries can result from both mechanisms. We hypothesized that infant head injuries from NAT have a distinct injury profile compared to falls.

Methods: The trauma registry and patient records were reviewed from 2004 to 2008. Infants with at least 1 head computed tomography were included.

Results: Ninety-nine infants were identified. Falls (67 patients) and NAT (21 patients) were the most common mechanism of injury. Falls had lower injury severity scores, 5 versus 17 compared to NAT ($P < 0.001$). Nonaccidental trauma patients had injuries to face, chest, abdomen, or extremities much more frequently, 62% versus 3% in falls ($P < 0.001$). Isolated intracranial hemorrhage was higher in NAT (60% vs. 23%, $P = 0.002$), whereas isolated skull fracture was higher in falls (42% vs. 5%, $P = 0.005$). Outcomes for NAT showed longer intensive care unit stays (4 days vs. 1 day; $P < 0.001$), longer hospital stays (7 days vs. 1 day; $P < 0.001$), and more intracranial operations (9 vs. 1; $P < 0.001$).

Conclusions: We recommend that all children younger than 1 year, with an isolated intracranial hemorrhage, have a full NAT work-up. Injury severity score greater than 20, Glasgow Coma Scale less than 13, and extracranial injuries should also increase suspicion of NAT.

Key Words: infant, nonaccidental, head injury, fall, trauma

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Children falling from short distances (<3–4 ft) rarely sustain significant injuries,[1–3] and those with minor head trauma are frequently discharged from emergency departments with only clinical examinations or skull radiographs.[4] In children who sustain injuries, it is important to differentiate accidental from nonaccidental mechanisms. Falls are one of the most common causes of traumatic injury in children and are commonly given by caregivers as an explanation for injuries caused by child abuse.[5] Differentiation between injuries sustained during falls versus inflicted injuries remains a challenge especially in nonverbal children. Most nonaccidental trauma (NAT) is perpetrated in children less than a year old; however, most studies evaluating child abuse look at broad age ranges.[6–9] The mean age for victims of NAT has been reported between 0.5 and 11.8 months, and NAT carries the highest mortality of all traumatic mechanisms, most often related to head trauma.[6,10] Additionally, infants are less mobile and lack self-protective reflexes which may change the injury complex during a fall. For these reasons, we feel that an in-depth evaluation of child abuse in children younger than 1 year is warranted. We hypothesized that infant head injuries associated with NAT have a distinct injury profile compared to falls, which may aid in improving identification of NAT.

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METHODS

After approval from the institutional internal review board, the hospital trauma registry and patient records at a tertiary, teaching children's hospital with a level 1 trauma designation were retrospectively reviewed from 2004 to 2008. Infants (<12 months old) evaluated for head injury were identified by having at least 1 head computed tomography (CT). Mechanism of injury was recorded based on initial trauma evaluation as well as discharge coding. Emergency medical services reports as well as parent statements were used to determine reported specifics, such as height of fall. Nonaccidental trauma was determined after evaluation by the institutional child abuse team and the state Department of Human Services. Statistical comparisons were made by Mann-Whitney *U* test for continuous variables and 2-tailed Fisher exact test for frequencies. A value less than 0.05 per comparison was considered statistically significant. Injury Severity Score (ISS), Abbreviated Injury Scale (AIS), and Glasgow Coma Scale (GCS) were recorded per the established definitions.

RESULTS

During the study period, 99 infants experienced a traumatic head injury. Falls and NAT were the most common mechanism of injury in 67 (68%) and 21 (21%) patients, respectively (Table 1). The other 11 patients included: 7 motor vehicle collisions, 2 incidents of furniture falling on patients, 1 dog bite, and 1 unknown cause. Almost all falls were reported as being from low height (<4 ft). The other specific mechanisms included 5 patients who fell down stairs, and 2 patients who fell from the second level of a house (neither of whom suffered significant injuries). Of note, 1 patient had suffered "multiple falls in the past few days," but inhospital investigation did not reveal abuse. Of the 21 patients who suffered abuse, 4 were described as having been "shaken," all others lacked additional descriptors.

In both groups, there was a male predominance and a high rate of transfer from other facilities (Table 1). Median ISS was markedly higher in the NAT group compared to those with falls. The distribution of ISS showed few fall patients with scores above 20 (Fig. 1). The GCS on presentation had a wide range in patients with NAT (3–15), whereas all patients with falls had GCS scores of 14 or 15 (Fig. 2). All patients in both groups had an AIS entry for head and neck, with higher injury scores in the NAT group. The AIS for other anatomic areas showed both groups had a high rate of external (soft tissue) injuries, but the difference was not statistically significant (Table 2). Values for AIS categories of chest, abdomen, and extremities were exclusively noted in NAT patients. Although facial injuries did occur in patients who fell, they occurred significantly more often in infants who were abused.

Initial head CT results more often revealed isolated intracranial hemorrhage (ICH) in NAT patients and isolated fractures in falls (Table 3). Fractures with concurrent ICH were seen more often in abused children than those with falls, but did not reach statistical significance. No patients with NAT had normal CT scans.

Additional CT imaging was performed on 90% of NAT patients (5 patients had 3 or more), compared to only 37% of patients

TABLE 1. Patient Demographics

	Fall Median (Range)	NAT Median (Range)	*P*
M:F	2.2:1	4.2:1	0.080
Transfer from other facility, n (%)	45 (66)	17 (80)	0.282
Initial GCS	15 (14–15)	14 (3–15)	<0.001
Injury severity score	5 (4–26)	17 (5–38)	<0.001
AIS head, neck, or c-spine	2 (2–4)	4 (2–5)	<0.001

who fell. Of the 2 NAT patients who did not get follow-up CT, one died, and the other was the only patient with an isolated skull fracture. Repeat CT scans were usually performed on post-injury day 0 or day 1, slightly later in NAT patients (median, 1 vs. 0). Second CTs more often showed worsening condition in NAT patients. A few patients in both groups had previously unidentified skull fractures, all but one had a concomitant bleed. There was no difference in the percentage of patients with stable findings.

Outcomes were worse for the NAT group, 9 of whom required intracranial surgery and 1 of whom expired. All but one of the patients with NAT were admitted to the intensive care unit. None of the 30 patients in the fall group who were admitted to the intensive care unit stayed longer than a day, and there were no deaths. Overall hospital stay showed a similar trend with longer stays in the NAT group.

DISCUSSION

Nonaccidental trauma represents a significant and highly morbid cause of pediatric injury. In studies evaluating all children injured by abuse, the average patient age is younger than 1 year, and the most morbid injuries are intracranial.[6,10] The complete work-up of suspected NAT includes a skeletal x-ray series, ophthalmologic examination, and thorough social work evaluation. Although the identification of multiple fractures or retinal hemorrhages are highly concerning for child abuse, these findings may go undiagnosed if clinical suspicion is low and the NAT work-up is not initiated. The decision to initiate a work-up is based on the initial clinical findings, and thus additional clinical criteria may aid in improving the identification of NAT. We evaluated infants with head injury at a Level I trauma center to determine the relationship between injury profile and mechanism and to identify triggers to prompt an NAT work-up.

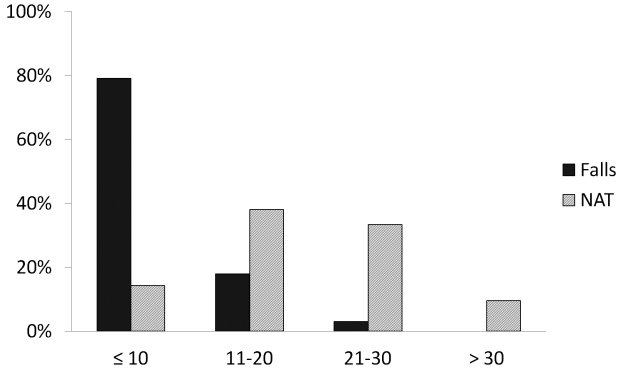

FIGURE 1. Injury severity scores. Percentage of patients within each score range.

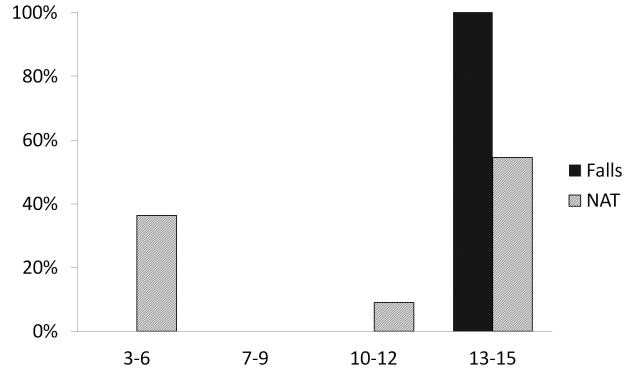

FIGURE 2. Initial GCS scores. Percentage of patients within each score range.

Our results indicate that ICH without skull fracture, high ISS, low GCS, and associate extracranial injuries should increase clinical suspicion for NAT in head injured patients. The current study and several previous studies demonstrate that patients with NAT have an increased rate of ICH, and patients with other mechanisms of injury have a higher rate of skull fracture.[11–13] Other studies grouped all occurrences of ICH or fracture and not whether the two occurred together. Our data suggest that isolated hemorrhages without a fracture are a better indicator of NAT than ICH with fracture, and we believe that infants with ICH alone should always receive a complete NAT work-up. Additionally, we found that isolated skull fracture could almost always rule out NAT, barring the presence of other suggestive clinical findings.

Evaluating injury profile is key in the determination of NAT, and multiple injuries should always be checked for consistency with the mechanism. We found that injuries of the chest, abdomen/pelvis, and extremities were only present in patients with NAT. These findings corroborate other studies showing higher rates of skeletal and visceral injuries in NAT compared other forms of trauma.[13,14] Facial and soft tissue injuries occurred in both groups, however our findings differed from studies using broader age ranges. Facial injuries were higher in our NAT group, compared to DiScala et al,[15] who found the rate similar between accidental and nonaccidental trauma. Conversely, soft tissue injuries (external AIS) were less common in our NAT group, with other reports showing their frequency to be equal[15] or higher in NAT.[13,16] These differences may be because of the fact that infants are nonambulatory and lack reflexes to protect themselves when falling or because we excluded motor vehicle collisions where the child may be protected in a safety seat. Overall, we suggest that patients with injuries to chest, abdomen/pelvis, and extremities in addition to their head trauma always have a complete NAT work-up.

TABLE 2. Rates of Injury by AIS Region

	Fall, n (%)	NAT, n (%)	*P*
Face	2 (3)	11 (52)	<0.001
Chest	0 (0)	4 (19)	0.003
Abdomen/pelvis	0 (0)	1 (5)	0.239
Extremities	0 (0)	2 (10)	0.054
External	47 (70)	10 (48)	0.071
Any face, chest, abdomen/pelvis, extremities	2 (3)	13 (62)	<0.001

TABLE 3. Findings on Head CT

	Fall, n (%)	NAT, n (%)	*P*
Initial head CT			
ICH	15 (23)	12 (60)	0.002
Fracture	27 (42)	1 (5)	0.005
ICH plus fracture	11 (17)	7 (35)	0.394
Normal	10 (16)	0 (0)	<0.001
Follow-up head CT	25 (37)	19 (90)	—
Worsening bleed/contusion/edema	7 (28)	10 (56)	—
New fracture	3 (12)	1 (6)	—
Stable/improved	16 (64)	10 (56)	—
Drain	1 (4)	6 (33)	—

Higher ISS scores in patients with NAT have been previously described,[15,16] and our data corroborate these findings. Our data support that ISS above 20 and GCS below 13 are highly suggestive of NAT and should prompt additional studies.

In clinical application, we believe most clinicians will already have an increased suspicion of NAT in patients with high ISS, low GCS, and associated extracranial injuries without the specific definitions given in this investigation. It is also important to note that ISS is not routinely calculated during the trauma evaluation, making it an interesting, but potentially irrelevant diagnostic tool. On the other hand, the radiographic finding of an isolated ICH, although not currently considered pathognomonic for NAT, we believe, should trigger an NAT work-up in infants.

The limitations of this study rest primarily with the retrospective nature of the data and possible inaccuracies in the medical and trauma records. It is important to note that we do not evaluate patients with head trauma who did not receive CT imaging. Because patients with minor head trauma are frequently discharged from emergency departments without imaging or treatment, it is possible that less significant forms of injury, whether inflicted or otherwise, went undetected in our analysis.[3,4] We also acknowledge that many incidences of NAT are not identified even after complete work-up, and these patients may have been miscategorized in our evaluation.

Early recognition of nonaccidental trauma is essential to improved outcomes from injuries and removal of children from ongoing risk. A more complete understanding of early clinical predictors will allow clinicians to appropriately initiate additional work-up and hopefully better the lives of these unfortunate children.

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