# Characteristics That Distinguish Accidental From Abusive Injury in Hospitalized Young Children With Head Trauma

Kirsten Bechtel, MD*; Kathleen Stoessel, MD‡; John M. Leventhal, MD*; Eileen Ogle, PAC§; Barbara Teague, RN‖; Sylvia Lavietes, MSW¶; Bruna Banyas, RN‖; Karin Allen, RN‖; James Dziura, PhD‖; and Charles Duncan, MD§

**ABSTRACT.** *Objective.* **To describe the clinical features that distinguish accidental from abusive head injury in hospitalized children <24 months of age.**

*Methods.* **Prospective study of children <24 months of age hospitalized for head injury between August 1, 2000, and October 31, 2002. During hospitalization, children had computed tomographic scans of the brain, serial neurologic examinations, dilated ophthalmoscopic eye examinations, evaluation by a social worker, and, in some cases, a child abuse specialist.**

*Outcome Measures.* **The main outcome measure was the proportion of children in each group with retinal hemorrhages (RHs). Secondary outcome measures were the proportion of children in each group who had vitreous hemorrhage; abnormal mental status on presentation; seizures; scalp hematomas; need for anticonvulsants; and operative procedures such as subdural tap, craniotomy, ventriculostomy, tracheostomy, and gastrostomy.**

*Results.* **Eighty-seven children were prospectively enrolled. Fifteen children were classified as having abusive head injury, and 72 were classified as having accidental head injury. Five children, all in the accidental head injury group, were excluded from statistical analysis, because they did not have a dilated ophthalmoscopic examination during their hospitalization. Thus 82 children were included in the statistical analysis. There were no significant differences between the 2 groups with respect to mean age, gender, or ethnicity. RHs were more likely to be seen in children with abusive head injury (60% vs 10%) and were more likely to be bilateral (40% vs 1.5%). Pre-RHs were more likely to be seen in children with abusive head injury (30% vs 0%). Premacular RHs and RHs that extended to the periphery of the retina were also more likely to be seen in children with abusive head injury (20% vs 0% and 27% vs 0%, respectively). Of the 7 children with accidental head injury who had RHs, 6 had unilateral RHs. Children with abusive head injury were more likely to have seizures (53% vs 6%) and an abnormal mental status on initial presentation (53% vs 1%). Children with accidental head injury were more likely to have scalp hematomas (6.7% vs 49%).**

*Conclusions.* **RHs are seen more often in abusive head injury and often are bilateral and involve the preretinal layer. Children with abusive head injury were more likely to have RHs that cover the macula and extend to the periphery of the retina. Unilateral RHs can be seen in children with accidental head injury. Children with abusive head injury were more likely to present with abnormal mental status and seizures, whereas children with accidental head injury were more likely to have scalp hematomas. Such characteristics may be useful to distinguish accidental from abusive head trauma in children <24 months of age.** ***Pediatrics*** **2004;114:165–168;** ***abusive head trauma, retinal hemorrhages, seizures, abnormal mental status, scalp hematoma.***

ABBREVIATIONS. RH, retinal hemorrhage; SDH, subdural hemorrhage.

Abusive head trauma is the most common cause of death due to child abuse and is the most common cause of traumatic death in children <12 months of age.[1] Abusive head trauma also causes significant morbidity, with up to 50% of survivors having permanent neurologic sequelae.[2] Up to 30% of cases of abusive head trauma may initially go unrecognized.[3] Because the majority of children with abusive head injury are <2 years of age, historical information cannot be obtained from patients. Therefore, it would be helpful to medical practitioners to have clinical features to help distinguish between accidental and abusive head trauma so that each can be diagnosed readily and accurately.

Retinal hemorrhage (RH) and subdural hemorrhage (SDH) are thought to be the hallmarks of abusive head trauma. Duhaime et al[4] and Reece and Sege[5] noted that RHs were found more often in children with abusive head trauma than in children with accidental head trauma. In the Duhaime et al study, only 1 patient with accidental head trauma caused by a motor vehicle crash had RHs. One of the limitations of this study was that not all patients had dilated eye examinations by a pediatric ophthalmologist. It was shown recently that nonophthalmologists may not detect RHs when examining the retina of children with abusive head trauma.[6] Johnson et al[7] found that of 200 children with intracranial hemorrhage or skull fractures due to accidental causes, none had RHs. However, Christian et al[8] reported a series of 4 cases of young children with accidental head trauma and SDH who had unilateral

From the Departments of *Pediatrics, ‡Ophthalmology, and §Neurosurgery, Yale University School of Medicine, New Haven, Connecticut; and ‖Children's Clinical Research Center and ¶Department of Social Work, Yale New Haven Children's Hospital, New Haven, Connecticut.

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Reprint requests to (K.B.) Section of Pediatric Emergency Medicine, WP 143 Yale New Haven Children's Hospital, 20 York St, New Haven, CT 06504. E-mail: kirsten.bechtel@yale.edu

RHs. Similarly, Schloff et al[9] found that up to 8% of children with intracranial hemorrhage from accidental causes or neurosurgical procedures may have RHs.

Therefore, the purpose of our study was to determine the incidence of RHs in young hospitalized children with accidental and abusive head trauma. We sought to improve on previous studies by prospectively enrolling patients, using a uniform approach to data collection, and having each child evaluated by a social worker and an ophthalmologist. We also sought to determine if there were any other clinical findings to help distinguish between accidental and abusive head injury, such as the presence of seizures, neurologic abnormalities, and the need for operative intervention.

## METHODS

All children <2 years of age who were admitted to the inpatient ward of Yale New Haven Children's Hospital between August 1, 2000, and October 31, 2002, with a diagnosis of head injury and who had computed tomography of the head were prospectively identified and entered into the study. All children were evaluated initially by a pediatric neurosurgeon (C.D.) and a social worker (S.L.). After initial review of the presenting history and physical examination findings, children were classified by one of the authors (K.B.), who was an expert in the evaluation of suspected child abuse, as either having accidental or abusive head injury according to predefined criteria (Table 1). When abuse was suspected, the child abuse team, headed by a physician who was an expert in the detection of child abuse (J.M.L.), also evaluated the children. All children then had a dilated eye examination by an ophthalmologist (K.S.) during hospital admission. Obtaining other radiologic studies such as skeletal radiographic survey or imaging of the cervical spine by plain radiography or by computed tomography and laboratory studies such as complete blood count and coagulation studies were obtained at the discretion of the treating physicians. The medical records of children enrolled in the study were reviewed by a nurse clinician (B.T., K.A., or B.B.) for the presence of the following: type of intracranial injury; skull fracture; abnormal mental status on presentation (unresponsive or poorly responsive to verbal or tactile stimulation, gaze palsies, decorticate or decerebrate posturing and flaccidity); seizures; and operative interventions such as subdural taps, craniotomy, ventriculostomy, tracheostomy, and gastrostomy. The Institutional Review Board of the Yale University of School of Medicine approved the study, and informed consent was waived.

Statistical analysis was done by using SPSS 11.0 (SPSS Inc, Chicago, IL) for Windows. Categorical data were analyzed by using $\chi^2$ analysis, and numerical data were analyzed by using the Student's $t$ test. Although unadjusted $P$ values are reported here, a Bonferoni corrected significance level of .005 was used to evaluate significance for the primary outcomes. Our sample size of 82 subjects was sufficient to detect only large differences in proportions with 80% power and a type 1 error of 0.05%. For instance, assuming the proportion of subjects with RH was 50% in the abused group, we would have adequate power to detect a significant difference of 41% between the accidental and abusive groups.

**TABLE 1.** Classification Scheme

| |
|---|
| Inflicted head injury, clinical and radiological evidence of brain injury with: |
| a. No history of traumatic event (fall, blow to head, motor vehicle crash) or |
| b. History of traumatic event that is incompatible with developmental level or |
| c. Witnessed inflicted head injury or |
| d. Confession by alleged perpetrator to inflicting the head injury or |
| e. Evidence of other physical injuries consistent only with inflicted injuries (eg, pattern bruises, occult rib or extremity fractures) |
| Accidental head injury, clinical and radiological evidence of brain injury with: |
| a. History of traumatic injury that is corroborated by more than one adult or |
| b. History of traumatic injury that is compatible with developmental level and |
| c. Absence of any physical injuries that are consistent with inflicted injury (eg, pattern bruises, occult rib or extremity fractures) |

Modified from Reece and Sege.[5]

## RESULTS

Eighty-seven children were eligible for the study. Five patients, who were classified as having accidental head injury, were excluded because a dilated eye examination was not performed before the patients were discharged from the hospital. Thus, 82 children were enrolled in the study. Sixty-seven patients (81%) were classified as having accidental head injury, and 15 (19%) were classified as having abusive head injury.

History of the mechanism of injury for the 2 groups was as follows. In the accidental head injury group, 97% patients had falls that were witnessed and compatible with the child's developmental level. Of these accidental falls, 73% were from heights of ≤4 ft. Of the remaining 2 patients in the accidental head injury group, a vehicle in the driveway struck 1 patient, and 1 patient was a passenger in a motor vehicle crash. In the abusive head injury group, 27% of the patients had occult fractures or solid organ injury in addition to their intracranial injuries, and 88% had no history of trauma to account for their intracranial injuries (Table 2).

There were no differences between the 2 groups with respect to mean age, gender, or ethnicity (Table 3). Significantly more patients who were classified as having abusive head trauma were found to have SDHs. There were no differences between the 2 groups with respect to the presence of epidural hemorrhage, skull fracture, or subarachnoid hemorrhage. There were no differences between the 2 groups with respect to obtaining laboratory tests, such as complete blood count, prothrombin time, and partial thromboplastin time, or cervical spine diagnostic imaging. No patient in whom these tests were obtained was found to have a cervical spine injury or a coagulopathy.

**TABLE 2.** History of Mechanism of Injury

| | |
|---|---|
| Accident ($N$ = 67) | |
| Witnessed falls | 65 |
| Falls from heights of ≤4 ft | 47 |
| Falls from heights between 5 and 20 ft | 9 |
| Did not have height of fall recorded | 9 |
| Patient's head run over by car (corroborated by another adult) | 1 |
| Passenger in motor vehicle crash (corroborated by other adults) | 1 |
| Abuse ($N$ = 15) | |
| Had no history of a traumatic event | 12 |
| Patient fell 4 in | 1 |
| Patient struck him- or herself in head with piece of wood | 1 |
| Patient's father admitted to shaking the patient 48 h before admission | 1 |

**TABLE 3.** Patient Characteristics

| | Abuse ($N = 15$) | Accident ($N = 67$) | $P$ Value |
|---|---|---|---|
| Mean age | 6.5 mo | 9 mo | 1.0 |
| Male | 60% (9/15) | 57% (38/67) | 1.0 |
| Ethnicity | | | .26 |
| White | 53% (8/15) | 58% (39/67) | |
| African American | 20% (3/15) | 6% (4/67) | |
| Hispanic | 27% (4/15) | 21% (14/67) | |
| Other | 0% | 15% (10/67) | |
| Epidural hemorrhage | 0% | 15% (10/67) | .20 |
| SDH | 80% (12/15) | 27% (18/67) | <.001 |
| Subarachnoid hemorrhage | 7% (1/15) | 3% (2/67) | .46 |
| Skull fracture | 27% (4/15) | 60% (40/67) | .02 |

Primary and secondary outcomes differed between the groups (Tables 4 and 5). Significantly more patients classified as having abusive head injury were found to have RHs (60% vs 10%; $P = < .001$). Bilateral RHs were more likely to be seen in those classified with abusive head injury (40% vs 1%; $P = < .001$). Pre-RHs were more likely to be found in children who were abused (30% vs 0%; $P = < .001$). Premacular RHs and RHs that extended to the periphery of the retina also were more likely to be seen in children with abusive head injury (20% vs 0% [$P =$. 005] and 27% vs 0% [$P = < .001$], respectively). RHs were unilateral in 6 of the 7 patients with accidental head injury who had RHs, and were a single hemorrhage in 3 patients. None of the patients with accidental head trauma had RHs that involved the preretinal layer, extended to the periphery of the retina, or covered the macula. There was a trend toward more patients with abusive head injury having vitreous hemorrhage, but this was not statistically significant (13% vs 0%; $P =$. 03).

Seizures were more likely to be present in those categorized as having abusive head injury (53% vs 6%; $P = < .001$). More patients with abusive head injury and seizures required anticonvulsant therapy, but this trend was not statistically significant (75% vs 0%; $P =$. 06). Abnormal mental status on initial presentation (defined as either being unresponsive or poorly responsive to painful stimuli or having gaze palsies or flaccidity) was seen more often in those who had been abused (53% vs 9%; $P = < .001$). Scalp hematomas were significantly more likely to be present in those with accidental head trauma (7% vs 51%; $P =$. 003). There was a trend, although not statistically significant, of more frequent need for operative interventions such as evacuation of an SDH or placement of a ventriculostomy in those who were abused (27% vs 7%; $P =$. 08).

**TABLE 4.** Primary Outcomes: Ophthalmoscopic Findings

| | Abuse ($N = 15$) | Accident ($N = 67$) | $P$ Value |
|---|---|---|---|
| RH | 60% (9/15) | 10% (7/67) | <.001 |
| Unilateral RH | 20% (3/15) | 9% (6/67) | .36 |
| Bilateral RH | 40% (6/15) | 1% (1/67) | <.001 |
| Pre-RH | 30% (5/15) | 0% (0/67) | <.001 |
| Single RH | 0% (0/15) | 4% (3/67) | 1.0 |
| With RH extending to periphery | 27% (4/15) | 0% (0/67) | <.001 |
| With premacular RH | 20% (3/15) | 0% (0/67) | .005 |
| Vitreous hemorrhage | 13% (2/15) | 0% (0/67) | .03 |

**TABLE 5.** Secondary Outcomes

| | Abuse ($N = 15$) | Accident ($N = 67$) | $P$ Value |
|---|---|---|---|
| Seizures | 53% (8/15) | 6% (4/67) | <.001 |
| Anticonvulsants | 75% (6/8) | 0% (0/4) | .06 |
| Abnormal mental status | 53% (8/15) | 10% (7/67) | <.001 |
| Scalp hematoma | 7% (1/15) | 51% (34/67) | .001 |
| Operative intervention | 27% (4/15) | 9% (6/67) | .08 |

## DISCUSSION

In this prospective study that included children <2 years of age who were hospitalized with head trauma over a 2- year period, we found that RHs were seen significantly more often in children with abusive head trauma than those with accidental head trauma. We also found that up to 10% of children with accidental head trauma were found to have RHs. Importantly, the type and location of RHs differed according to group. Those seen in children with accidental head trauma were most often unilateral, involved only the retinal layer, and in 42% of patients were a single hemorrhage. In contrast, RHs in children with abusive head trauma were more likely to be multiple, bilateral, involve the preretinal and intraretinal layers, cover the macula, and extend to the periphery of the retina. Thus, it is not the presence of RHs but the location and number of them that are most helpful in distinguishing accidental from inflicted head injury.

In our study, children with abusive head injury were more likely to have seizures and an abnormal mental status on initial presentation than children with accidental head trauma. One possible mechanism for these findings is that children with abusive head trauma are often not brought to medical attention until they have significant injuries with dramatic symptoms. As such, children with significant head injuries then may be at greater risk of having abnormal mental status and seizures. We also found that children with accidental head injury were more likely to have scalp hematomas, which is likely because of the fact that the majority of the accidental head injuries in our study were caused by household falls in which children's heads struck either the floor or another object such as a table. If these results were to be replicated, they would be helpful diagnostic indicators to help distinguish between accidental and abusive head injury.

One limitation of our study could be the manner in which children were classified as having either abusive or accidental head injury. Unlike the classification scheme used by Duhaime et al,[4] we used only historical and physical examination findings and an extensive evaluation of the child's psychosocial status, rather than the type of intracranial injury, to classify children as having either accidental or abusive head injury. This classification scheme is in keeping with the manner in which such children are routinely evaluated after sustaining head trauma at

our institution and is similar to that used by Reece and Sege.[5]

A second limitation is that the child abuse evaluation team did not evaluate all the children enrolled in this study during their hospitalization. It is conceivable that if the child abuse evaluation team had evaluated all children, some of them may have been classified as having abusive head injury rather than accidental. All children had a thorough psychosocial evaluation by a senior clinical social worker (S.L.), who also has considerable experience in the recognition of child abuse. The medical records of all children enrolled were evaluated by one of the authors (K.B.) who is an expert in the evaluation of child abuse. In addition, the neurosurgical team (C.D. and E.O.), to whose service all children enrolled in the study were admitted, also has considerable experience in the detection of abusive head injury. If any of these practitioners were concerned that a child's head injury was due to abuse, then a referral to the child abuse evaluation team was made. We believe that this approach to classification accurately characterized children as having either abusive or accidental head injuries.

Finally, our sample size was relatively small, and thus our results may not be applicable to a larger population of patients. With the number of subjects that were enrolled in our study, we have ~85% power to detect an absolute difference in proportions of 41% between the 2 groups with a type 1 error of 5%. With a larger sample size, we might have found significant differences between the 2 groups with respect to the presence of vitreous hemorrhage, the need for anticonvulsant therapy, or operative intervention.

## CONCLUSIONS

Children with abusive head trauma more frequently have RHs, abnormal mental status, and seizures than children with accidental head trauma. RHs in children with abusive head trauma also may involve the preretinal and intraretinal layers. Children with accidental head trauma may occasionally have RHs, and frequently these RHs will be unilateral, few in number, and involve only the intraretinal layer. Children with accidental head trauma more frequently will have scalp hematomas than those with abusive head trauma. These clinical features may aid the clinician in making the distinction between abusive and accidental head trauma when evaluating young children with head injury.

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