Childhood Head Injuries

Accidental or Inflicted?

Robert M. Reece, MD; Robert Sege, MD, PhD

Objectives: To determine the relative incidence of accidental and abusive causes of head injuries in children younger than 6.5 years, to identify the types of cranial-cerebral damage resulting from reported mechanisms of injury, and to assess the likelihood of injuries being accidental or inflicted.

Methods: Retrospective review of medical records of 287 children with head injuries aged 1 week to 6.5 years admitted to a metropolitan children's hospital from January 1986 through December 1991. Those patients with diagnoses of skull fracture; concussion; subarachnoid hemorrhage (SAH); subgaleal, epidural, or subdural hematoma (SDH); parenchymal contusion or laceration; and closed head injury were included. Criteria were used for inclusion in categories of definite abuse or accident.

Results: Accidents accounted for 81% of cases and definite abuse for 19%. The mean age of the accident group was 2.5 years and for the definite abuse group, 0.7 years. Major differences were seen in the incidence of the following: SDH, 10% in the the accident group and 46% in the the definite abuse group; SAH, 8% in accident group and 31% in the definite abuse group; and retinal hemorrhages, 2% in the accident group and 33% in the definite abuse group. Associated cutaneous injuries consistent with inflicted injury were seen in 16% of the accident group and 50% of the definite abuse group. Twenty-three percent of those in the accident group were injured in motor vehicle crashes (MVCs), 58% by falls, 2% in play activities, and the rest had insufficient medical record information. In 56% of those in the definite abuse group, there was no history to account for the injuries and no history of MVC. In 17%, a fall was said to have been the mechanism of injury. In 24%, inflicted injury was admitted. Mortality rates were 13% in the definite abuse group and 2% in the accident group. Median hospital stay was 9.5 days for the definite abuse group and 3 days for the accident group. In falls less than 4 feet in the accident group, 8% had SDH, 2% had SAH, and none had retinal hemorrhages; among those in the definite abuse group reportedly falling less than 4 feet, 38% had SDH, 38% had SAH, and 25% had retinal hemorrhages.

Conclusions: A substantial percentage of head injuries requiring hospitalization in children younger than 6.5 years are attributable to inflicted injury. Subdural hematoma, subarachnoid hemorrhage, retinal hemorrhages, and associated cutaneous, skeletal, and visceral injuries are significantly more common in inflicted head injury than in accidental injury.


Craniocephalic trauma is the most common cause of mortality in physically abused children, second only to motor vehicle–related injuries as a cause of traumatic mortality in the pediatric age group. Annegers estimated that in the United States, children between the ages of 1 year and 15 years die of head trauma–related injuries at a rate of 10 per 100,000, a rate 5 times the death rate of childhood leukemia, the next leading cause of death. In 1985, about one third of the 75,270 deaths among infants and children aged 0 to 19 years in the United States were from injuries of all types. Applying rates for mortality caused by head injury derived from Minnesota and San Diego County, this means that there were approximately 7000 brain injury deaths in 1985—a bout 29% of all injury deaths in this age group. In the San Diego study, 37% of all brain injuries were caused by motor vehicle crashes (MVCs), 24% were caused by falls, and 21% were caused by sports and recreational activities. In a 1990 study, 17% of all brain injuries and 56% of serious brain injuries in children younger than 1 year were caused by assault. In a 1985 study of 84 infants, ranging in age from 3 weeks to 11 months, with head injuries, 64% of injuries were attributed to accidents and 36% were the result of abuse. In a prospective, 3-hospital study of 100 children younger than 2 years who had sustained head injuries, 24% of the injuries were judged to be the result of inflicted trauma. In a retrospective review of medical records submitted to the National Pediatric Trauma Registry during the 10-year period from 1988 to 1997, children categorized as victims of child abuse were younger (mean age, 12.8 months vs 27.5 months) than in accidental injury.
PATIENTS AND METHODS

SELECTION OF PATIENTS

The medical records of children aged 1 week to 6.5 years admitted to Rainbow Babies and Children's Hospital of Cleveland, Ohio, from January 1986 through December 1991 were reviewed. Diagnoses selected for this study included simple (linear, not crossing suture lines, and less than 2 mm of separation), complex (linear, crossing suture lines, and more than 2 mm of separation), and depressed, diastatic, compound, multiple, stellate, comminuted, or basilar skull fractures; concussion (loss of consciousness, signs of increased intracranial pressure that cleared rapidly); subgaleal, epidural, and subdural hematomas; subarachnoid hemorrhages; parenchymal contusions or lacerations; closed head injuries with loss of consciousness; and death resulting from head injuries.

DATA COLLECTED ON EACH PATIENT

Caretakers were asked for history of injury and whether witnessed, signs and symptoms, physical and neurological findings, laboratory and radiographic findings, length of stay, social work evaluation of family where present, demographic data (age, sex, address, and insurance status), and disposition after hospitalization. Criteria were established for categorization as shown in Table 1. Those cases substantiated as inflicted injury by multidisciplinary team review supplemented by comprehensive review by the medical director of the Child Protection Program (R.M.R.) were included in the definite abuse category. Cases in which there was poor supervision or caretaker neglect resulting in unintentional injury (unrestrained infant or child in an MVC, falls from bleachers) were included in the accident group. Those cases in which the intracranial lesion was of medical origin or secondary to another disease process were excluded from further statistical analysis.

STATISTICAL METHODS

Descriptive statistics were calculated for the definite abuse and the accident groups. The median and hospital length of stay were compared between definite abuse and accident groups using the Wilcoxon rank sum test. The χ² test was used to compare the sex distribution, rates of various types of injuries, mortality rates, and the distribution of survivor disposition between the definite abuse and accident groups. All statistical tests were 2-sided and used an α level of 0.05 to determine significance. The data analyses were performed using the SAS system version 6.12 for Windows.

Two hundred ninety-seven medical records had 1 or more of the diagnoses listed in the “Patients and Methods” section. Eight cases were excluded based on nontraumatic causes for the intracranial abnormalities. Two cases were excluded because they did not fit the criteria for abuse or accident because of insufficient data available in the record. Accidents accounted for 233 (81%) of 287 cases. Definite abuse occurred in 54 cases (19%). Males accounted for 57% of the subjects (n = 31) in the definite abuse category and 62% in the accident group (n = 145), thus showing a male predominance in both categories. The mean age of children in the definite abuse group was 0.7 years (median, 0.3 years; range, 0.1-4.0 years), and the mean age of the accident group was 2.5 years (range, 0.1-6.6 years) (Table 2).

The frequency of injury types within the categories for all ages was determined. Linear skull fractures were common in both groups (definite abuse, 22 cases [41%];...
In 25 (46%) of 54 cases in the definite abuse group, SDH was recorded in 23 (10%) of 233 cases in the accident group (P = .001). Concussions were recorded only in the accident group (33 cases [14%]).

Subarachnoid hemorrhage was present in 17 cases (33%) in the definite abuse group compared with 14 (10%) in the accident group. Subgaleal hematoma was present in 25 cases (50%) in the definite abuse group and in 14 (10%) in the accident group. Retinal hemorrhage occurred in 18 cases (35%) in the definite abuse group and in 4 (3%) in the accident group. These differences were all significant (P = .001).

### Given Mechanism of Injury

The recorded histories for the mechanism of injury are shown in Table 2. Fifty-four of the accidental head injuries were recorded as being caused by MVCs (23%), 135 (58%) as caused by falls, 5 (2%) as caused by play, and the rest of the medical records had no mechanism of injury recorded. In 30 cases (56%) in the definite abuse group there was no history to account for the injuries. No MVCs were blamed for the injuries in the definite abuse group. A fall was said to have been the mechanism of injury for 9 cases (17%) in the definite abuse group, and in 13 cases (24%) inflicted injury was admitted.

### Falls from Heights Less Than 4 Feet

There were 62 cases classified as accidents and 8 cases classified as definite abuse attributed by history to falls of less than 4 feet. In the accident group, 38 (61%) had simple...
Inflicted head injuries account for a substantial portion of all pediatric hospital admissions for head trauma. Most of these occur in children younger than 3 years. The recognition of an abusive cause has improved since the report by Caffey in 1946. A number of studies have elucidated the clinical differentiation between accidental and inflicted head trauma. \(^1\)\(^2\)\(^3\)\(^4\)\(^5\)\(^6\)\(^7\)\(^8\)\(^9\)\(^10\)\(^11\)\(^12\)\(^13\)\(^14\)\(^15\)\(^16\)\(^17\)\(^18\)\(^19\)\(^20\)\(^21\)\(^22\)\(^23\)\(^24\)\(^25\)\(^26\)\(^27\)\(^28\)\(^29\)\(^30\)\(^31\)\(^32\)\(^33\)\(^34\)\(^35\)\(^36\)\(^37\)\(^38\)\(^39\)\(^40\)\(^41\)\(^42\)\(^43\)\(^44\)\(^45\)\(^46\)\(^47\)\(^48\)\(^49\)\(^50\)\(^51\)\(^52\)\(^53\)\(^54\)\(^55\)\(^56\)\(^57\)\(^58\)\(^59\)\(^60\)\(^61\)\(^62\)\(^63\)\(^64\)\(^65\)\(^66\)\(^67\)\(^68\)\(^69\)\(^70\)\(^71\)\(^72\)\(^73\)\(^74\)\(^75\)\(^76\)\(^77\)\(^78\)\(^79\)\(^80\)\(^81\)\(^82\)\(^83\)\(^84\)\(^85\)\(^86\)\(^87\)\(^88\)\(^89\)\(^90\)\(^91\)\(^92\)\(^93\)\(^94\)\(^95\)\(^96\)\(^97\)\(^98\)\(^99\)\(^100\)

WALKER FALLS

Falls while in infant walkers accounted for 18 (6.3%) of 287 cases of all head injuries, all deemed to be accidental. The types of injuries seen in these cases included simple skull fractures in 72% (n = 13), complex skull fractures in 22% (n = 4), SDHs in 6% (n = 1), and no SAH or retinal hemorrhages. There were 2 each of contusions or concussions (11% each) and 1 subgaleal hematoma (6%). None of these children died.

Mortality Rate

Seven (13%) in the definite abuse group died as a result of their injuries; only 2% (n = 4) died from accidental injuries (P = .001). Three of the 4 accidental deaths were the result of injuries sustained in MVCS and the fourth was caused by injuries sustained in a fall from 2 stories onto a hard surface.

Length of Stay

The definite abuse group had a median stay of 9.5 days (range, 1-51 days), and the accident group a median stay of 3 days (range, 1-91 days).

Disposition

The survivors in the 2 groups (accidents, 229; definite abuse, 47) had the following dispositions: 15 children (32%) in the definite abuse group went home with parents, 23 (49%) went into substitute care, and 9 (19%) entered a long-term care facility. In the accident group, 218 (95%) went home, 2 (1%) went to substitute care, and 9 (4%) entered a long-term care facility.

Comment

Conflictions of abuse injuries have been and continue to be accurate diagnosis. The dire consequences of either false-positive or false-negative diagnosis intensify the need to establish accurate diagnostic criteria. This report used explicit criteria to retrospectively identify cases of child abuse. Subsequent data analysis provided descriptions of patterns of physical injuries that differed in those children injured through accidents and those injured through abuse.

Several salient observations can be made based on these cases: one third of all children younger than 3 years and one fifth of those younger than 6.5 years were abused. If injuries subsequent to MVCS (a diagnosis that is easily determined) were excluded, these proportions would be even higher: 49% younger than 3 years and one third of all persons with non-MVC injuries younger than 6.5 years were abused. This warrants a high degree of clinical suspicion for abuse among all children with head injuries serious enough to require hospital admission.

Certain sentinel injuries have previously been described as associated with child abuse. Our study corroborates the findings that SDH, SAH, and retinal hemorrhages were each far more commonly seen in abused children than in other injured children. While the higher incidence of SDH and SAH in the child abuse group was highly significant, the finding of retinal hemorrhage was nearly diagnostic of child abuse. Four of the 5 children in the accidental trauma group with retinal hemorrhage had each sustained massive witnessed trauma: MVC, fall from a great height, or gunshot wound to the face. In a clinical setting, there would be no difficulty in differentiating these children from those whose injuries were caused by abuse.

There is an abundance of literature attesting to the fact that short falls (<4 feet) do not cause serious injury in children, except in the case of epidural hematoma, which commonly occurs after short falls and involves arterial bleeding from one of the branches of the middle meningeal artery. \(^30\)\(^31\) This study corroborates and adds to this literature. Simple skull fractures are common in accidental falls and complex skull fractures are less frequently seen. Subdural hematomas and SAHs are seldom seen and retinal hemorrhages are virtually never seen in short falls. When these lesions are seen, the veracity of the history of a fall is open to serious question. \(^32\)\(^33\)\(^34\)

Infant walker falls have been described in the pediatric literature and are generally attributed to accidents. \(^40\) According to the US Consumer Product Safety Commission, 1 infant dies each year from infant walker-related injuries; 29,000 injuries were attributed during 1991 to walker and jumper equipment. \(^48\) In the present study, 83% of the head injuries sustained in walkers were simple skull fractures, 22% were complex skull fractures, 16% had SDH, but none had either SAH or retinal hemorrhage. There were no deaths.

Outcomes were more severe in the child abuse group compared with the accident group. The length of stay in the hospital was 3 times longer, although an undetermined portion of the increased length of stay may have been attributable to the child abuse investigation and placement issues. However, the 5-fold increased mortality rate (13% vs 2%) highlights the severity of the abuse suffered by these children, which may have been compounded by a delay in seeking medical attention.
Several caveats apply to a study of this type. First and foremost, retrospective data used in the analysis are limited to those data available in the medical record. For example, funduscopic examinations were not recorded on all 287 cases. Skeletal surveys were not performed on all suspected abuse cases younger than 2 years. There is difficulty in ascertaining with certainty the mechanism of injury in some of the cases.

CONCLUSIONS

Serious pediatric head injury in children younger than 6 years, and especially in those younger than 3 years, is caused by inflicted trauma in a substantial number of cases. When these injuries are seen in cases with no history or with a history of short falls leading to severe signs and symptoms, the likelihood of abuse should be strongly suspected. Subdural hematomas and SAHs are markedly more common in inflicted head injury and the length of hospital stay considerably longer. Skeletal surveys should be routine procedures for children younger than 3 years when there is any suspicion of inflicted head injury. Greater attention needs to be given to the dispositional decision for the child who has sustained inflicted head injury. Expert medical consultation should be made readily available to state or county Child Protective Services investigators so that their decisions can be informed by well-interpreted medical information and timely decisions can be made with regard to disposition. Prospective, well-designed multicenter studies of pediatric head injury would yield valuable information and should be carried out.

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Corresponding author: Robert M. Reece, MD, Department of Pediatrics, Tufts University School of Medicine, The Floating Hospital for Children at New England Medical Center, Box 351, 750 Harrison Ave, Boston, MA 02111.

REFERENCES