ARTICLE

Childhood Head Injuries

Accidental or Inflicted?

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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 craniocerebral 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 abuse; 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.

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CRANIOCEREBRAL 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.[1,2] Annegers[3] 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.[4] Applying rates for mortality caused by head injury derived from Minnesota[5] and San Diego County,[6] this means that there were approximately 7000 brain injury deaths in 1985—about 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.[7] In a 1985 study of 84 infants, ranging in age from 3 weeks to 11 months, with

See also pages 9 and 16

head injuries, 64% of injuries were attributed to accidents and 36% were the result of abuse.[1] 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.[2] 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

PATIENTS AND METHODS

SELECTION OF PATIENTS

The medical records of children aged 1 week to 6.5 years admitted to Rainbow Babies and Childrens 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 χ^2 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 .05 to determine significance. The data analyses were performed using the SAS system version 6.12 for Windows.

months for the nonintentional group). The child abuse group also had a higher mortality rate than the unintentional injury group (12.7% vs 2.6%) and the child abuse survivors were more severely injured (Injury Severity Scores between 20 and 75 in 22.6% of those in the child abuse group vs 6.3% in the unintentional injury group).[8] In a study comparing 20 children with inflicted head trauma with 20 children with uninflicted head trauma, Ewing-Cobbs and colleagues[9] found a similar age distribution (10.6 months in the child abuse group, 35.6 months in the unintentional injury group) and a much higher frequency of subdural hematoma (SDH) in the child abuse group (16 of 20) than in the unintentional injury group (9 of 20); SDHs seen in the accident group were all the result of MVCs. Retinal hemorrhages were seen in 70% of those in the child abuse group and in none in the unintentional group.

Table 1. Criteria for Classification of Head Injuries as Abuse or Accident

Definite abuse
Witnessed abuse
Confession of abuse
No history accounting for patient's serious head injury
Positive skeletal survey (new fractures or fractures of differing ages with no history accounting for the injuries), coupled with serious head injury
Physical findings consistent only with abusive injuries (patterns, old and new lesions, locations), coupled with serious head injury
Accidental
Motor vehicle crash, pedestrian/vehicle crash
Witnessed accident (eg, falls from porches, upper-story windows)
Isolated or unique incident

One of the major considerations in pediatric head trauma is to determine whether the origin is accidental or abusive. To address this issue, the medical records of all consecutive cases of children younger than 6.5 years with head injury serious enough to be admitted to a metropolitan children's hospital in Ohio between January 1, 1986, and December 31, 1991, were reviewed. Goals of the study were to determine the relative incidence of accidental and abusive causes in this series of hospitalized children with head injuries; to identify the types of craniocerebral damage resulting from particular reported mechanisms of injury; and to gain a better understanding of the relative likelihood of certain injuries being either accidental or abusive in origin.

RESULTS

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%];

Table 2. Comparison of Categories of 287 Pediatric Head Injuries

Sample Sizes	Definite Abuse (N = 54)	Accident (N = 233)	*P*
Age, y			.001†
Median	0.3	2.3	
Mean	0.7	2.5	
Minimum-maximum	0.1-4.0	0.1-6.6	
Male, No. (%)	31 (57)	145 (62)	.56
Injury types, No. (%)‡			
Linear fracture	22 (41)	126 (54)	.08
Complex fracture	8 (15)	44 (19)	.49
Concussion	0 (0)	33 (14)	.003
Parenchymal contusion	9 (17)	23 (10)	.16
Subdural hematoma	25 (46)	23 (10)	.001
Subarachnoid hemorrhage	17 (31)	19 (8)	.001
Subgaleal hematoma	4 (7)	21 (9)	.64
Retinal hemorrhage	18 (33)	5 (2)	.001
Cutaneous injuries	27 (50)	37 (16)	.001
Skeletal injuries	19 (35)	16 (7)	.001
Visceral injuries	10 (19)	9 (4)	.001
Mechanism of injury by caretaker history, No. (%)			
Motor vehicle crashes	0 (0)	54 (23)	. . .
Falls (all heights, walker)	9 (17)	135 (58)	. . .
<4 ft	8 (15)	62 (27)	
>4 ft	1 (2)	56 (24)	
Walker	0 (0)	18 (8)	
Play	0 (0)	5 (2)	. . .
Stairway	2 (4)	19 (8)	. . .
Admitted assault	13 (24)	0 (0)	. . .
Handgun	0 (0)	1 (0.4)	. . .
Struck by object	0 (0)	18 (8)	. . .
No history	30 (56)	5 (2)	. . .
Mortality, No. (%)	7 (13)	4 (2)	.001
Length of stay, d			.001
Median	9.5	3	
Minimum-maximum	1-51	1-91	
Disposition of survivors, No. (%)§			
Home with parents	15 (32)	218 (95)	.001
Substitute care	23 (49)	2 (1)	. . .
Long-term care facility	9 (19)	9 (4)	. . .

**Ellipses indicates that the* P *value was not calculated or indignificant.*
†P *value comparing accident group with definite abuse group. The* P *value is from the Wilcoxon rank sum test for age and hospital length of stay and from the* χ^2 *test for all other variables.*
‡*Children could have more than 1 injury type.*
§*There were 47 survivors in the definite abuse group and 229 survivors in the accident group.*

accident, 126 cases [54%]). There were no significant differences in the incidence of complex skull fractures (accident, 44 cases [19%]; definite abuse, 8 cases [15%]), or parenchymal contusions (accident, 23 cases [10%]; definite abuse, 9 cases [17%]). Concussions were recorded only in the accident group (33 cases [14%]).

A major difference was seen in the frequency of SDHs: SDH was recorded in 23 (10%) of 233 cases in the accident group and in 25 (46%) of 54 cases in the definite abuse group ($P = .001$). Subarachnoid hemorrhage was seen in 19 cases (8%) in the accident group and in 17 cases (31%) in the definite abuse group ($P = .001$). Subgaleal hematomas were seen in 21 cases (9%) in the accident group and in 4 (7%) in the definite abuse category. Retinal hemorrhages were seen in only 5 cases (2%) in the accident group but were present in 18 (33%) in the definite abuse group,

Table 3. Data Analysis on 195 Children Younger Than 3 Years

Sample Sizes	Definite Abuse (N = 51)	Accident (N = 144)	*P*
Age, y			.001*
Median	0.25	0.8	
Mean	0.5	1.2	
Minimum-maximum	0.1-2.3	0.1-2.9	
Male, No. (%)	31 (61)	89 (62)	.90
Injury types, No. (%)†			
Linear fracture	21 (41)	84 (58)	.04
Complex fracture	7 (14)	32 (22)	.20
Concussion	0 (0)	16 (11)	.01
Parenchymal contusion	8 (16)	19 (13)	.57
Subdural hematoma	25 (50)	14 (10)	.001
Subarachnoid hemorrhage	17 (33)	13 (9)	.001
Subgaleal hematoma	4 (8)	16 (11)	.51
Retinal hemorrhage	18 (35)	4 (3)	.001
Cutaneous injuries	24 (47)	25 (17)	.001
Skeletal injuries	19 (37)	12 (8)	.001
Visceral injuries	10 (20)	6 (4)	.001

**P value comparing accident group with definite abuse group. The* P *value is from the Wilcoxan rank sum test for age and hospital length of stay and from the* χ^2 *test for all other variables.*
†*Children could have more than 1 injury type.*

a significant difference ($P = .001$). In both the accident and definite abuse groups there were both unilateral and bilateral retinal hemorrhages. Old and new cutaneous injuries considered to be consistent with inflicted origin were seen in 37 cases (16%) in the accident group but in 27 (50%) in the definite abuse group ($P = .001$). Associated skeletal and visceral injuries were seen more frequently in the definite abuse group than in the accident group (Table 2).

When analyzing those cases younger than 3 years (**Table 3**), SDH occurred in 25 cases (50%) in the definite abuse group compared with 14 (10%) in the accident group. Subarachnoid hemorrhage was present in 17 cases (33%) in the definite abuse group and in 13 (9%) 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

linear skull fractures, 5 (8%) had complex skull fractures, 12 (19%) had concussions, 2 (3%) had brain contusions, 5 (8%) had SDHs, 1 (2%) had SAHs, 6 (10%) had subgaleal hematomas, and none had retinal hemorrhages. In the definite abuse group, 4 (50%) had simple linear skull fractures, 1 (12%) had complex skull fractures, 3 (38%) had SDHs, 3 (38%) had SAHs, none had subgaleal hematoma, and 2 (25%) had retinal hemorrhages.

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

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[10] in 1946. A number of studies have elucidated the clinical differentiation between accidental and inflicted head trauma.[1,2,11-29] Despite the importance of distinguishing inflicted from noninflicted head injuries, few large series examining children with head injuries have been reported. This article describes 54 cases of significant head trauma caused by child abuse. These cases are compared with 233 children treated at the same institution for head injuries with noninflicted causes. We believe that this is the largest such case series published to date.

The major issue plaguing the description of abuse-related injuries to young children has been and continues 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.[30-39] 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.[2,31]

Infant walker falls have been described in the pediatric literature and are generally attributed to accidents.[40-47] 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 6-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 abusive injuries. Retinal hemorrhages are, if not diagnostic, compelling findings; most are seen in abusive head trauma. The mortality rate is significantly higher in inflicted 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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