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Epidural Hemorrhage: Is It Abuse?

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ABSTRACT. *Objective.* **To determine whether children presenting with epidural hemorrhage (EDH) are as likely to have been abused as are children presenting with subdural hemorrhage (SDH).**

Design. **Retrospective chart review.**

Setting. **Level I regional trauma center and a regional children's hospital.**

Patients. **All children at both institutions 3 years old or younger with a diagnosis of EDH or SDH identified by a search of the computerized trauma registry and hospital medical records from 1985 through 1991.**

Measurement and Results. **Complete records were found for 93 of 94 eligible subjects. The diagnosis of accidental or inflicted injury was ascertained from the patient's hospital medical record or the records of Child Protective Services. Of all subjects (n = 93), 52% (48/93) were male and the median age was 15 months. Abuse was diagnosed in 47% (28/59) of children with SDH and 6% (2/34) of those with EDH. Other significant injuries were found in 47% of children with SDH and 18% of children with EDH. There was no statistically significant difference between the two groups with respect to the likelihood of identifying a skull fracture, the need for surgical evacuation of the hemorrhage, or mortality.**

Conclusions. **Our data are consistent with current biomechanical concepts of intracranial injury. EDHs result from brief linear contact forces that commonly occur in unintentional falls. SDHs are caused by global high-energy rotational acceleration/deceleration forces that are commonly generated in episodes of abuse. Compared with SDH, EDH rarely results from abuse.** *Pediatrics* **1996;97:664–668;** ***epidural hemorrhage, subdural hemorrhage, child abuse.***

ABBREVIATIONS. SDH, subdural hemorrhage; EDH, epidural hemorrhage; CT, computed tomography; CHMC, Children's Hospital and Medical Center; HMC, Harborview Medical Center; CPS, Child Protective Services; OR, odds ratio; CI, confidence interval.

Recognition of the association of subdural hemorrhage (SDH) and multiple healing fractures in infants prompted Caffey[1] to publish the pioneering paper that alerted pediatricians to the physical and radiographic findings in victims of child abuse. Subsequent to his work, a large number of studies have confirmed the strong correlation he noted between child abuse and the development of SDH.[2–8] The association between abuse of infants and children and the development of epidural hemorrhage (EDH) has received far less attention.

In Seattle during the 1980s, an increasing number of infants and young children with EDH were identified. This increase was likely attributable to an increased frequency of use of computed tomography (CT) scans in the evaluation of children with head injury. With limited guidance from the literature regarding the frequency of abuse in these children, our hospital staff commonly considered the possibility that the injury was nonaccidental. Using the information gained from these evaluations, this study was designed to determine whether children with EDH were as likely to have been abused as were those with SDH.

METHODS

Site

We identified patients from Children's Hospital and Medical Center (CHMC) and Harborview Medical Center (HMC) in Seattle, Washington. CHMC is the regional children's hospital serving the four-state region of Washington, Alaska, Montana, and Idaho. HMC is a tertiary care hospital that serves as the region's only level one trauma center. Children in both CHMC and HMC are evaluated by pediatric housestaff from the University of Washington. Both hospitals have child abuse evaluation teams. Few infants with serious trauma are admitted to other institutions in King County.

Sample

We conducted a retrospective chart review of patients admitted to HMC and/or CHMC during the study period of January 1985 through December 1991. All children age 0 through 3 years of age with a discharge diagnosis of either SDH or EDH were identified through a search of the HMC trauma registry and medical records at CHMC. Sources of information for each case included the medical records at HMC and CHMC, the HMC trauma registry and, when applicable, original radiographs and the case files of Child Protective Services (CPS).

All cases of SDH and EDH were confirmed by a review of written CT reports in the medical record. Films on all cases in which the discharge diagnosis could not be confirmed from the written CT report were independently reviewed by an attending neurosurgeon and an attending radiologist. These cases were included in the study only if the independent reviewers reached the same diagnosis.

Classification of Injuries and Histories

Injuries were classified as either nonaccidental or unintentional on the basis of hospital or CPS records. For those cases in which CPS was consulted, the CPS classification was taken as final. For those cases in which CPS was not consulted, the pediatric attending staff classification was taken as final.

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Medical records were searched for evidence of significant injuries in addition to the index intracranial hemorrhage including rib, long bone, or skull fractures, visceral injuries, subarachnoid or retinal hemorrhage, or burns and bruising patterns indicative of abuse.

The initial injury history provided by the care giver to the pediatric staff was classified as indicative of either minor or major trauma. Histories classified as major included falls from a height greater than 6 feet, bicycle injuries, motor vehicle injuries, and motor vehicle-pedestrian injuries. Histories classified as minor included falls less than 6 feet, falls down stairs, peer assaults, and no clear history given. This classification system was chosen because caretakers of abused children frequently report minor falls as explanations for inflicted head injury,[9] yet studies of children with documented falls from the height of normal infant and toddler activities (4 to 8 feet) rarely report significant intracranial injury.[9-11] Similarly, stairway falls have been shown to behave like linked minor falls rarely causing intracranial pathology.[12]

This study was approved by the institutional review boards of CHMC, HMC, and CPS and the Department of Social and Health Services, Washington State. Categorical data were compared using the χ^2 test and Fisher's exact test.

RESULTS

Study Population

Over the study period, a total of 2109 patients from 0 through 17 years of age were admitted to either CHMC or HMC for the evaluation and treatment of head injury of any type. Children from 0 through 3 years of age comprised 759 of the total. Of the 759, 94 (12.3%) children met the case definition for inclusion in this study. One patient was excluded because the hospital chart was lost. Among the final study population of 93 subjects, 59 (63%) had SDH and 34 (37%) had EDH. Age, sex, mortality, the likelihood of identifying a skull fracture, and the likelihood of needing surgical evacuation of the intracranial hemorrhage did not differ significantly between patients with EDH and those with SDH (Table 1).

If a skull fracture was identified, the likelihood that the skull fracture was complex did not differ significantly between the two groups (EDH = 48% vs SDH = 66%). Because the majority of children in this study were treated nonoperatively, the proportion of children with venous as opposed to arterial hemorrhages is not known.

The age distribution for children with EDH and SDH is displayed in the Figure. The majority of children with either EDH (53%) or SDH (67%) were under 15 months of age. A small proportion of both groups were between 36 and 48 months of age (EDH = 21% vs SDH = 12%). Although there was no statistically significant difference between the two groups, children with EDH did tend to be slightly older than children with SDH.

TABLE 1. Clinical Characteristics*

	SDH (n = 59)	EDH (n = 34)
Males	48%	58%
Mean age (months)	12.8	18.7
Skull fracture identified	51%	68%
Hemorrhage evacuated	34%	38%
Died in hospital	12%	3%

Abbreviations: SDH, subdural hemorrhage; EDH, epidural hemorrhage.
* $P > .05$ for all comparisons.

Risk of Abuse

Attending pediatricians determined that 46 of the 93 patients sustained unintentional injuries. The remaining 47 patients were referred to CPS for further evaluation. Of these 47 patients, CPS determined that injuries to 10 were also unintentional, injuries to 30 resulted from abuse and injuries to 1 resulted from neglect. CPS was unable to determine the etiology of the injuries for the remaining 6 patients. Thus, overall 60% (56/93) of injuries were unintentional, 32% (30/93) were from abuse, 6% (6/93) were indeterminate, and 1% (1/93) was from neglect.

Of all children with SDH, 47% were determined to have sustained the hemorrhage as the result of abuse compared to only 6% of those with EDH (Table 2).

All 6 patients in the indeterminate category had SDH. The single patient with injuries resulting from neglect had an EDH (Table 2). This child was a 47-month-old who fell from the hood of a car that was driven by his intoxicated parent.

Evaluation for Abuse

Children with SDH were more likely than those with EDH to be referred for social work evaluation. Similarly, children with SDH were more likely than children with EDH to be referred for CPS evaluation and were more likely to undergo a skeletal survey (Table 3).

Associated Injuries and Parental History

Of all children with SDH, 49% (29/59) had significant additional injuries. Of these, 79% (23/29) were determined to have been abused (Table 4). Children with SDH and additional significant injuries had a 19-fold increased risk of abuse compared to those children with SDH and no additional injuries (odds ratio [OR] = 19.1, 95% confidence interval [CI] 4.4–92). Of all children with EDH, only 18% (6/34) had significant additional injuries. Of these, 17% (1/6) were determined to have been abused (Table 4). Children with EDH who had additional significant injuries did not demonstrate a significantly increased risk of abuse when compared to those children with EDH and no additional injuries (OR = 5.4, 95% CI 0.06–439).

Despite the fact that abused children were far more likely than nonabused children to have sustained multiple injuries, their caretakers were more likely than caretakers of nonabused children to give a history of minor trauma leading to the injury. All caretakers of abused children gave a history of minor trauma while 62% (35/56) of caretakers of unintentionally injured children gave a history of minor trauma.

DISCUSSION

Our finding that only 6% of young children with EDH had been abused suggests a weak association between child abuse and the development of EDH. Our finding that 47% of young children with SDH had been abused confirms previous investigators' reports of a strong association between SDH and abuse.[2-8]

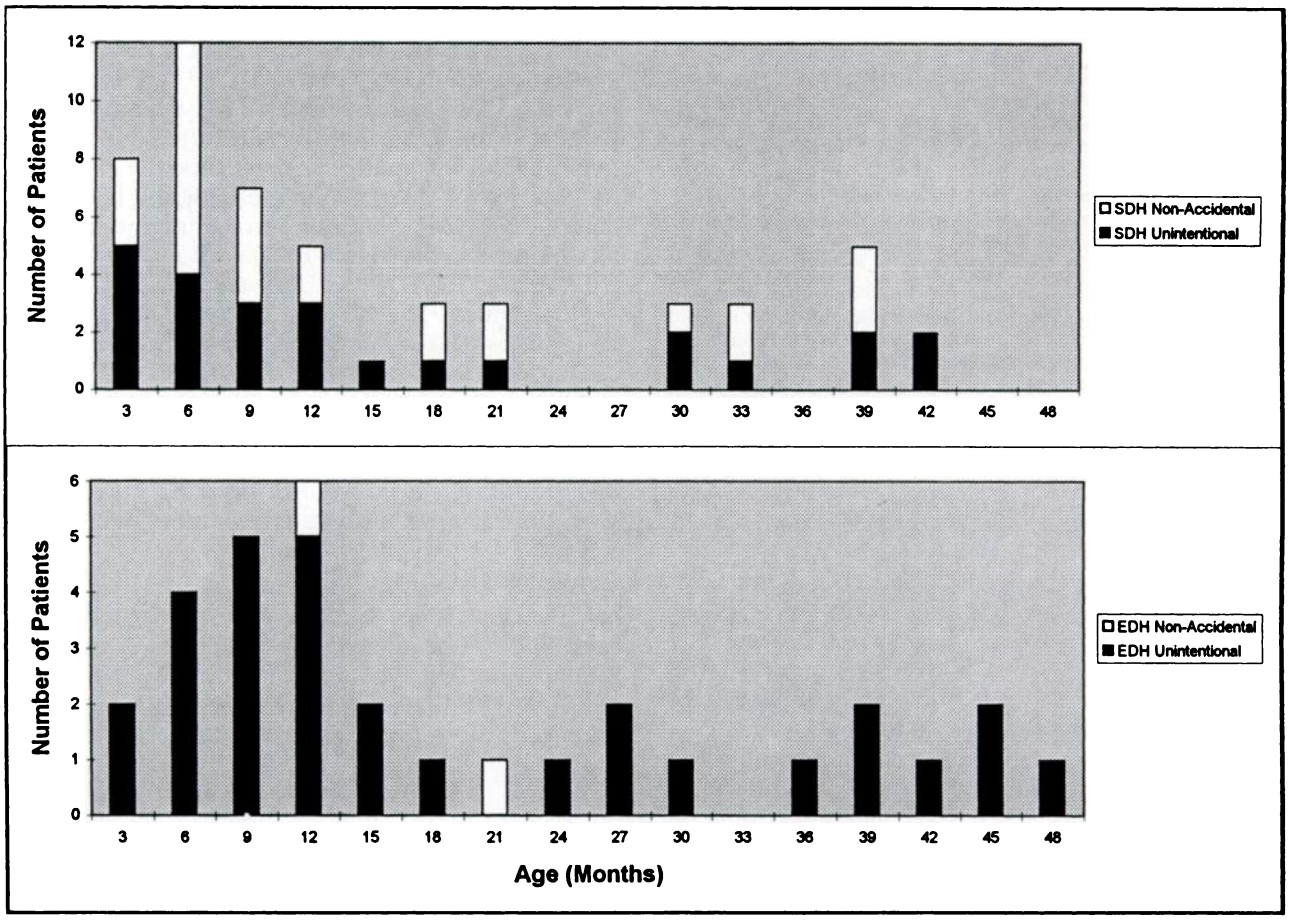

Figure. Age distribution for children with epidural hemorrhage and subdural hemorrhage.

TABLE 2. Etiology of Injury by Hemorrhage Type

	SDH (n = 59)	EDH (n = 34)	OR	95% CI
Nonaccidental	28 (47%)	2 (6%)	14.4	3.0–96.0
Unintentional	25 (42%)	31 (91%)	0.2	0.06–0.55
Neglect	0 (0%)	1 (3%)	IND*	NS†
Uncertain	6 (10%)	0 (0%)	IND*	NS†

Abbreviations: SDH, subdural hemorrhage; EDH, epidural hemorrhage; OR, odds ratio; CI, confidence interval.
* OR indeterminate.
† $P > .05$.

TABLE 3. Evaluation for Abuse by Hemorrhage Type

	SDH (n = 59)	EDH (n = 34)	OR	95% CI
Referred to social work	49 (83%)	18 (53%)	4.4	1.5–12.7
Referred to CPS	37 (63%)	10 (29%)	4.0	1.5–11.1
Skeletal survey obtained	31 (52%)	7 (21%)	4.3	1.5–12.8

Abbreviations: SDH, subdural hemorrhage; EDH, epidural hemorrhage; OR, odds ratio; CI, confidence interval; CPS, Child Protective Services.

Given what is known regarding the biomechanics of intracranial injury in infants and children, the difference in rates of abuse for children with SDH and EDH is not surprising. EDH in children is most commonly associated with falls.[13–15] Schutzman[15] observed that 24 of 53 childhood EDHs (45%) were caused by falls of less than 5 feet. Our observation that 16 of 34 unintentional EDHs (47%) resulted from falls of less than 6 feet and falls down stairs is similar.

The impact of a fall results in linear deceleration of a child. If a child's head is the lead point of a fall, the skull comes to an abrupt stop against the impact surface. If there is a skull fracture or acute skull deformation at the impact site, the arteries and veins that are adherent to and tightly encased in the potential space between the skull and the dura may be sheared. The bleeding that results accumulates as an EDH.

In contrast, the vessels involved in subdural and subarachnoid hemorrhage are delicate, less tightly bound and bridge the space between the meninges and the skull, particularly at the dural sinuses. The vessels are relatively immune to injury from direct impact but are more susceptible to tearing with rotational accelerations or decelerations that occur with shaking, with blows to the head that initiate its rotation on the axis of the neck, or with rapid deceleration of the body during which the head remains free to rotate (as in auto crashes in which the passenger's body is restrained).[7,16,17] Such forces result in disconjugate motion of the brain and skull. Biomechanically, the bridging vessels are most susceptible to brief, rapid angular accelerations while more sus-

TABLE 4. Associated Injuries

	SDH		EDH	
	Unintentional (n = 31)	Nonaccidental (n = 28)	Unintentional (n = 32)	Nonaccidental (n = 2)
1. Rib fracture(s)	0	9	0	0
2. Long bone fracture(s)	0	4	0	0
3. Unusual bruise	0	11	0	0
4. Abdominal injury	3	2	3	0
5. Subarachnoid hemorrhage	4	15	2	1
6. Retinal hemorrhage	0	15	0	1
Any of numbers 1 through 6:	6 (19%)	23 (82%)	5 (16%)	1 (50%)

Abbreviations: SDH, subdural hemorrhage; EDH, epidural hemorrhage.

tained, moderate to high accelerations result in brain injury.[16]

These observations on the mechanics of head injury correlate well with our observations. We found epidural bleeding to be commonly associated with simple and more complex skull fractures, but rarely with brain injury, other intracranial bleeding, or injuries suggestive of abuse. On the other hand, subdural bleeding was frequently found in association with long bone or rib fractures, patterned bruising, retinal hemorrhage, and parenchymal brain injury—all suggestive of infant shaking, severe rotational forces, and abusive events. We can not exclude that some infants with EDH were injured in intentional dropping or impact events; however, other injuries associated with abuse in infants with SDH were rarely found.

The more complex brain injury pattern associated with SDH frequently results in a higher mortality for children with SDH[7] in comparison to children with EDH.[15] We also found a higher mortality rate for children with SDH; however, the difference did not reach the level of statistical significance.

There are important limitations within the design of this study that might have the potential to distort the difference in rates of abuse found between children with EDH and SDH. Because this study was retrospective, we were unable to insure that comparable abuse evaluations were conducted for all children. In our study, a greater percentage of children with SDH underwent a skeletal survey and were referred to social work and CPS for evaluation. Nonetheless, we do not believe that the entire difference found in the risk of abuse between the two groups can be attributed to ascertainment bias. Even if all children with EDH who were not referred to social work had been abused at the same rate as those with EDH who were referred to social work, the rate of abuse in the entire EDH group would still have been only 12%.

Similarly, we do not believe that the entire difference found in the risk of abuse for the two groups can be attributed to misclassification. Even if all children with EDH or SDH who were referred to CPS and were judged to have unintentional injury had in fact suffered nonaccidental injury, the rate of abuse in the two groups would still have remained markedly different (EDH = 29% vs SDH = 61% $P < .01$).

There is no single test to differentiate unintentional from nonaccidental injury. It is difficult to make definitive diagnoses for any condition in which there is no widely accepted gold standard. In retrospect, we did not feel it was appropriate to attempt to assess or correct the diagnosis of unintentional vs nonaccidental injury. In this study, we relied on the final diagnoses of experienced attending pediatricians, multidisciplinary child abuse teams, and the evaluations of CPS, all of which were made at the time the children presented.

The striking difference in the number of associated injuries found in children with EDH in comparison to children with SDH adds strong support to the differing rates of abuse that were found. Almost 50% of all children with SDH and over 80% of all abused children with SDH had significant injuries in addition to intracranial hemorrhage. Many of these additional injuries, such as retinal hemorrhage,[6,8,18] patterned bruising[19] and rib fractures,[20] have been highly correlated with inflicted injury. Only 18% of all children with EDH had any of these significant additional injuries.

Finally, the rate of abuse reported for children with SDH is likely an underestimate. In general, CPS required more than an isolated SDH to make the diagnosis of nonaccidental injury. Of the 29 children with SDH who had no other associated injuries, only 5 were attributed to abuse. Given what is known regarding the biomechanics of SDH and the rates of nonaccidental injury for children with SDH reported in other studies,[5,18] the likelihood is high that some patients in our unintentional SDH group were, in fact, abused.

We believe that the findings of this study are important for any pediatrician working with seriously injured children. Although all injured children deserve a thorough evaluation to determine if their injuries were nonaccidental, the identification of an EDH should not, in isolation, raise the same level of concern regarding abuse that is raised by the identification of a SDH.

ACKNOWLEDGMENTS

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NEW HEART FOR RETARDED WOMAN

A woman with Down syndrome who was at first refused a heart-lung transplant because doctors did not think she was smart enough to handle the effects underwent the operation today.

The woman, Sandra Jensen, 35, is believed to be the first seriously retarded person in the United States to receive a major transplant. She was listed in critical but stable condition after the five-hour operation, which occurred after Stanford Medical Center reversed course.

"I'm ecstatic," said Dr. William Bronston, a state rehabilitation administrator and friend of Ms. Jensen who had helped lead the fight for her transplant. "This is a miracle. The struggle to get Sandra on the transplant list was really a struggle to get everyone in the country on the list."

New York Times. January 24, 1996.

Noted by J.F.L., MD