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Disappearing Subdural Hematomas in Children

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Abstract
Subdural hematomas in infants and young children are uncommon, usually occurring from nonaccidental trauma in infants or from trauma associated with motor vehicles. We report 4 children with apparent unilateral convexity subdural hematomas, 3 of which occurred from household falls and 1 occurring from a fall out of a window. These injuries were characterized by clinical symptoms consistent with the apparent forces involved, which were relatively minor in the first three instances. The clots resolved spontaneously within the first 1–2 days after injury. Such collections are likely located at least partly within the subarachnoid space, but may mimic more clinically significant subdural hematomas. Their recognition may influence decisions regarding both surgical evacuation and the likelihood of nonaccidental injury. Clinical and radiographic features distinguishing these 'disappearing subdurals' from more typical subdural hematomas are discussed.

Introduction

Subdural hematomas in infants and young children are uncommon, usually occurring in association with motor vehicle trauma in young children and nonaccidental injury in infants [1, 2]. In these settings subdural hematomas appear to result from large angular acceleration-deceleration forces which result in rupture of bridging veins over the cerebral surface or from impact with distortion and failure of deep draining veins [3–6]. Because of the large forces involved, significant brain injury often accompanies the hemorrhage, and children with accidental subdural hematomas are usually unconscious with Glasgow Coma Scores in the severe injury range. The subdural hemorrhages seen in nonaccidental injuries are more often bilateral than unilateral, often involve the posterior interhemispheric space, and may be associated with neurologic symptoms ranging from mild to severe [7–9].

When the diagnosis of subdural hematoma is made in children, two questions are raised for the treating neurosurgeon. First, does the collection warrant surgical evacuation? This decision is usually made on the basis of the child's clinical condition and the width and degree of mass effect of the clot. Secondly, in the case of infants and young children, subdural hematomas from other forms of trauma, particularly household falls, are distinctly unusual. When such a mechanism is given as the history of the injury, should nonaccidental trauma be suspected or even, as some authors have suggested, assumed [1]?

We have observed a group of children with apparent subdural hematomas on computerized tomographic (CT) scans whose mechanism of injury, clinical presentation, acute course and radiographic follow-up differ from the majority of patients with traumatic subdural hematoma. In each of these cases, at the time of presentation the collection was of sufficient size and its CT appearance suggestive enough of a subdural location that questions both of the need for surgery and, in the younger children, mechanism of injury, were raised. Our experience with these cases reiterates that of other authors who have

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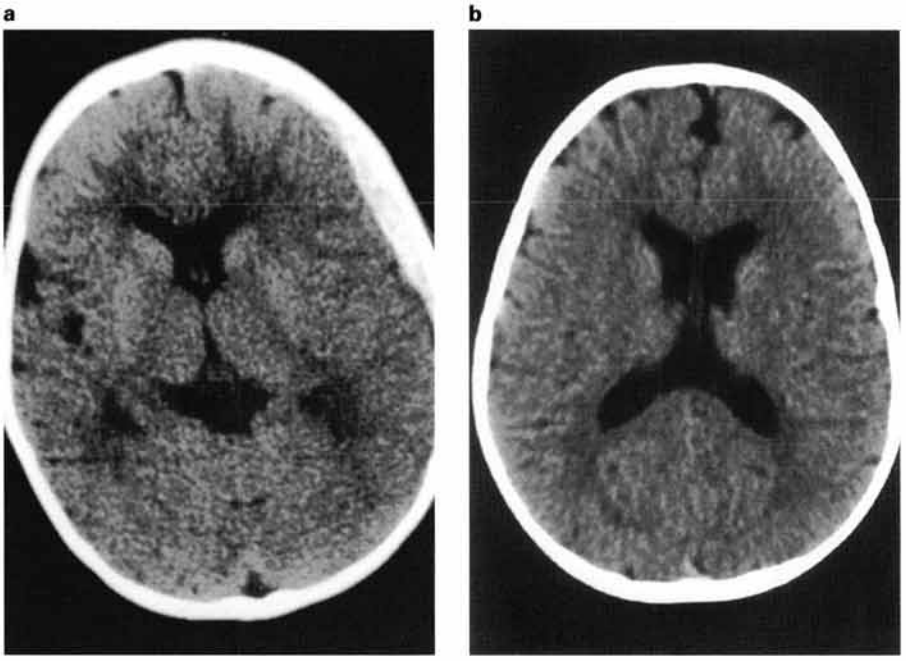

Fig. 1. Axial CT brain scan of a 10-month-old boy who fell backwards from standing, striking his occiput on the floor. **a** Acute study, demonstrating a moderate-sized left-sided extra-axial hematoma with mild mass effect. **b** At follow-up study performed 48 h after injury, there is a lack of evidence of mass effect but with loss of sulcal detail consistent with blood in the subarachnoid space or gyral edema.

reported rapid resolution of apparent subdural collections [10–13]. Because of different implications regarding surgical intervention, outcome, and the issue of abusive injury, this phenomenon should be recognized and considered when children present with similar findings.

Case Reports

Case 1

A 10-month-old boy pulled himself to a standing position by holding on to a bathroom vanity at about 11:00 h. He let go and was observed to fall straight backward, without breaking the fall by sitting, and struck his occiput on a thin rug covering a tile floor. This pattern of falling backwards had been previously observed to occur in this child by various family members on other occasions. On this instance, he cried immediately, but then returned to his usual activities. At about 15:00 h on the same day, he was standing when his twin brother bumped into him, and he again fell backwards in the same way, striking his occiput. Again he cried immediately, but then was observed to have a brief period of limpness and questionable apnea. He was taken to the local emergency room where he was described as sleepy but responsive. A CT scan was interpreted as showing a left subdural hematoma with mild mass effect (fig. 1a). On admission to this institution he was sleeping but was readily arousable, with a Glasgow Coma Score of 14. No soft tissue swelling or bruising was found. Complete blood count and coagulation studies (PT/PTT) were normal. Anticonvulsants were begun. He had several episodes of vomiting and spent more time sleeping than usual for the first 2 days after injury, but while awake he was alert, interactive, with no focal neurologic deficits. Ophthalmologic exam with mydriatics showed normal fundi. Skeletal survey was negative, and evaluation by the Suspected Child Abuse/Neglect team disclosed no suspicion of abuse. Repeat CT scan 2 days after admission revealed that the hematoma had resolved; some mild changes in the gyri suggested minimal underlying contusion (fig. 1b). By the third postinjury day he had returned to his baseline activity level. The child's anticonvulsants were discontinued and he had no further neurologic problems.

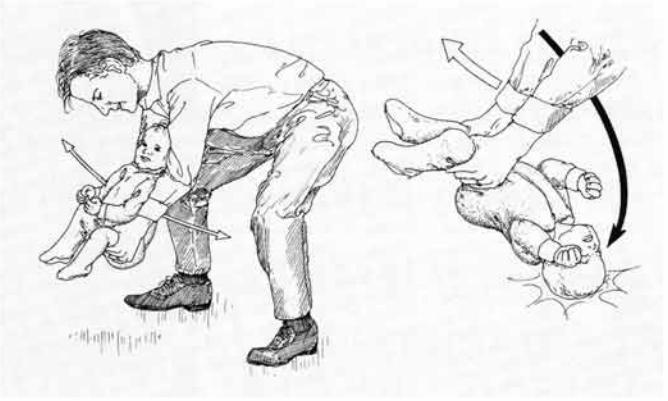

Fig. 2. Drawing of the mechanism of injury in case 2. The child was being held and swung by his father, then slipped through the father's arms, falling approximately 30–45 cm and striking his occiput on the floor.

Case 2

A 9-month-old baby was being swung in play while supported in his father's arms (fig. 2). This was a characteristic form of play by this parent with his children and had been witnessed by other family

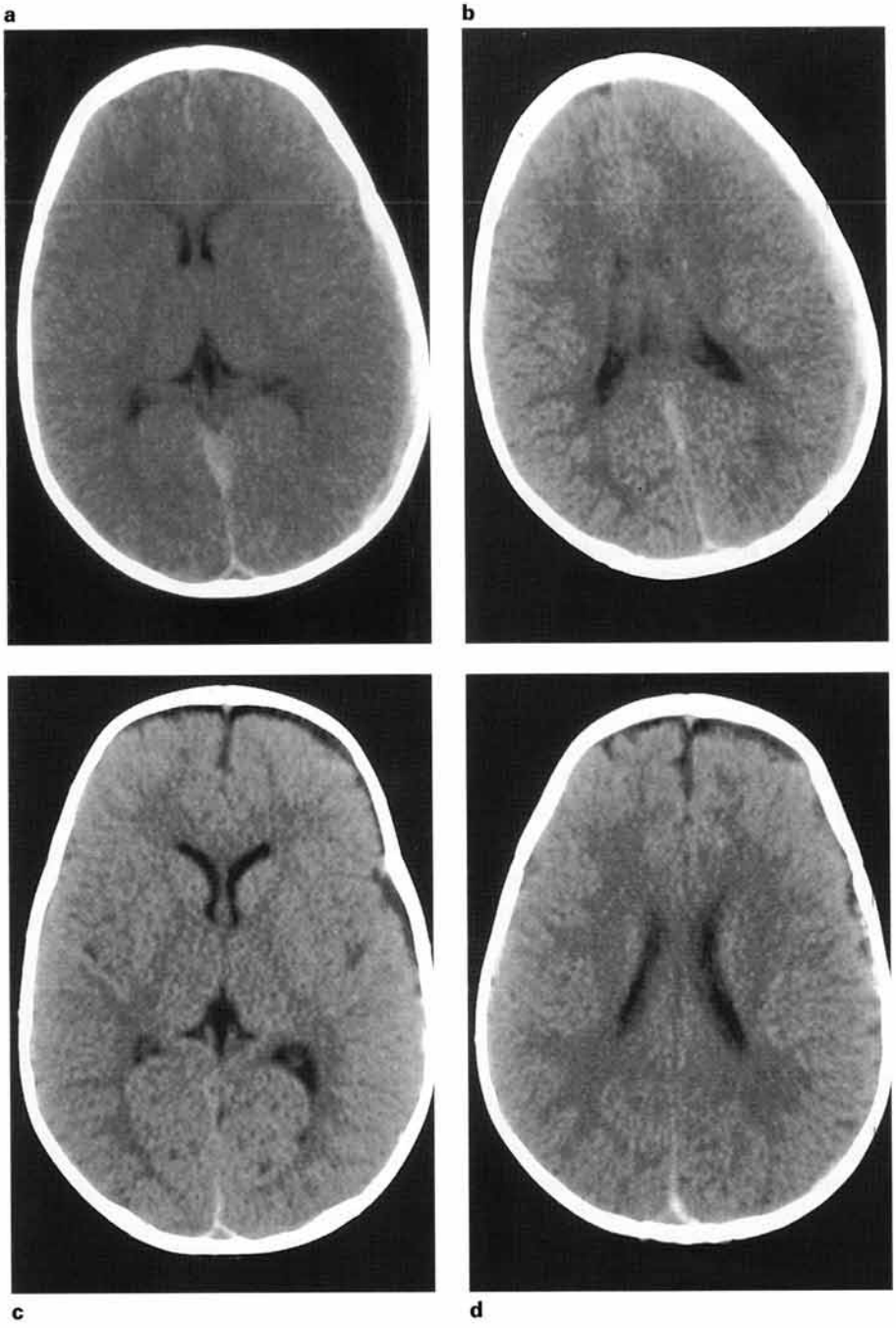

Fig. 3. CT scans case 2. **a**, **b** Acute unenhanced study, showing a heterogeneous collection of blood overlying the convexity of the left cerebral hemisphere and extending in a subdural location along the interhemispheric fissure. **c**, **d** 24 h later, subdural blood still outlines the posterior sagittal sinus but with almost complete clearing of the high attenuation in the superficial CSF spaces.

members on numerous occasions. In this instance, the father lost his grip and the child fell approximately 30–45 cm, striking the back of his head on the floor (fig. 2). The event was witnessed by friends visiting the house and the mechanism was reproducibly demonstrated by the patient's father and adult witnesses. After the fall, the child cried initially but then became briefly unresponsive with stiffening of the limbs. On arrival at the local emergency room he was noted to have some extension of the arms and a right lateral gaze. He was intubated and a CT scan revealed blood over the left hemisphere with slight mass effect (fig. 3a, b). On arrival to our hospital he had spontaneous eye opening, grimacing to pain, and spontaneous extremity movement. There was no apparent soft tissue swelling nor bruises elsewhere.

The child was treated with anticonvulsants and extubated. Complete blood count and coagulation parameters were normal. Ophthalmologic examination was significant for intraocular and retinal pathology in the left eye only. After pharmacologic pupillary dilation, indirect ophthalmoscopic examination showed diffuse intraretinal

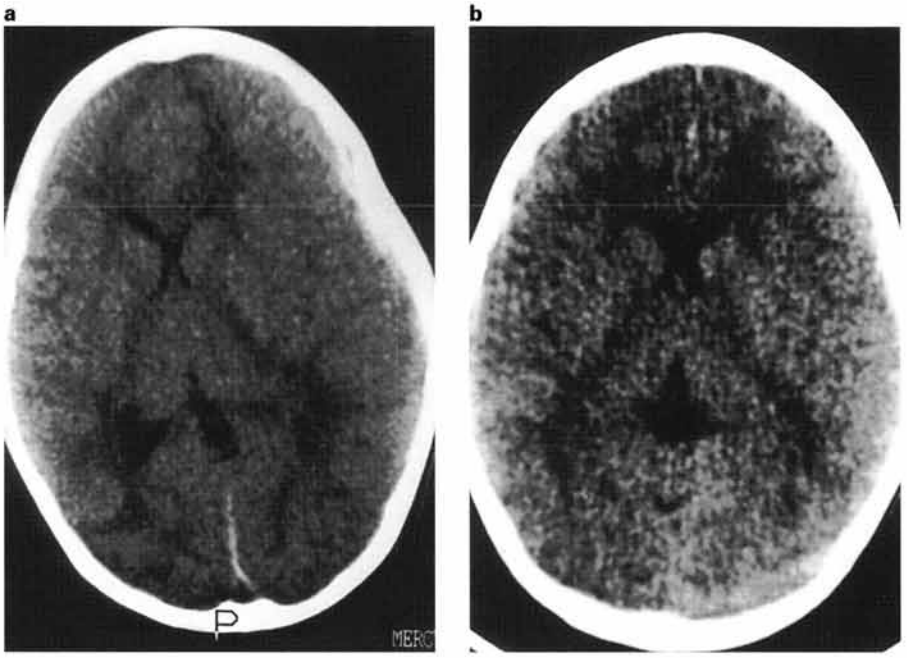

Fig. 4. CT scans of a 4-year-old girl who fell down steps onto concrete. **a** Acute study showing a left-sided extra-axial hematoma producing mass effect and midline shift, with extension of blood into the posterior interhemispheric fissure. **b** Follow-up study 1 day after injury. There has been spontaneous clearing of the hematoma with resolution of the mass effect.

flame-shaped hemorrhages and round intraretinal hemorrhages confined predominantly to the posterior pole of the left eye. The left macula showed significant foveal edema without exudates. There were also two small, posteriorly located vitreous hemorrhages arising from the superficial retinal vasculature along the posterior pole arcade. The remainder of the examination of the left eye and the entire examination of the right eye were normal. Skeletal survey was negative for any bony injuries.

The baby remained somewhat irritable and hypoactive but recovered his usual level of activities during the subsequent 2–3 days. A CT scan done on the day after admission showed resolution of the hemorrhage and an otherwise normal-appearing brain (fig. 3c, d). The baby was neurologically and behaviorally normal at 3 and 6 month's follow-up.

Case 3

A 4-year-old girl fell down several steps onto concrete. She had a brief loss of consciousness but rapidly regained alertness. In the local emergency room she was alert with a nonfocal neurologic examination. Funduscopic examination without mydriatics did not reveal retinal hemorrhages; general physical examination was notable for scratches of the face and neck and a bruise of the right thigh. CT scan showed a left subdural hemorrhage with some mass effect and midline shift (fig. 4a). Plain radiographs of the spine, pelvis, chest, hips, and femurs showed no fractures, and CT of the abdomen was unremarkable. She was observed in the intensive care unit and remained awake, alert, and interactive. Follow-up CT scan 1 day after injury revealed resolution of the hemorrhage and mass effect (fig. 4b). In outpatient follow-up 3 weeks later she was neurologically and behaviorally normal, and remained so at 8 months after her injury.

Case 4

A 9-year-old boy, who had a premorbid history of cognitive and behavioral deficits, fell head first onto cement from a second story window. He was awake, crying and talking, and was taken to the local emergency room where he was pharmacologically paralyzed and intubated. CT scan was performed, and transport was arranged for management of a 'large subdural hemorrhage'. This scan revealed a diffuse extra-axial hemorrhage over the left convexity, along with a right temporal fracture, right temporal contusion, and multiple left frontotemporal contusions; the midline was shifted approximately 0.5 cm from left to right (fig. 5a).

On transfer to the referral center, the child was agitated, with spontaneous eye opening and spontaneous strong purposeful movements. He had marked soft tissue swelling of the face and head. No retinal hemorrhages were noted on funduscopic examination without mydriatics. Intracranial pressure was 24 mm Hg. Because of his multiple contusions, he was treated with sedation, isotonic fluids, and mild hyperventilation; he remained purposeful and agitated between sedative administrations. CT scan on the day after admission showed resolution of the extra-axial hemorrhage, with persistence of the focal contusions (fig. 5b). Intracranial pressure normalized after 3 days. The child is verbal, ambulatory, with persistent cognitive and behavioral deficits similar to his premorbid state 4 months after injury.

Discussion

When a diagnosis of acute subdural hematoma is made in infants and young children, two clinical questions are faced by the treating neurosurgeon. The first decision to be made is whether the clot must be surgically evacuated.

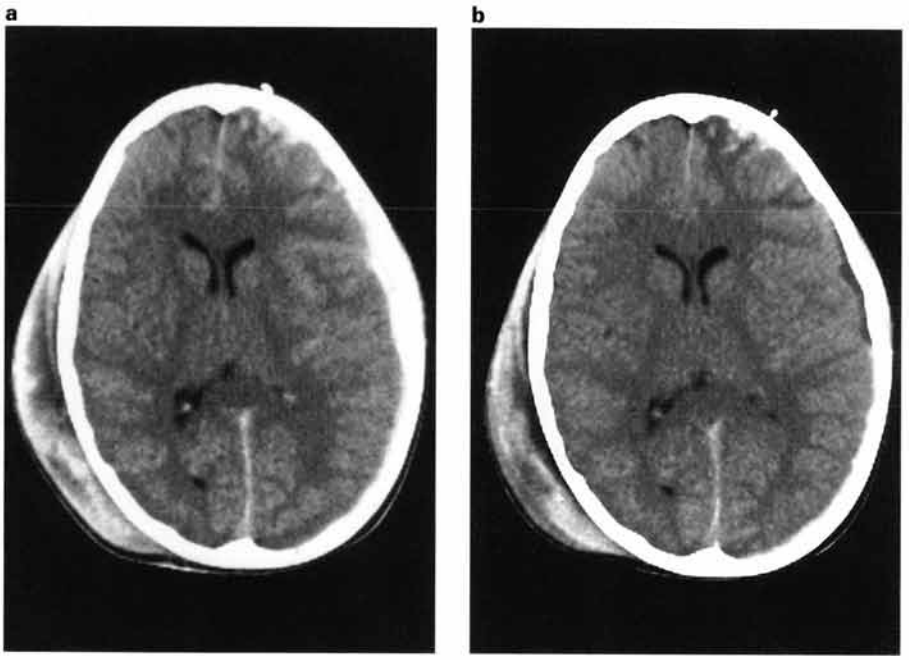

Fig. 5. a CT scans of a 9-year-old boy who fell from a second story window, striking his head on cement. Acute study, showing a shallow but extensive left-sided extra-axial hemorrhagic collection with subarachnoid extension. Skull fractures and bilateral frontal and temporal contusions were seen in addition to a right scalp hematoma. **b** Follow-up scan 1 day afer injury. The contusions persist, but the extra-axial collection has largely resolved without evacuation. There is some persistence of mass effect.

This decision is made on the basis of the clinical status of the patient and on the radiologic findings (hematoma volume, mass effect, appearance of the basal cisterns and brain parenchyma).

In each of the present cases, acute unilateral convexity extra-axial hemorrhage with the crescent-shaped appearance typical of subdural hematoma was seen after an impact injury to the head in an infant or child, and the radiologic diagnosis of subdural hematoma was made. In the first three instances, the mechanism of injury suggested smaller forces than those typically associated with accidental subdural hematoma. In each case, the child appeared clinically normal or with only mild symptoms. The first 3 children were therefore treated conservatively, with clinical improvement, and CT scans done within the first 1–2 days of injury showed resolution or near resolution of the clot. This led to the question of whether these apparent subdural clots were, in fact, partly or largely composed of blood in the subarachnoid space, which might be expected to resolve rapidly. The last child's scan showed evidence that blood was indeed present in the subarachnoid space; the mass effect seen ipsilaterally was thought more likely related to contusion than mass effect of the extra-axial blood. Because of the previous experience with the first 3 cases, this child was also treated nonsurgically, with spontaneous resolution of the extra-axial blood by the second postinjury day.

Rapidly resolving, conservatively managed subdural hematomas have been reported previously, most often in adults, but at least 1 young child (age 3 years and 10 months) also has been described whose subdural collection occurred after reportedly mild trauma [10–13]. Postulated mechanisms of the radiologic resolution of these hemorrhages include redistribution of the clot along the surface of the brain and 'washing out' of the clot by cerebrospinal fluid which comes in contact with the subdural clot through a tear in the arachnoid membrane [10–13].

An alternative explanation for rapid resolution of apparent subdural hemorrhages is that some or most of the clot may be in the subarachnoid space initially, rather than being confined to the subdural space. In acute trauma there is often bleeding into both compartments; indeed, the distinction between the subdural and subarachnoid space has been questioned on anatomic grounds [14]. Magnetic resonance imaging has been used to localize more chronic collections in these compartments, but its value in evaluating acute hemorrhage is unclear [10, 15].

In each of the cases presented here, the initial CT scan was interpreted at the referring hospital as showing a subdural hematoma. Whether the hematomas seen in the present patients were, in fact, subarachnoid, subdural, or both, remains uncertain, as CT scans cannot always distinguish these compartments fully. Nonetheless, CT scan-

ning remains the most common radiologic study performed for acute trauma, and several characteristics of the initial scan in the present patients with 'disappearing subdurals' have emerged. First, the density of the clot may be less than that often seen in surgically treated acute subdural hematoma, or may have an inhomogeneous appearance. This may result from dilution of the blood by cerebrospinal fluid in the subarachnoid space. Secondly, blood may be seen in the sulci and fissures of the corresponding brain region. Third, the underlying brain typically does not appear significantly compressed, nor is there loss of differentiation between gray and white matter.

Clinically, these patients looked less impaired than do children with typical acute subdural hematoma. Level of consciousness was preserved, and none of our patients exhibited motor weakness or pupillary asymmetry. An early seizure was seen in 1 patient (case 2), followed by rapid recovery. This combination of clinical and radiographic findings led to nonoperative management of the hemorrhages. In both infants and older children whose clinical symptoms do not suggest an expanding mass lesion, and in whom careful evaluation of the radiologic findings demonstrates evidence of subarachnoid blood and absence of significant brain compression related to the collection, initial conservative management is indicated.

The second decision for the neurosurgeon, especially in infants with subdural hematomas, is whether the reported mechanism is consistent with the injury, or whether nonaccidental injury must be suspected and this suspicion reported to child-protection authorities. This decision is not made lightly, as it sets in motion events which may profoundly affect the child and family.

The issue of nonaccidental injury is particularly troublesome for the clinician, and always should be strongly suspected when a subdural hemorrhage is attributed to a household fall or play. This is particularly true when retinal hemorrhages are found, as in case 2. However, while missing a diagnosis of inflicted injury must be carefully avoided, recognizing that uncommon injuries such as those reported here may mimic findings seen more commonly in abusive injuries is equally important. These cases can be distinguished from typical abusive injuries in that details of the histories were clearly and consistently reported by all parties, medical care was sought immediately, and the childrens' neurologic findings were consistent with the reported mechanisms. The radiologic picture in each of these cases was one of a focal or multifocal convexity impact injury, rather than the more diffuse, bilateral and/or interhemispheric injury often seen in subdural hemorrhage from infantile abuse which is most likely related to rapid angular deceleration. Rapid resolution of the focal extra-axial clot occurred consistently in all cases. Finally, thorough evaluation of the 2 injured infants by the child abuse evaluation team failed to disclose any evidence of nonaccidental causation.

While these features link the present cases, it is recognized that similar features may be encountered in the more mild injuries due to inflicted trauma. However, nonaccidental injuries tend to show some common characteristics. Subdural and subarachnoid hemorrhages are usually extensive but thin collections, occurring over both hemispheres and in the interhemispheric fissure, particularly posteriorly. Surgically significant unilateral subdural hematomas with mass effect, when they occur, are found most often in older infants who are severely impaired at presentation [9]. Extra-axial proteinaceous collections with lesser degrees of underlying atrophy are usually seen in follow-up scans of children with less severe injury, while focal or hemispheric areas of hypodensity which progress to infarction and subsequent marked atrophy frequently occur in more severely affected infants [6].

With respect to retinal hemorrhages, while there is a strong association between this finding and nonaccidental injury, there are no specific clinical features of the hemorrhages which are pathognomonic for nonaccidental etiology. However, in our experience retinal hemorrhages in inflicted injury tend to be multiple, usually bilateral, and more severe, whereas the few retinal hemorrhages that can be found in association with nonfatal accidental trauma tend to be sparse and few. Retinal hemorrhages have been reported in accidental trauma in children, but are uncommon, usually occurring in severe injuries along with subdural hematoma [2, 16, 17]. Retinal hemorrhages have been reported in young children after falls, but the details of the injury severity and specific characteristics of the hemorrhages were not reported [17]. Other authors have stressed the rarity of retinal hemorrhages in accidental trauma [16, 18]. The exact biomechanical forces necessary to produce retinal hemorrhages are unknown, but several mechanisms have been postulated, including increased retinal venous pressure, extravasation of subarachnoid blood, and traction of retinal vessels at the vitreoretinal interface due to angular deceleration [19, 20]. In both accidental and nonaccidental injuries, retinal hemorrhages virtually always occur in association with subdural and/or subarachnoid hemorrhage. In the present series, only 1 child had retinal hemorrhage, and this was unilateral. It should be noted that the 2 older children in

this series did not undergo dilated fundus examinations and small hemorrhages may have been missed.

The most common history for nonaccidental trauma is no history of trauma, or of mild injury; such a history is often vague, uncorroborated, changing, or developmentally incompatible [21]. Skeletal survey and careful physical examination remain invaluable in identifying additional injuries which cannot be explained by the reported mechanism. These findings were not present in the current series.

It should be stressed that great caution must be exercised in accepting minor trauma as an explanation for apparent subdural hematoma, and it is hoped that the present report does not erode the progress made in the recognition of nonaccidental injury. However, while a clear distinction cannot always be made with certainty, the authors believe that injuries mimicking acute subdural hematoma can occur from accidental impact forces, perhaps with an angular component, as was likely the case in the first 3 children. These injuries are characterized by a clear history, relatively well-appearing child, and focal subdural/subarachnoid convexity clot which resolves spontaneously within 1 or 2 days.

While not performed in the present cases, magnetic resonance imaging may prove useful in further characterizing this type of injury. The 'disappearing subdural' should be considered in the differential diagnosis of selected cases of pediatric head trauma.

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