Accidental Injuries

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Suffice to say that significant injury usually is the result of a significant fall. Although simple skull fractures, epidural hemorrhages, and fractures of the clavicle, distal humerus, forearm, and tibia may result from short toddler falls, subdurals, major brain injury, and rib and proximal extremity fractures rarely result (Paez et al., 1993; Thomas, 1991). Running and twisting events may result in spiral femur injuries in toddlers (Thomas, 1991). Case series of accidental falls are likely to be contaminated with abuse cases, unless injury scenarios are carefully corroborated and other evidence of inflicted injury is carefully sought and excluded. Open or unguarded upper story windows cause a particular risk for accidental falls. Building code changes requiring window grates on upper-story apartments have been successful in reducing these injuries (Bergner et al., 1971). Similarly, code regulations for porch rails can reduce falls from elevated porches. Although stairway falls usually act like a series of short and relatively benign falls, children in infant walkers are at heightened risk. The walker seems to present the infant's head to trauma. (Joffe and Ludwig, 1988) Playground equipment can allow children to climb to and fall from significant heights (Werner, 1982). Standards for energy absorbent surfaces under play equipment provide a significant countermeasure.

In many cases, evaluation of agent, environment, and victim factors may suggest prevention strategies. In general, passive strategies that do not require repetitive child or caretaker actions are more effective than active ones.

Strangulation

Playground equipment and many household infant furniture items such as cradles and high chairs present significant strangulation risk (Werner, 1982; Feldman and Simms, 1980). Clothing catch points, design cutouts, wide crib slats, defective crib side rails, and high chair trays or waist belts that allow submarining can entrap infants' heads and necks (Feldman and Simms, 1980). Children can become asphyxiated when wedged between furniture. Their necks can become entangled in dangling ropes and cords (e.g., curtain cords).

Prevention

The sources of accidental childhood injury are innumerable, but repetitive scenarios can be recognized (Feldman, 1980). They thus become not "accidents" but predictable interactions of child behavior and development with the environment. In many cases, evaluation of agent, environment, and victim factors may suggest prevention strategies. In general, passive strategies that do not require repetitive child or caretaker actions are more effective than active ones.

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ABUSIVE HEAD INJURY

—by Wilbur L. Smith

The leading cause of death among abused children is head injury. Estimates of the actual prevalence of child abuse-related head injury are imprecise and probably artificially low owing to difficulties in diagnosis, reporting, and case finding. In 70% of children documented to be suffering from abusive head injury, there is concrete evidence that the victims have suffered an injury prior to the one that brought them to attention (Alexander et al., 1990a). It is reasonable to assume, therefore, that some children's brain injuries are never detected and that there is a large degree of underdiagnosis, with an unknown number of children suffering subclinical abusive head injury, making published prevalence data artificially low.

Allowing for these difficulties, it is possible to estimate an admittedly conservative prevalence figure. Most abusive head injuries occur in children younger than two years of age; therefore, this is the population to which the prevalence figures are most germane. According to the 1992 figures available through the Department of Health and Human Services there were approximately 8 million children in the United States, age 0 - 2 years.

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Estimates for the number of fatalities owing to child abuse in the United States range from 1,500 - 3,000 per year (McCurdy and Daro, 1994), and approximately 12% of children diagnosed with abusive head injury die as a result of the injury. A calculation using an estimate of 800 head injury fatalities per year as 12% of the total prevalence of head injury puts the overall prevalence of symptomatic abusive head injury at roughly one per 2,000 in the United States population of children. The magnitude of this disorder is clearer if compared to other serious diseases in the United States. An attack rate of one per 2,000 is slightly lower than the rate of serious congenital heart disease in the United States, far exceeds the prevalence of childhood malignancies, and approaches the incidence of HIV infection in the United States. On a simple prevalence basis, an eight-week-old male child with vomiting is as likely to be vomiting from head injury as he is to be vomiting from pyloric stenosis. Looked at this way, it is apparent that abusive head injury is of epidemic proportions and represents a major source of mortality and morbidity for American children

Serious injuries take serious trauma, and a child with serious head injury who is not involved in an automobile accident or a fall from several stories should be considered a possible victim of child abuse in the process of differential diagnosis.

The mortality figures are merely the tip of the iceberg in measuring the pain inflicted by abuse. In most series of children suffering from abusive brain injury, the majority of children who survive suffer substantial permanent neurological deficits. Even for those who survive without gross perceptible deficit, the outcome is not necessarily clear. Some of the "softer" signs of neurological injury, such as attention deficit disorders, may result owing either to the injury or the chaotic environment that facilitated the abuse in the first place. It is usually impossible to sort out cause and effect in these "lesser" injury cases. Furthermore, we do not have any prior knowledge of the intellectual potential (before injury) of abused children who suffer injury but recover. Did the injury knock 20 points off the IQ of a genius, rendering that child only high average? Often the best we can say, even with the children who are apparently normal after injury, is that suffering the injury did nothing to enhance their intellectual potential.

The early clinical diagnosis of shaken baby syndrome is frequently obscured owing to the lack of clinical history. The urgency and difficulties of caring for a critically ill child with the often ambiguous symptoms of elevated intracranial pressure are compounded by a fallacious history which further obscures the true nature of the injury. In one series, over 95% of the initial histories supplied by the caretakers of abused children were false. This certainly mirrors our experience. We have received a correct initial history in very few cases, and even in those cases the extent of trauma was minimized. The specious history often features a fall or choking event, rather than the true cause. Health care professionals are not trained criminal investigators, and are therefore reluctant to accuse individuals even though the histories correlate poorly with the severity of injury. Compounding this difficulty, the initial physician to whom the child is brought may not be well versed in the understanding of the dynamics of injury in small children. The initial diagnosis is also confused because the child often presents in a state of extreme physical distress, near death. The life support activities and immediate concerns of trying to revive the child and ensure survival take precedence over careful examination, documentation of bruising, and establishing the definite diagnosis.

Given these limitations, a few points are in order. The literature is nearly unanimous that short falls, those less than four feet, are very unlikely to cause the type of serious brain injuries seen in abused children (e.g., Chadwick, 1981). Serious injuries take serious trauma, and a child with serious head injury who is not involved in an automobile accident or a fall from several stories should be considered a possible victim of child abuse in the process of differential diagnosis. Subdural hematomas, parenchymal shearing injuries, brain parenchymal concussion, and epidural hematomas preponderantly occur owing to trauma. Other conditions causing intracranial bleeding in children are unusual; therefore, the presence of any such lesions should lead to a primary consideration of child abuse. The presence of associated injuries can be supportive of the diagnosis. Approximately half of the children who suffer an abusive head injury have accompanying long bone fractures; therefore, all children under the age of two with injuries that may have been caused by abuse should have a radiographic long bone study. The coincidental presence of long bone fractures absent a history of major trauma is highly specific for the diagnosis of abusive injury.

The possible mechanisms for inflicting an abusive head injury are multiple and include hitting the head with blunt objects, inflicting penetrating injury to the head, strangulation with resultant hypoxic ischemic injury, malnutrition affecting brain growth, and the shake/impact syndrome. The latter is the most prevalent, particularly among children less than two years of age. Shaking was first described as an explanation for the clinical findings of long bone fractures, retinal hemorrhages, and intracranial injuries without obvious external signs of cranial trauma. Guthkelch (1971) and Caffey (1972) are generally recognized as the first persons to clearly delineate this combination of injuries, leading to the label "shaken baby syndrome." After their initial description, a number of scientific works emerged which further defined the scope and type of intracranial injuries encountered

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owing to the assault and expanded the spectrum of injuries recognized as part of the syndrome. The original descriptions emphasized the subdural hematoma as characteristic; however, further experience identified subarachnoid bleeding, cerebral edema, and parenchymal shearing injuries as further manifestations of abusive head injuries. Duhaime et al. (1987) suggested that a terminal impact was necessary to cause many of the injuries reported in the shaken baby syndrome, and from their work an appreciation of the shake/impact syndrome became widespread. Several studies, including one of our own, suggest that while many infants do suffer a definable impact, shaking alone can produce a serious spectrum of injuries (Alexander et al., 1990b). Absolute delineation of the mechanism of injury awaits further research and development of better models; however, there is no disagreement among professionals in the field that the violent shaking, whether or not it is accompanied by an impact, is not a casual act but rather one that would indicate to a rational observer that severe injury was being inflicted to the infant. While the author does not advocate mild shaking of babies or throwing babies up in the air, the violence of the abusive shaking is several orders of magnitude greater than any of these playful activities.

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Imaging has grown to be a major factor in the diagnosis and management of abusive head injury. Early on it was evident that computerized tomography (CT) was going to play a key role in the diagnosis of abuse (Zimmerman, 1978). In general, CT scans are available in any trauma center, and the initial CT without contrast enhancement is sufficient to indicate any life-threatening conditions for which neurosurgical intervention is necessary. CT also permits the visualization of bone windows so that scans can be reviewed for fracture, depressed bony fragment, and scalp and soft tissue injury. Careful review of the initial CT often provides data that allow correlation with the clinical history to precisely pinpoint the timing as well as the nature of the injury. CT data also can be of prognostic value, particularly in the area of the severe injury where brain architecture is disrupted. Visualization of extensive and severe injury on the initial CT is virtually always associated with a poor outcome. Reviewing the CT data, one must be aware that CT underestimates the severity of injury. There are a number of well documented fatal cases of abusive head injury with normal CT; therefore, a normal CT examination in no way excludes a diagnosis of abusive head injury. The converse of the situation does not pertain—rarely is an abnormal CT associated with no or minimal symptoms. In studies where Magnetic Resonance Imaging (MRI) was performed in conjunction with CT, a number of additional lesions were evident on MRI (e.g., Sato et al., 1989). Therefore, it is our policy in selected cases to follow the CT with magnetic resonance imaging, as MRI is more accurate for the diagnosis of subdural hematomas and brain parenchymal head injuries than CT. We have also found MRI valuable in instances with clinical symptoms and physical findings of abusive head injury but normal CT scans.

While MRI has proven of great value in defining injuries from child abuse, it remains a second-line imaging tool. Access to MRI, particularly for severely injured children, is much more difficult than access to CT. MRI devices are not as widely available, and life support within MRI devices requires specialized sophisticated equipment that is not widely available. An MRI scan generally takes longer to accomplish than a CT scan and is about double the price of a CT scan. Therefore, in many institutions it is impossible or prohibitively expensive to put a patient on a respirator in an MRI for scanning. However, MRI provides considerably more definition both of injury and precise anatomic location of injury than CT. Sato et al., in studying children who had suffered abusive head injury, showed that 50% more subdural hematomas were found using MRI than by CT. In the same study the investigators documented that parenchymal injuries, either concussions, diffuse axonal injuries (shears), and acute cortical necrosis were better shown by MRI than CT. At issue still is whether acute cerebral edema and acute subarachnoid bleeding is imaged to advantage by MRI. We advocate MRI as a followup to CT scanning in any instance where (1) there is clinical evidence of a severe cranial injury and the CT is normal or has minimal findings; (2) a small subdural hematoma is present but severe injury is suspected; or (3) parenchymal brain injury is an important issue and precise localization of the gyri or area of the brain traumatized is needed for establishing either the patient's prognosis or to explain the patient's symptoms.

A description of imaging would not be complete without mentioning the role of plain radiographs in evaluation of children suffering from abusive head injuries. As noted earlier, the classical descriptions of abusive head injury included the presence of bone fractures as one of the criterion of the syndrome. As understanding of the extent of abusive head injury has progressed, it has become evident that one can suffer severe abusive head injury without necessarily having long bone fractures. In fact, approximately one-half of the patients we see with abusive head injury have accompanying long bone fractures. Certainly, the presence of long bone fractures substantially increases the likelihood of abuse, while the absence of long bone fractures is not evidence against the presence of an abusive head injury. The skull x-rays are the best single modality for showing most skull frac-

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tures. Studies have shown that, in general, skull fractures do not occur in children after short falls, although theoretically it is possible to fracture a desiccated skull by a precise fall of one foot onto concrete. In fact, this rarely happens in the clinical situation. Most studies of nonabusive falls under four feet onto hard surfaces show less than a one percent incidence of skull fractures. In those rare instances where skull fracture does occur owing to these accidents, the fracture is usually in the parietal bone and usually short. Long fractures, extending the length of the parietal bone or crossing several bones, or diastatic fractures (those with widely separated edges) do not occur as a result of short falls. Stellate fractures, giving a cracked egg appearance to the skull, also occur only after very significant trauma and are not associated with short falls. It is therefore of great value to have a skull film to evaluate the nature and appearance of the fracture and to correlate these with the history given for an injury.

Retinal hemorrhages are a very important clue in the diagnosis of abusive head trauma, occurring in approximately three-quarters of children who suffer severe shaking injuries. Studies of children with very severe accidental traumatic injuries accompanied by increased intracranial pressure document an occasional instance of retinal hemorrhaging, but this finding is the exception rather than the rule after direct head trauma without shaking. Retinal hemorrhages occasionally are reported with coagulation abnormalities and vasculopathies. Sparse and scattered retinal hemorrhages have been seen with some forms of chronic meningitis, particularly tuberculosis and malaria. There are scattered reports of retinal hemorrhage after cardiopulmonary resuscitation, particularly after chest compression; however, documenting that CPR-related retinal hemorrhages followed rather than preceded CPR was not possible in most of the reports.

Most studies of nonabusive falls under four feet onto hard surfaces show less than a one percent incidence of skull fractures.

Most of these clinical co-morbid conditions are easily diagnosed, and the overwhelming majority of retinal hemorrhages in children older than 30 days result from child abuse. Ophthalmological studies have documented that retinal hemorrhages involving the periphery of the retina associated with retinal detachments, retinal tears, and large numbers of retinal hemorrhages are virtually always due to abuse. Special note should be made of the retinal hemorrhages in neonates. Somewhere between one-tenth and one-third of vaginally delivered neonates will develop scattered retinal hemorrhages. Smith et al. (1992) have looked for the association of any intracranial injuries with the retinal injuries of birth, and in fact these intracranial injuries do not happen. Therefore, in a child with a combination of intracranial injuries and retinal hemorrhages, the birth process, unless carefully documented, cannot be blamed even if the child is younger than 20 days of age.

In summary, abusive head injury is a prevalent disorder with a very high morbidity and mortality. The diagnosis in most cases is not difficult, providing that individuals with sufficient experience and understanding of the condition are involved in the case. Early case documentation involving professionals in the medical, social, and investigative fields is critical for subsequent determination of responsibility for the act. Current efforts to prevent this horrible social problem are primitive and unsuccessful. At present no effective treatment for the abusers has been found. Given the high morbidity and mortality, it is imperative that children be protected from individuals who might inflict such injury.

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PROFESSIONAL NETWORK BEGINNING

Professionals currently involved in providing support to surviving siblings, other family members, or professionals involved with children who have died can now make contact to share ideas and resources. To get involved, call or write Michael Durfee, MD, at the Los Angeles County Department of Health Services, Child Abuse Prevention Program, 241 N. Figueroa, Room 306, Los Angeles, CA 90012. Phone: 213-240-8146. See article in this issue, pg. 47, for more information