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Overview and clinical presentation of inflicted head injury in infants

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Any neurosurgeon that provides care for children with traumatic injuries is involved in the management of child abuse at some point. Inflicted injury (including infanticide) has been described in every major culture since the beginning of recorded history, and there is no evidence that the incidence of this phenomenon is decreasing. Childhood inflicted injury occurs in all ethnic and socioeconomic groups and a wide variety of perpetrators are identified. As a result, the suspicion of child abuse should never be ignored because of the belief that a family is "too nice" to be involved. Although such beliefs are usually motivated by sincerity, they do not serve as a substitute for a formal evaluation for inflicted injury in those cases where an accidental mechanism is implausible.

The magnitude of the problem of inflicted head injury is high and, by its nature, it is underreported. The incidence of inflicted injury is estimated at 15 per 1000 children per year (or approximately 30 times the incidence of new cases of myelomeningocele in the United States). As many as one quarter of children less than 2 years of age hospitalized for head injury has been abused; the proportion is likely higher for infants with fatal injuries. Approximately 1000 deaths caused by inflicted injury are confirmed annually in the United States [1].

Despite the enormous scale of this public health issue, the history of the recognition and management of child abuse is a relatively recent one. Although neurosurgeons have presumably been involved in the care of abused children since the dawn of the specialty, the original descriptions of this entity were provided by pediatricians and radiologists. In 1946, the pediatric radiologist Caffey [2] reported a series of six infants with the syndrome of subdural hematomas associated with long bone fractures. He correctly surmised that the injuries resulted from the same traumatic forces and in one of the cases believed that the injury was likely intentional [2]. The gradual recognition that children were being treated for traumatic injuries that presented without a clear history of trauma finally culminated in the landmark publication in 1962 of Kempe's et al [3] article "The Battered Child Syndrome." This study reported on a survey of district attorneys who were involved in the legal issues of children who had been severely beaten and served to bring the problem to national attention. Neurosurgical publications began to appear more frequently in the 1980s, but it seems likely that the earliest pediatric neurosurgeons were aware of, or at least tacitly recognized, the existence of inflicted injury. Although Matson did not mention inflicted injury in any of his publications, Kindt (who was his clinical fellow in 1965) recalled Matson's observation that the behavior of the families of infants with subdural hematomas differed significantly from those of children with other injuries and believed that it related to the circumstances of the injury (G.W. Kindt, personal communication, 1998).

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Associated injuries

Inflicted injury in childhood is often a combination of injuries, either sustained at the same time as an inflicted head injury, or at an earlier time when the child may or may not have come to medical attention. Abusive injuries are recurrent by nature unless the child is removed from the at-risk environment, and hence it becomes important to try to identify the injured child as soon as possible. Although the history and clinical features of inflicted head injury are detailed later, the possibility of associated injuries must always be considered and they are reviewed separately. The key feature in the history of the child with inflicted trauma is that the history given either does not fit with the observed injuries or is not given in the first place. Hence, a symptom is commonly given as the history, such as "he was not breathing," or "she would not stop crying." Sometimes an implausible history is given (e.g., a noncrawling 4 month old that pulls a saucepan off of a stove or an injury involving an 8-lb pound cat knocking over a baby swing, producing retinal hemorrhages and subdural hematomas). Both authors have had the experience of the pseudoconfession in which an apneic baby is shaken "to get him breathing again." Rarely, an abusive injury is witnessed and is reported, but more often no clear history is obtained and multiple opportunities for injury exist. For this reason the neurosurgeon is often asked to give an opinion as to the timing of a particular injury. Probably the best advice in this setting is to avoid going beyond the physician's obligation to testify as to the facts of the case by being drawn into the position of giving testimony as an expert, unless one is carefully prepared to do so.

The examination features of specific associated injuries are considered briefly. Ocular injuries (particularly retinal hemorrhages) are such an important finding that they are the subject of another article in this issue. Burns are relatively uncommon in childhood, but up to 25% of childhood burns are inflicted, most often using tap water. Burn patterns may be pathognomonic for inflicted injury based on dipping and splash patterns, and although the acute management often involves trauma surgeons or burn specialists, the injuries need to be documented and assessed by a child abuse specialist. Abdominal injuries carry the second highest risk of death in child abuse after head injury, with up to 50% case mortality. The injuries usually result from a blow by a fist or foot, crushing the viscera or solid organs against the spine. Often there are no external marks because bruising is less commonly seen over the abdomen, and hence the child may present with few clues of the severity of the injury until life-threatening complications develop.

Skeletal injuries are often occult and most are found only after an intentional search for them. Although they are only found in about one fifth of abused children, certain fractures are highly specific for abuse, such as multiple rib fractures (Fig. 1) or the epiphyseal-metaphyseal fracture of the lower extremity (Fig. 2), which results from jerking or shaking of the child's limbs. Bruising is a less specific, but frequently helpful finding in the abused child. Normal bruises are typically irregular, present over a bony prominence and can be related to the child's level of activity. For example, the toddler who is just learning to walk may often have a bruise on the forehead, but bruises in the precruising child should be a source of concern. Abuse-related bruises are more often found in areas that are well-padded and typically protected from injury. Often bruising in abuse can identify the offending instrument, such as a hand mark or a loop from an electrical cord. Care must be taken, however, to avoid mistaking natural variation in skin coloration or even intentional folk remedies as being intentional injuries [4].

Clinical history of inflicted head injury

Throughout a number of published series over several decades, the clinical history in inflicted head

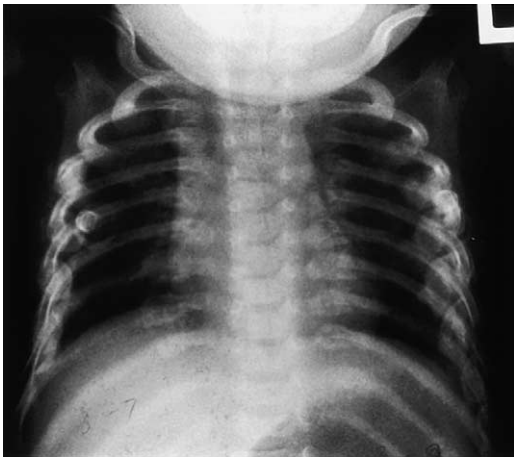

Fig. 1. Chest radiograph showing multiple, bilateral rib fractures resulting from direct pressure to the chest wall. (*From* the American Academy of Pediatrics. Visual diagnosis of child abuse; with permission.)

Fig. 2. Classic example of a "corner" fracture involving the distal metaphyses of the tibia and fibula at the level of the epiphyseal plate (*arrow*). (*From* the American Academy of Pediatrics. Visual diagnosis of child abuse; with permission.)

injury in infancy has remained remarkably consistent. Most often, one of two histories is given: (1) either a history of a short-height fall or similar minor blunt trauma mechanism, or (2) no history of trauma is provided, and the baby is brought to medical attention because of the development of symptoms. These may include a range of symptom types and severities including poor feeding, irritability, vomiting, seizures and other abnormal movements, lethargy, breathing difficulties, and unresponsiveness [5–8]. Sometimes the child presents because of symptoms or signs caused by a related injury, such as leg swelling associated with a long bone fracture. Because the presenting symptoms are nonspecific, in some cases the diagnosis of trauma is made after a lumbar puncture for evaluation of sepsis reveals bloody cerebrospinal fluid.

When a history of trauma is obtained, it is most likely to describe a fall from a low height. A history of shaking is provided in the minority of cases, and may be found in response to direct questions about shaking, or be offered in the context of shaking to resuscitate [5,6,9]. In some cases in which the clinical and radiologic findings suggest a pattern typical for inflicted injury, a more complex history may be given or evolve over time with repeated questioning.

Although significant head injuries from household falls are rare, with the exception of arterial epidural hematomas, they occasionally occur under unusual circumstances. It is important that the clinician be aware of biases that may be introduced because of cultural or socioeconomic differences in the caretakers' ability or willingness to articulate a history. Nonetheless, as a general rule the histories in accidental cases are usually clear, consistent, with specific details and time line of the events surrounding the injury consistently provided. The caretakers can typically narrate exactly what they did and when in response to the accident, and both the actions taken and the emotional response seem appropriate to the circumstances. This type of history is often distinctly different from those provided in nonaccidental situations, where the history may be vague, poorly described, change with time, or include descriptions of actions on the part of the infant that are developmentally implausible.

In questioning the caretakers, it is important to get as much specific information as possible. Exactly what happened and when; how did the child look; what position was the child in; who did what, where, and when; and how did the child respond? It is useful to know if there were symptoms that suggest seizures. Leading questions and an accusatory tone should be absolutely avoided. The focus should be on determining exactly what happened to the infant, and in understanding what might be relevant to coming to the correct diagnosis and providing optimal care.

Examination

Infants with traumatic brain injury can be divided into two main categories: (1) those that are

responsive, and (2) those that are unresponsive. Although both groups require a full evaluation, the order and time course may differ.

In an awake infant, the overall appearance is assessed. Is the child awake spontaneously, or only to handling or noxious stimulation? Does the child fix and follow visually, attend to the examiner, smile responsively? It goes without saying that an infant who sleeps unless stimulated, wakes just to cry, and does not fix visually or interact is seriously ill, and has the potential to deteriorate. Fullness of the fontanelle is an important finding. Such infants should be considered to have a significant brain injury, and treated expectantly, with careful attention to monitoring, airway control, recognition of seizures, or other changes that signal deterioration and might prompt an increased level of intervention.

All infants should have a complete physical examination, with careful inspection of all body surfaces. Clothing and diaper should be removed. Bruises and other marks should be documented and, ideally, diagrammed on a trauma sheet. Care should be taken to examine the scalp, ears, and face for bruising or swelling. The mouth and frenulum should be examined, both of the tongue and of the upper lip, because a torn frenulum is an important finding in some forms of nonaccidental trauma. Missing or broken teeth should be noted.

Retinal examination is imperative. If in the acute setting mydriatics are contraindicated because of interference with the clinical examination, a nondilated examination should be performed. A dilated examination should be undertaken as soon as practical to document retinal hemorrhages, preferably before potential brain swelling occurs and may obscure interpretation of the findings.

In children who are unresponsive or actively seizing, attention is directed toward stabilization, with airway control, administration of anticonvulsants, and other measures instituted as needed. During this process, the fontanelle can be palpated, bruises documented, and other findings assessed. A brief retinal examination can be performed.

Assessment of neurologic status with standard coma scales may be difficult in infants. Nonaccidental injuries may be particularly troublesome in this regard, because they often occur in very young infants with cortical immaturity. For this reason, such patients may have preservation of brainstem function but have deficits in cortical function. Such infants may move in response to stimulation or move spontaneously (sometimes because of seizures), and may even exhibit eye opening, despite major cortical injury. The Glasgow Coma Score may seem spuriously high in these patients. A variety of infant coma scales have been developed, most of which translate the Glasgow Coma Score into infant-appropriate behaviors. Recently, a coma scale designed specifically to include an assessment of cortical function in infants with traumatic brain injuries has been developed [10]. This scale is based on the observation that more normal EEG activity in infants, which reflects preservation of cortical activity, correlates with the ability to grimace and cry in response to noxious stimulation. Whether the specific scale is used or not, it may be helpful to assess whether the infant maintains the ability to grimace and cry in response to pain as a reflection of the degree of cortical function in this very young population. Experience suggests that infants with nonaccidental injuries who go on to develop diffuse loss of grey-white differentiation on CT scan, reflecting widespread cortical loss, may be differentiated from those with less severe injuries based on this behavioral characteristic.

Determination of inflicted head injury: mechanistic issues

In the initial descriptions of inflicted injury, the diagnosis rested on the findings of a constellation of multiple injuries that were characteristic [3,11]. As more subtle and acute forms of nonaccidental injuries began to be described, the notion of "history insufficient to explain injury" became prevalent. Although this concept is important, exactly what mechanism is suitable to explain a particular injury may be problematic, and has been the source of enormous controversy. Arguments over whether shaking or impact are necessary to cause subdural hematomas have been voiced, along with debates about the meaning of retinal hemorrhages, fall heights necessary for fractures, and the role of multiple injuries or other predisposing conditions [9,12–22]. This uncertainty and disagreement has fueled countless debates in hospitals and courtrooms over whether a given history explains the findings in a particular child.

Cases in which the diagnosis of inflicted injury is entertained fall into one of three categories. A number of cases are unequivocally caused by abuse. Another group is clearly consistent with an accidental mechanism. A third group is in a gray zone in which the findings are suspicious, but not

definitive, for inflicted injury. Although detailed data are not available as to the distribution of these cases, anecdotally these groups in a typical pediatric hospital setting are roughly equal in size.

The most heated arguments in medicine and in other fields are those for which the correct answer is not known. There are two main impediments to arriving at the correct answer in the field of child abuse. The first impediment is the circular reasoning that plagues many attempts to describe and classify child abuse. When one is attempting to discern, for example, if a given finding is associated with abuse, and the presence of that finding is used in the determination of whether the injury is classified as abusive, the conclusion is invalidated. The antidote to this problem is the development of strict criteria for the inclusion of cases into a category of inflicted injury. To this end, algorithms and clearly defined criteria are extremely helpful, and have begun to appear in more recent series [23–25]. Although none of these schemes is streamlined and simple, each attempts to use objective criteria to determine whether a given set of clinical and radiologic findings, in the setting of a specific history, is likely to be caused by abuse or accident.

The second impediment to determining whether a given mechanism can be correlated with a specific injury type is incomplete data. The data base for discerning what injuries result from what mechanisms includes case series of accidental injuries, case reports, experimental data from animal and modeling studies, and anecdotal clinical experience. Although progress is being made on all fronts, it remains true that some clinical cases are incapable of fitting into a known set of facts about whether the findings could be caused by a particular described mechanism. What causes consternation is that the child protective and legal systems generally wish the physician to categorize each case into a dichotomous system (abuse or not abuse), whereas the reality is that there are three categories from which to choose: (1) presumed abuse, (2) likely accident, or (3) suspicious for abuse but not presumptive. Adding to the friction is the intrinsic difference between the medical and legal approaches to uncertainty. The physician is trained to seek the actual truth of the situation, and to express uncertainty when it exists. The legal approach is one of advocacy—arguments are presented to support a predetermined point of view, and experts can be used to persuade, even if the facts are incomplete or obscure. It is the duty of the physician caring for a child with a possible inflicted injury to remain objective, to express certainty when it exists, and to admit uncertainty when facts regarding mechanisms necessary or sufficient to cause a given set of findings are not yet known. To this end, the algorithms and criteria mentioned previously may serve as a useful starting point, until such time as better data are available.

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