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CLINICAL Pediatric Emergency Medicine

Inflicted Traumatic Brain Injury: Making the Diagnosis in the Emergency Department

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Inflicted traumatic brain injury (iTBI) is a common cause of morbidity and mortality in young children. Inflicted traumatic brain injury can present with a wide spectrum of symptoms and clinical findings. Children who have milder forms of iTBI and less ominous symptoms, such as vomiting and irritability, may not be recognized until they present later with more serious injury. Although retinal hemorrhages, rib fractures, and subdural hemorrhage are the triad typically associated with iTBI, a minority of patients will have all 3 findings. The importance of recognizing iTBI in a timely manner in the emergency department is vital to protect the child from future and possibly more severe brain injury.
Clin Ped Emerg Med 7:138-142 © 2006 Published by Elsevier Inc.

KEYWORDS **inflicted traumatic brain injury, noninflicted traumatic brain injury, subdural hemorrhage, retinal hemorrhage, rib fractures, metaphyseal fractures, child protective services**

In children younger than 2 years, inflicted traumatic brain injury (iTBI) (eg, shaken baby syndrome) is the leading cause of death from trauma and a major cause of disability. Nearly one quarter of all pediatric hospital admissions for traumatic brain injury (TBI) [1] and two thirds of all infant homicides are the result of iTBI [2]. The incidence of severe or fatal iTBI in infants younger than 1 year is approximately 1 in 3300 [3], making it much more common than most childhood cancers and only slightly less common than type I diabetes. The pediatric emergency department (ED) physician is therefore likely to encounter many children with iTBI during the course of his or her career.

Compared with victims of noninflicted TBI (nTBI), victims of iTBI are typically younger and often have evidence of prior (and therefore repetitive) TBI. They are also more likely to experience noncontact (ie, rotational cranial acceleration and deceleration) injury mechanisms and have more diffuse brain injury and edema [3-7]. Outcome after iTBI is dismal; up to one third of infants die of their injury, and most of the survivors have significant long-term disabilities [8,9]. When compared with children with nTBI, children with iTBI have a worse outcome when adjusting for age and severity of injury [9,10].

The highest incidence of iTBI is in infants younger than 6 months, although it can occur at any age. Infants younger than 6 months are at highest risk for a combination of reasons: (1) infants are more difficult to care for than older children, and therefore, caretakers are more likely to become frustrated; (2) the smaller and lighter the child, the easier it is to shake them; (3) because an infant's head is proportionally larger than an adult's head and because infants have poor neck control, if an infant is shaken, the injury threshold is lower than that in older children. It is important to remember, however, that iTBI can occur at any age, and that children with disabilities and those in the process of toilet training may be at particularly high risk.

The importance of early recognition of iTBI cannot be overemphasized; if not recognized, an abused child may be discharged from an ED or in-hospital setting and

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1522-8401/$ - see front matter © 2006 Published by Elsevier Inc.
doi:10.1016/j.cpem.2006.05.002

returned to a violent environment where he or she may be reinjured or killed. More importantly, the child being evaluated in the ED may not be the only victim; there may be other children at home who are also victims of abuse and/or a caretaker who is the victim of domestic violence.

In this article, we will review (1) the important components of history and physical examination in infants who may be victims of iTBI, (2) the neuroimaging in cases of suspected iTBI, (3) the evaluation for possible coexisting injuries, and (4) the reporting to authorities when iTBI is suspected.

Presentation of iTBI: Early Recognition is the Key

Proper diagnosis of iTBI is challenging even for experienced and astute ED physicians. Often, the difficulty is recognizing that an infant or young child has been the victim of trauma. At other times, the difficulty facing the ED physician is determining whether a given TBI is the result of an inflicted or noninflicted event. Identification of an infant who may be the victim of trauma and/or differentiation of inflicted from noninflicted trauma depend on the history and physical examination, both of which can be difficult to assess in these situations.

The History

Although most young victims of nTBI present for medical care with a clear and consistent history of a major head injury event (eg, a motor vehicle collision), many children with iTBI present with either no history of trauma at all, a vague history without details, or a changing and/or inconsistent history of a minor event such as a short distance fall [4,11,12]. In a retrospective, descriptive study of 110 children hospitalized for child abuse over a 5-year period by O'Neill et al [13], the history of injury was either inaccurate or deliberately evasive in 95 (86%) of the cases. In a more recent study by Ettaro et al [14], 37% of the children with iTBI had no history of trauma compared with just 0.3% of the children with nTBI. When a history is absent altogether, it may be that the person seeking care actually has no idea an injury has occurred. Someone else may have harmed the baby without the caregiver's knowledge.

When there is no history of trauma, the history provided may be such as, "I found him like this when he awoke from a nap." There may be suggestion of a remote poorly defined event, such as, "He may have fallen off the couch yesterday," or of a minor injury such as, "His brother hit him in the head with a toy." In some cases, the perpetrator may provide some part of the truth, such as the child fell against the coffee table when in truth he was thrown against the coffee table. It is extremely important for the ED physician to obtain and document a complete and detailed history of the traumatic event or lack of event that resulted in the child being brought to the ED. This should be done before a child's family learns what injuries the child has sustained. Once caregivers are aware of the injuries, the history of the event often changes, and traumatic events may suddenly be "remembered," which were not presented initially. When traumatic events are described, it is imperative that the ED physician collects as much detailed information as possible, including a description of the position of the child before and after the injury. Asking a caregiver to reenact the event using a doll is often very helpful.

It is important for the ED physician to be aware that there is an extensive base of literature demonstrating that household falls or falls downstairs rarely result in life-threatening brain injury, with the exception of a space-occupying lesion, such as an epidural [11,15,16]. In the absence of a major traumatic event such as a motor vehicle crash, it is imperative that abuse be considered for any child younger than 2 years who presents with intracranial injury.

The Physical Examination

Children with iTBI can present with a wide spectrum of symptoms and signs. Though we typically think of children with iTBI presenting with specific signs of brain dysfunction such as apnea, unresponsiveness, seizures, or cardiopulmonary arrest, this only occurs in a subset of children, often those with the most severe injuries. More commonly, children present with nonspecific clinical signs such as irritability, vomiting, poor feeding, or sleepiness and can have a normal neurologic examination [12,17]. Because such symptoms overlap with many common pediatric illnesses, including gastroenteritis and upper respiratory tract infections, it is easy to attribute them to something other than iTBI, particularly when the child's caretaker does not report any history of trauma.

Some children can have an entirely normal neurologic examination despite having an intracranial injury; multiple studies have shown that up to 6% of children with intracranial injury have an entirely normal neurologic examination [18-23]. A recent study using data from the Pennsylvania Trauma Outcomes Study suggested that some young victims of *fatal* TBI can initially present as lucid (Glasgow Coma Scale score > 12) [24]. In addition to the lack of a clear history of trauma or symptoms of brain injury, almost half of the children with iTBI present without any evidence of external trauma [25,26]. Others present with only subtle indications of trauma such as a scalp or facial bruise that can easily be overlooked [12,20]. It is also possible that subtle changes in the neurologic examination may represent subtle clinical signs of central nervous system (CNS) pathology; asymmetry in the amount of clonus in the infant or asymmetry in tone can point to a CNS cause of symptoms rather than innocuous diagnoses such as colic or gastroenteritis.