

## **Understanding Abusive Head Trauma**

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The decision that a child's head injury resulted from abusive trauma has profound implications for the child and family involved. Questions about mechanism, timing of injury and, consequently, who was the likely perpetrator are also put before medical personnel by legal practitioners who may bear considerable pressure designed to elicit answers expressed in terms of certainty. Despite the obvious import of these decisions and the desire of the legal system for a definitive answer, an unequivocal diagnosis of deliberate inflicted injury is among the most difficult diagnoses to make, because it relies both on facts that were unwitnessed and on comparisons against a data base which is incomplete.

This talk will cover some of what is known and what is unknown in the field of abusive head trauma. A practical approach to the diagnosis of suspected and presumptive inflicted head injury which relies on the clinical history, physical and radiologic findings will be provided. Cases illustrating these principles as well as exceptions will be presented. Areas of controversy, including injury thresholds to specific mechanisms, the significance of retinal hemorrhages, alternate diagnoses, and others will be discussed.

### **Anatomy**

"Head trauma" is a nonspecific, general term that can describe anything from a bruise on the forehead to injury to the brain tissue itself. In order to understand the medical findings related to abusive head trauma, some basic understanding of anatomy is needed. From the exterior of the head inward, the following layers are found:

- Scalp- with the underlying galea
- Skull- also referred to as the cranium
- Membranes surrounding the brain:
  - Dura
  - Arachnoid membrane
  - Pia arachnoid
- Brain

The location of bleeding or injury is described in relationship to the brain and the layers covering the brain. For example, hemorrhage underlying the dura and superficial to the arachnoid is termed "subdural" (from the latin *sub*, under). Likewise, subgaleal hemorrhage denotes bleeding under the scalp.

### **Basic Biomechanics**

CONTACT injuries to the brain result in either a deformation or fracture of the skull, and generally result in FOCAL injury. Resulting injuries include scalp swelling, scalp bruising, cephalohematoma, skull fracture, epidural hemorrhage (EDH), local subdural hemorrhage (SDH), and cortical contusion.

INDIRECT forces, such as acceleration/ deceleration rotational forces seen in abuse, result in differential movement of the brain and vessels inside the skull. These forces result in strain and shear injuries to the brain parenchyma, subdural hemorrhage due to injury to bridging veins, and in significant injury are typically associated with secondary problems such as hypoxic-ischemic injury, cerebral edema and tissue death.

Although there is debate in the medical literature regarding the necessity of impact to cause the typical injuries seen in non-accidental head injury, it is generally agreed that many abused young infants, and the majority of older infants and toddlers, have evidence of both contact and indirect forces accounting for their injury. Furthermore, almost all contact injury includes some amount of indirect force, and are the result of a combination of forces on the head and brain.

### **Epidemiology**

Inflicted trauma is the most common cause of traumatic death in infancy, and CNS injury is the principal cause of child abuse fatalities. The majority of infants admitted to a hospital with brain injury and approximately 25% of children under 2 years of age hospitalized with head trauma will be victims of abuse. The incidence of abusive head trauma is unknown, as many mild injuries go undetected. Recent population-based studies suggests that severe and fatal head trauma occurs in approximately 20/100,000 children. Fathers and boyfriends are the most common perpetrators of abusive head trauma, followed by babysitters and mothers.

### **Presentation**

Clinical findings in non-accidental head injury are, in themselves, non-specific. There is no single clinical finding that can make a definitive diagnosis of abusive head injury. This is because inflicted head injuries include a range of injury types and severities, and these may be manifested in a range of findings identifiable on physical examination, including visible physical findings of the soft tissues, neurologic findings, and non-specific “systemic” findings such as vomiting. Many children have minimal or no physical findings of external injury, but are brought to medical attention because of symptoms – changes in behavior or activity that may or may not be apparent during the examination of the child.

### **Taking a History for Mechanism of Injury and Initial Findings**

When a history of trauma is offered, it is important to get the specific facts. In order to use the information, specific questions need to be asked. These include the following (paraphrased from Pediatrics 90(2):179-185, 1992): What exactly happened, from start to finish? What time did it occur? Was the accident witnessed? By whom? What position was the baby/child in prior to the fall/accident? Through what distance did the baby move? What position was the baby in after the fall/accident? Did the baby strike the head? If so, where and against what? If the baby was struck by an object, how was it moving and how did it strike the baby? If the accident was unwitnessed, what was

the estimated time between the accident occurring and when the baby was first seen? What did the baby do immediately after the accident (or, if unwitnessed, when first seen)? Was the baby unresponsive? Did he/she cry? Were there any changes in breathing? Color? Did any abnormal movements occur (eyes rolling back, other seizure-like behavior)? What happened next? Give a description of how the baby looked until the time medical attention was obtained, and after (e.g., during an ambulance ride, in the ED, etc.). What was the baby doing?

In cases of abusive head trauma the history provided is almost universally inaccurate or false. The caregiver often reports the child's symptoms, without providing a history of injury. Minor trauma, such as falls less than 3 or 4 feet, is sometimes reported. Children with serious abusive head injury present with neurological symptoms, including seizures, vomiting, coma, unresponsiveness, apnea, or impaired consciousness. The physical examination may not reveal evidence of external injury, underlying the importance of clinical awareness regarding the possibility of abuse in symptomatic infants. Jenny, et al, reported that more than 30% of 173 symptomatic infants with abusive head injuries seen by a primary care physician were given an incorrect diagnosis. In 24% of cases, the child was reinjured before the correct diagnosis of abuse was made. Young infants, those without seizures or respiratory compromise, Caucasian infants, and those who came from 2-parent households were more likely to be missed.

### **Physical Examination**

The physical examination of the child may not reveal external evidence of injury. Subtle bruises should be carefully sought, and are sometimes found on the arms, back or chest of the child. Bruises in infants less than 6 months of age, and those who do not yet cruise, should be suspect, as bruising is notably uncommon in this age group. More obvious injuries may be found, including burns, patterned bruises, bite marks. Scalp injuries are not easily detected, and are sometimes not recognized until autopsy.

RETINAL HEMORRHAGES are highly associated, although not diagnostic of, abusive head trauma. The hemorrhages can be unilateral, bilateral, and in multiple layers of the retina. Severe, bilateral hemorrhages that extend to the periphery of the retinas, with or without retinal folds or detachments, are highly suggestive of abuse. Retinal hemorrhages can be detected with direct ophthalmoscopy, but are best evaluated by indirect ophthalmoscopy performed by an ophthalmologist. The differential diagnosis of retinal hemorrhages includes vaginal birth (which typically resolve within days, and are all resolved by one month of age), significant accidental trauma (often in association with SDH), papilledema, sepsis, coagulopathy, galactosemia, severe hypertension, and other unusual conditions. Outside of the neonatal period, abusive head trauma is the most common cause of retinal hemorrhages in children. Retinal hemorrhages have been reported in significant accidental household trauma and from playground falls.

SKELETAL INJURIES can be found in 30 to 70% of patients with inflicted intracranial injury. When present, acute or healing fractures provide strong support for the diagnosis of trauma. Many abusive skeletal injuries, such as rib and metaphyseal fractures, may not

be evident by physical examination. Therefore, skeletal survey is essential in the evaluation of suspected abusive head trauma. A wide variety of skeletal injuries can be seen in association with inflicted head injury, but certain patterns of skeletal injury are characteristic. Rib fractures typically result from indirect forces that occur with anteroposterior thoracic compression during shaking. Rib fractures may be difficult to identify acutely, before the formation of callus. In highly suspicious cases, radionuclide bone scan or repeated plain films completed a few weeks after the initial diagnosis may be a useful adjunct to the evaluation.

Metaphyseal fractures, although found in a minority of infants with inflicted head trauma, are highly characteristic of inflicted injury, and were reported in Caffey's landmark description of abused infants. Metaphyseal fractures are due to planar microfractures through the immature metaphysis. They are most commonly located in the tibia, distal femur, proximal humeri and distal ulnar and radius, and usually heal without orthopedic intervention. Like rib fractures, they may not be evident radiographically until they begin to heal; another reason that repeat skeletal survey can be very useful in the evaluation of suspected abuse.

### **Radiologic Findings**

Intracranial injuries can be detected by a number of imaging techniques, including CT, MRI and ultrasonography. Computed tomography (CT) done initially usually reveals subdural hemorrhage, which can be located anywhere around the cortex, but is often seen in the posterior interhemispheric fissure or along a cerebral convexity. Cerebral hypodensity, indicating edema and infarction, may be absent on the first scan, but occasionally can be seen within an hour or two of injury. Cerebral hypodensity typically progresses in the first few days after presentation. Magnetic resonance imaging (MRI) is typically used in the subacute and chronic phase of injury to identify the extent of an injury. MRI is more sensitive than CT in detecting intracerebral contusions, shear injuries (axonal injury), and may assist in determining approximate ages of extra-axial hemorrhage. MRI is not as sensitive as CT scan in detecting acute SAH, and is not as specific as CT for detecting acute intracranial hemorrhage. CT and MRI scans can be used to approximate the timing and dating of injuries, although these methods have limitations, and the dating of injury relies on both clinical and radiographic features.

### **Management, Outcome and Prevention**

The initial approach to management of children with suspected abusive head trauma is dependent on the severity of injury. Most children require hospitalization, and those severely injured require intubation, ventilation, fluid resuscitation, and anticonvulsants. Initial therapy is aimed at limiting increased intracranial pressure and preventing or treating seizures. Severely injured children (those with bilateral cerebral hypodensity) have poor outcome despite therapy. Children with more moderate to mild injury can have variable outcomes. Abusive head injury carries a worse overall prognosis than accidental injury. Focused prevention efforts to date have not been critically researched. Nurse home visitation for young, first-time mothers has been shown to have numerous benefits, including reduction in child abuse and neglect (Olds). A recent

program that teaches parents of newborns the dangers of shaking through video and nurse education suggests success at decreasing rates of abusive head trauma, although results have not been replicated to date. These approaches, along with increased public awareness, may favorably impact the incidence and consequences of abusive head trauma.

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