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The recognition of non-accidental injury is critical for a pediatric trauma patient. In the year 2000, almost 3 million reports of child abuse were made to social service agencies.¹ More importantly, 1200 children died from neglect or abuse in that same year.¹ Forty-four percent of the fatalities were children younger than 1 year of age.¹ Not only are these statistics alarming, but they point out the need for emergency department (ED) and trauma physicians and nurses to recognize non-accidental injury and aggressively protect the children who seek our medical expertise and protection.

—The Editor

Child abuse and neglect are not uncommon, and clinicians who provide trauma care to children will encounter from several to many cases during a career. Child abuse is defined by federal legislation that provides minimum guidelines for states to incorporate into their criminal and civil statutes. Subsequently, each state in the United States has a working legal definition of child abuse and neglect.²⁻⁵

There are four basic types of child maltreatment—physical abuse, sexual abuse, emotional abuse, and child neglect.⁵ Child neglect is the most common form of child maltreatment investigated and is the failure to provide for a child's basic needs. This

can include physical, emotional, medical, supervisory, and educational neglect. Each state has different definitions that help determine if a given situation meets the standard for neglect. Child Protective Services (CPS) is the branch of public social services that investigates reports of child abuse and neglect in

which caretakers are involved as possible perpetrators. Law enforcement is involved in many of these cases and also has primary responsibility for investigating cases in which strangers and noncaretakers are the alleged perpetrators. CPS has to investigate any reported child maltreatment and then provide support services to the family if indicated.

Physical abuse and sexual abuse probably are the most common types of child maltreatment seen in ED settings. The physicians and nurses in these situations have the responsibility of recognizing clues to abuse or neglect and reporting them to appropriate agencies.

A medical provider must be very familiar with his or her state's reporting laws covering child maltreatment. All states list health care workers as mandated reporters of child maltreatment. To report a case to CPS, the provider need only have a suspicion that maltreatment or neglect has occurred, not proof.² CPS is

Non-accidental Injury: Recognizing Child Abuse in the Pediatric Trauma Patient

Authors: Elaine Cabinum-Foeller, MD, Director, Forensic Pediatrics, Department of Pediatrics, Brody School of Medicine, Greenville, NC; Ronald M. Perkin, MD, MA, Professor and Chairman, Department of Pediatrics, Brody School of Medicine, Greenville, NC.

Peer Reviewer: Steven E. Krug, MD, Professor of Pediatrics, Northwestern University Medical School, Division of Pediatric Emergency Medicine, Children's Memorial Hospital, Chicago, IL.

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Chief of Trauma and Surgical Critical Care
Associate Professor of Pediatric Surgery
Department of Pediatric General and Thoracic Surgery
Children's Hospital of Philadelphia, PA.

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given the job of investigating any report when the agency believes the report meets a minimal standard of likelihood. All states mandate reporting without risk of liability if the report is made without malicious intent.² A medical provider can incur liability for failing to report a case of suspected child maltreatment. It is important to emphasize to parents (or other caretakers) that reporting is not an accusation, but is a legal requirement based on the assessment to that point.

Important factors to assess in possible abuse or neglect situations are the history, the child's developmental abilities, physical examination findings, and the presence of other risk factors for abuse and neglect. These risk factors include, but are not limited to, young maternal age (< 15 years), prior social service investigations, prior law enforcement involvement, substance abuse in the family, domestic violence, low socioeconomic status, and disability or prematurity of the child.^{4,6,7} It also is important to remember that the absence of risk factors does not rule out abuse, and is not a reason to fail to report if suspect findings are present.

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Vice President/Group Publisher: Brenda Mooney

Editorial Group Head: Valerie Loner

Managing Editor: Allison Mechem

Marketing Manager: Schandale Kornegay

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The intended audience for this publication is emergency, family, osteopathic, and general practice physicians and nurses who have contact with trauma patients.

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The abused child presents a unique set of epidemiologic, physiologic, and social circumstances.^{9,10} The clinical history often is difficult to obtain, and deliberately may be obfuscatory, false, or contradicted by physical findings or known patterns of injury. The presentation frequently is delayed, allowing many mechanisms of secondary injury to become well established. Abused children, especially infants, often present with nonspecific complaints and findings.¹¹⁻¹³ These children frequently present with respiratory distress or apnea, but vomiting, mental status changes (lethargy or irritability), poor feeding, or nonspecific behavioral changes also are common.^{11,14} Seizures are reported in up to 70 % of patients.¹¹ Many abused children are repetitively traumatized; thus, the presenting incident may simply be the worst (or most recent) of several episodes.^{15,16}

An unsuspecting physician may accept a false history of trauma and not consider the possibility of abuse. To identify abused children, child abuse needs to be included on the differential list of all pediatric injuries.⁴ In most instances, child maltreatment quickly will be eliminated from the differential, but a small dose of suspicion is needed to identify abused children.

The diagnosis of child abuse is made like all others—a careful history, complete physical examination, and supporting laboratory and radiographic data lead to a working diagnosis. In some cases, the physical examination alone indicates abuse, but in most cases, the comparison of the history of trauma and the resulting injuries suggests the diagnosis. The following are general indicators of possible child abuse:⁴

- Infants and children with unexplained injuries;
- The history provided does not adequately explain the injuries;
- The history provided changes with time;
- The history provided does not correlate with the child's developmental abilities; or
- There is an unexplained delay in seeking medical care.

Clinically, child abuse may be obvious or subtle. A child with external signs of trauma, known as a "battered" child, should be treated the same as any trauma victim.^{12,13,17} Abused children with less obvious presentations often have injuries falling into certain patterns. Retinal hemorrhages are common after head injury from child abuse, and need to be documented and taken into consideration with other clinical and radiographic findings.^{11,18,19} Retinal hemorrhages are not all the same and should be described thoroughly, including amount, type, distribution, and side affected (bilateral, unilateral, or asymmetric).

Suspicion of nonaccidental trauma should prompt immediate investigation. Social work, CPS, and any appropriate social or legal authorities should be involved as soon as possible.

History and Physical Examination

The initial history often is the first clue to the detection of child abuse. Obtain a detailed history, including location, time, and mechanism of any injury described. The identification of significant injury unaccompanied by a history of trauma is cause for concern. If the history does not seem to explain the injury identi-

fied, the possibility of abuse should be considered. Parents who provide a false history of trauma to explain a child's abusive injuries most commonly offer simple household trauma as an explanation.¹² For example, infants or toddlers with abusive head injury often are said to have fallen off a bed or couch.

It is important to document the events from the time of the injury leading to the medical visit. Some parents, in an effort to explain inflicted injuries, provide various histories to explain an injury, or change the story once additional injuries are identified. A comparison of histories obtained from various health care providers, pre-hospital personnel, emergency physicians, hospitalists, or intensivists may reveal inconsistencies. Also, compare histories obtained from adult caregivers present at the time of injury.

An unexplained delay in seeking medical care should be recorded and explored. In an effort to prevent detection of abuse by professionals, parents occasionally will keep their injured child at home, despite the obvious need for medical intervention.

The physical examination of the child must be complete. Examine all surfaces of the child's skin carefully, and document any injuries. In infants, subtle external injuries are often a clue to more serious internal injury, and should not be dismissed. Bruises, burns, and scars should be measured, and their size, shape, location, and color recorded. Photographs are an important adjunct to the recorded physical examination, but are not an appropriate substitute for accurate medical documentation.

Craniofacial, head, face, and neck injuries occur in more than half of the cases of child abuse.³ Careful intraoral and perioral examination is necessary in all cases of suspected abuse. Some authorities believe that the oral cavity may be a central focus for physical abuse because of its significance in communication and nutrition.³ The injuries most commonly are inflicted by blunt trauma with an instrument, eating utensils, hands, or fingers or by scalding liquids or caustic substances.^{3,20} The abuse may result in contusions; lacerations of the tongue, buccal mucosa, palate, gingiva alveolar mucosa, or frenum; fractured, displaced, or avulsed teeth; facial bone and jaw fractures; burns; or other injuries. These injuries, including a lacerated frenum, also can result from unintentional trauma. Gags applied to the mouth may leave bruises, lichenification, or scarring at the corners of the mouth.

Laboratory and Radiographic Data

Abused children often have occult injuries, and some medical diseases may mimic abuse. Therefore, the laboratory and radiographic evaluation of the abused child is guided not only by the history and physical examination findings, but also by the above considerations. Necessary laboratory and/or radiographic testing varies by age, injury pattern, and severity. The following studies may be appropriate in the evaluation of an abused child.

Laboratory Studies. Hematologic Evaluation. A complete blood count (CBC) with platelet count, prothrombin time (PT), and partial prothrombin time (PTT) are indicated for children who present with bleeding or bruising. Elevations of PT and PTT may be the result of severe inflicted head injury.²¹

Liver Function Tests/Pancreatic Enzymes. Alanine aminotransferase (ALT), aspartate aminotransferase (AST), amylase, and/or lipase may be elevated with acute liver or pancreatic injury. Such injuries can be asymptomatic, and screening is recommended for injured infants and children in whom the abdominal examination may not be a sensitive indicator of injury.

Urinalysis. The urinalysis is used as a screen for renal or bladder trauma, and can detect myoglobinuria secondary to rhabdomyolysis from severe beatings.

Toxicology screens are indicated for infants and children with unexplained neurological symptoms.

Diagnostic Imaging. Imaging studies often are critical in the assessment of the infant and young child with evidence of physical injury, and they also may be the first indication of abuse in a child who is seen with an apparent natural illness.^{4,22,23} When viewed in conjunction with clinical and laboratory studies, imaging findings commonly provide support for allegations of abuse. For severely abused infants, the imaging findings alone may form the basis for a diagnosis of inflicted injury.²² The role of imaging in cases of suspected abuse is not only to identify the extent of physical injury when abuse has occurred, but to elucidate all imaging findings that may point to alternative diagnoses. Because most conventional imaging studies performed in these settings are noninvasive and entail minimal radiation risks, recommendations about imaging should focus on examinations that provide the highest diagnostic yield at acceptable cost.²²

Roentgenographic Skeletal Survey. The skeletal survey is an important adjunct to the evaluation of abused infants and toddlers, and is indicated for all children younger than 2 years with any suspicious injury.⁴ Guidelines for the appropriate imaging methods have recently been updated by the American Academy of Pediatrics.²²

Although skeletal injuries rarely pose a threat to the life of the abused child, they often are the strongest radiologic indicators of abuse. In fact, in an infant, certain patterns of injury are sufficiently characteristic to permit a firm diagnosis of inflicted injury in the absence of clinical information.²² This fact mandates that imaging surveys performed to identify skeletal injury be performed with at least the same level of technical excellence routinely used to evaluate accidental injuries. The "body gram" (a study that encompasses the entire infant or young child on one or two radiographic exposures) or abbreviated skeletal surveys have no role in the imaging of these subtle but highly specific bony abnormalities.²²

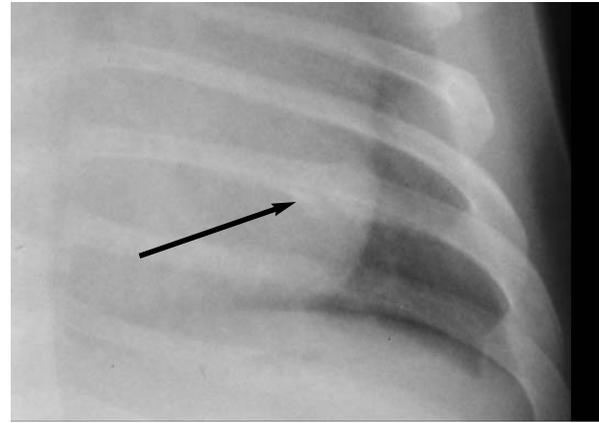
In general, the radiographic skeletal survey is the method of choice for global skeletal imaging in cases of suspected abuse. The standard skeletal survey imaging protocol that has been developed by the American College of Radiology is given in Table 1.^{22,24} Anteroposterior and lateral views of the skull are mandatory even when cranial computed tomography (CT) has been performed because skull fractures coursing in the axial plane may be missed with axial CT. Skeletal injuries, especially those requiring orthopedic management, necessitate at least two radiographic projections. Oblique views of the thorax increase the yield for the detection of rib fractures. (See Figure 1.) Recent

Table 1. Standard Skeletal Survey

APPENDICULAR SKELETON	AXIAL SKELETON
Humeri (AP)	Thorax (AP and lateral)
Forearms (AP)	Pelvis (AP; including middle and lower lumbar spine)
Hands (Oblique PA)	Lumbar spine (lateral)
Femurs (AP)	Cervical spine (lateral)
Lower legs (AP)	Skull (frontal and lateral)
Feet (AP)	

AP= anteroposterior; PA=posteroanterior

Figure 1. Oblique View to Detect Rib Fracture



Shallow oblique radiograph demonstrating a subtle rib fracture in a victim of child abuse.

evidence suggests that a follow-up skeletal survey approximately two weeks after the initial study increases the diagnostic yield, and this procedure should be considered when abuse is strongly suspected.^{24,25} The repeated study may permit more precise determination of the age of individual injuries. Lack of interval change may indicate that the initial radiographic finding is a normal anatomic variant or is related to a bone dysplasia.

Radionuclide Bone Scan. A bone scan identifies areas of increased bone turnover, and is a sensitive method for detecting rib fractures fewer than 7-10 days old, subtle diaphyseal fractures, and early periosteal elevation.²⁴ A bone scan is most commonly used as an adjunct to the skeletal survey when abuse is strongly suspected and the skeletal survey is normal. Conversely, the skeletal survey can be repeated 3-4 weeks after the initial survey to increase the detection of healing injuries.

Computed Tomography Scan. A CT scan is the method of choice for diagnosing acute intracranial, pulmonary, and solid abdominal organ abnormalities in children with serious injuries.²²⁻²⁴

Magnetic Resonance Imaging (MRI). MRI scans of the brain are more sensitive than CT scans in detecting certain traumatic injuries, including axonal shearing, cortical contusions, and brainstem injuries.²²⁻²⁴

Manifestations of Physical Abuse

Nonaccidental injuries may affect any organ system in the body, alone or in combination. The following are common manifestations of child abuse.

Head Trauma. Trauma is the most common cause of death in childhood, and inflicted head injury is the most common cause of traumatic death in infancy.^{6,11,26,27} On average, among children hospitalized for blunt trauma, those injured by abuse sustain more severe injuries, use more medical services, and have worse survival and functional outcome than children with unintentional injuries.^{16,26,28-30} This is despite a plethora of interventions developed over the last 30 years, including legislatively mandated reporting and the establishment in 1974 of the National Center on Child Abuse and Neglect as a mechanism to increase knowledge of the problem and identify steps to prevent it.⁶

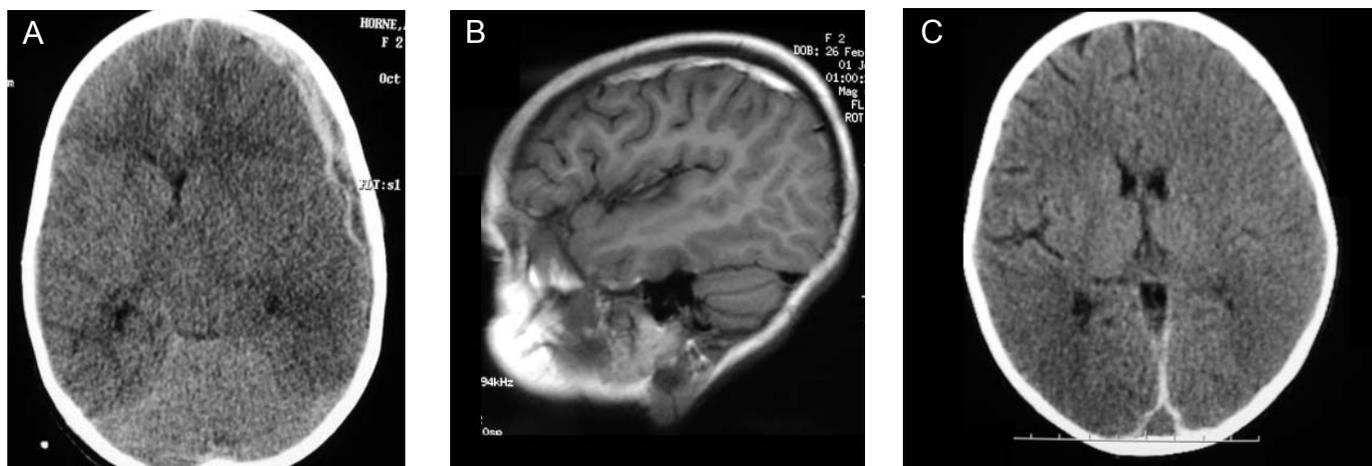
The major issue plaguing the description of abuse-related injuries to young children has been and continues to be accurate diagnosis.^{26,31,32} The dire consequences of either false-positive or false-negative diagnosis intensifies the need to establish accurate diagnostic criteria.

Because of some unique features of the infant brain, the risk for severe intracranial injury is great.¹² With a large head-to-body ratio and relatively weak neck muscles, infants are more susceptible to the acceleration/deceleration forces of abusive head trauma. In addition, the immature brain, not fully myelinated, has only 25% of its adult weight at birth, and 75% by age 2 years.³³ There is more subarachnoid space, and therefore a greater vulnerability to shearing of blood vessels causing significant hemorrhage. There is a common misconception that infants will tolerate an acute insult better than their adult counterparts because the fontanel is open; however, it must be remembered that the brain is encased by the inelastic dura.³³ The infant has a shorter craniospinal axis than the adult and thus has less of a “potential space” to displace blood volume and cerebrospinal fluid; this can make the infant brain more susceptible to increased intracranial pressure and secondary brain injury.³³

Head injuries in infants and toddlers can be difficult to diagnose because symptoms are often nonspecific.¹² Vomiting, fever, irritability, and lethargy are common symptoms of a variety of conditions seen in children, including head trauma. When caretakers do not give a history of injury and the victim is preverbal, an abusive head injury mistakenly can be diagnosed as a less-serious condition. When medical personnel fail to recognize that the child’s symptoms are secondary to nonaccidental head injury, the child is frequently re-injured or has serious complications of the unrecognized, untreated head injury.³⁴

The primary brain injury attributed to child abuse was originally thought to result from repetitive accelerative-decelerative forces of shaking, hence the term “shaken-baby syndrome.”¹¹ However, biomechanical studies subsequently suggested that the inertial forces developed from shaking were insufficient to cause diffuse axonal injury (DAI), suspected to be the primary mechanism of neuronal injury after abuse.¹¹ Because impact with even a soft surface, such as a bed or crib, could theoretically cause DAI, the concept of the “shaken-impact syndrome” developed.¹¹ Recent reports have shown, however, that diffuse changes consis-

Figure 2. CT and MRI in Children with Subdural Hemorrhage and Ischemic Changes



A—Computed tomography (CT) from a 2-year old showing subdural hemorrhage, edema, and shift. **B**—T1-weighted magnetic resonance imaging (MRI) scan showing subdural hemorrhage in a nonaccidental trauma victim. **C**—Interhemispheric hematoma demonstrated on CT scan.

tent with hypoxic-ischemic damage are more common than DAI, which is found mostly in the brainstem, and that cervical spine injury is frequent.^{9,35-37} This suggests that the inertial forces of shaking cause brainstem and spinal injuries, which lead to respiratory impairment and subsequent hypoxic injury.

Apnea induced by shaking or by shaking combined with impact plays a major role in the pathophysiology of nonaccidental head trauma and accounts for the poor outcome in this group of patients.^{14,38} Trauma induced apnea causes cerebral hypoxia and possibly ischemia, which may be more fundamental to outcome than the mechanism of injury (shaken vs shaken with impact), subdural hemorrhage, subarachnoid hemorrhage, diffuse axonal injury, parenchymal shear, or brain contusion. In addition, the timing of the primary injury is closely linked to the onset of apnea.^{37,39}

CT scanning is a mainstay of the diagnosis of nonaccidental head injury.^{22,40} Subdural or subarachnoid hemorrhage almost always can be detected on CT scans, although the more subtle findings may be missed by less experienced observers.⁴⁰⁻⁴⁴ The most frequent CT findings in nonaccidental traumatic brain injury are a combination of subdural convexity and interhemispheric hematomas.^{16,26,45} The interhemispheric subdural hematoma is particularly characteristic of the shaking or shaking-impact mechanisms in which angular acceleration and deceleration forces are involved. (See Figure 2.)⁴⁶ The majority of subdural hemorrhages in children younger than 2 years are due to child abuse.^{40,43} MRI is useful in detecting and characterizing small extraaxial hemorrhages in infants with equivocal CT findings.^{46,47}

The neuroradiologic findings of abuse often are present within a few hours of the assault, particularly when the event results in hypoxia-ischemia.^{14,37,46} In these cases, the CT may show findings of edema as early as 2 hours following the documented event.⁴⁶ The earliest CT sign is often a loss of cerebral gray-white matter

differentiation in the cortical and subcortical regions, in deep basal ganglia and capsular regions, or in both. Hypoxic-ischemic brain injury may result from associated brainstem injury with apnea, from progressive edema and increased intracranial pressure, or from additional suffocation or strangulation.⁴⁶

All infants and children with suspected intracranial injury must undergo either cranial CT or MRI. (See Figure 2.) Strategies should be directed toward the detection of all intracranial sequelae of abuse and neglect with a thorough characterization of the extent and age of the abnormalities. In the acute care setting, efforts are directed toward rapid detection of treatable conditions. Subsequent studies are designed to delineate more fully all abnormalities, determine the timing of the injuries, and monitor their evolution.^{44,46}

Radiologists evaluating imaging studies of young children, even those in whom there is no suspicion of physical abuse, should routinely assess subtle signs of chronic brain damage in addition to acute findings.^{16,41,44} Investigators have identified elevated rates of cortical atrophy, ventriculomegaly, and subdural hygroma only in children with inflicted traumatic brain injury.¹⁶

MRI is the best modality to assess fully intracranial injury, including extraaxial collections, intraparenchymal hemorrhages, contusions, shear injuries, and brain swelling, or edema.⁴³ Imaging should be performed with T₁ and T₂ weighting with proton-density or inversion-recovery sequences to differentiate cerebrospinal fluid collections from other water-containing lesions. Diffusion imaging is a new and valuable technique for the evaluation of cerebral ischemia and likely will have a role in the assessment of inflicted cerebral injury.^{36,48} Abused infants may not demonstrate neurologic signs and symptoms, despite significant CNS injury. The MRI offers the highest sensitivity and specificity for diagnosing subacute and chronic injury and should be considered whenever typical skeletal injuries associated with shaking or impact are identified.

Table 2. Nonaccidental Trauma: Hints to Facilitate an Early Diagnosis

FRACTURES

- No single fracture is pathognomonic of child abuse.
- Certain patterns of fractures should increase the concern for abuse, including multiple fractures and fractures of different ages.
- Multiple, bilateral posterior rib fractures in infants are almost always the result of abuse.

BABIES WITH BRUISES

- With advancing age and motor skills, bruises occur more commonly.
- Bruises in mobile infants normally are located on the front of the body, typically on the shins and forehead.
- Bruises in infants younger than 9 months who are not yet beginning to ambulate should lead to consideration of abuse or illness.
- Bruises in toddlers that are located in atypical areas, such as the trunk, genitalia, neck, hands or buttocks, should be considered abuse.

SKULL FRACTURES: ACCIDENTAL VS. NON-ACCIDENTAL

- Inflicted
 - History does not correlate with mechanism of injury, OR no history
 - Associated with intracranial injury, especially subdural hematomas
 - Bilateral
 - Non-parietal
 - Comminuted/Stellate
 - Depressed
 - Wider than 1 mm
 - Associated with other injuries
 - Crossing suture lines
- Accidental
 - History consistent with injuries
 - Not associated with intracranial injury
 - Unilateral
 - Parietal
 - Linear
 - Nondepressed
 - Narrower than 1 mm
 - Involves only one body area
 - Does not cross suture lines

Many studies have demonstrated the usefulness of MRI in suspected acute nonaccidental head injury. It is particularly useful for the diagnosis of subdural hematomas in the subtemporal area, illustrating tearing of the bridging veins, delineating subdural hematomas of different ages, and demonstrating hemorrhages at the gray-white matter junction.⁴⁷ All these features are not well defined by CT.

Several selected points culled from an extensive literature review may prove useful in recognizing nonaccidental trauma in infants and children. (See Table 2.)^{2,27}

There is an abundance of literature attesting to the fact that short falls (< 4 feet), such as from beds, couches or down stairs,

do not cause serious injury in children, except the case of epidural hematoma, which can occur after short falls.^{2,26,49-58} However, some of the most severe infant head injuries occur when an adult falls on the stairs while carrying an infant.^{55,59,60} The relative severity of these injuries is probably the result of two different injury mechanisms: fall from a height and a fall down stairs.⁶⁰ These two mechanisms can increase the impact force.

Simple skull fractures are common in accidental falls, with complex fractures seen less frequently.²⁶ Subdural hematomas and subarachnoid hemorrhages seldom are seen and retinal hemorrhages virtually are never seen in short falls.²

Inflicted head injury in infants commonly presents as shaken baby syndrome. Altered level of consciousness, coma, seizure, listlessness/lethargy, irritability, apnea or respiratory difficulty, and poor feeding can be associated with shaken baby syndrome. Although not pathognomonic for child abuse, retinal hemorrhages occur in up to 75-85% of these cases and frequently correspond with subdural or subarachnoid bleeding.^{13,18} Skeletal trauma, such as sternal fractures and posterior rib fractures, frequently are seen in shaken baby syndrome due to the placement of the perpetrator's hands. Acceleration/deceleration forces are created as the head whips forward, stopping as the chin strikes the chest, then backward until the occiput strikes the back, as well as when the baby is thrown on the sofa or bed. Shearing injuries to the intracranial bridging veins and incompletely myelinated cortical nerves are sustained. CT scanning is an excellent tool for detecting subdural and subarachnoid hemorrhages, especially when associated with retinal hemorrhages. Epidural hemorrhage in infants is less likely to be caused by shaking and more likely to be due to a blow or fall.^{13,61,62} Epidural hemorrhages are rarely a result of abuse.

Finally, the evaluating physician also must be aware of certain conditions that are known to have clinical and imaging features that may mimic abuse.^{2,12,63} These include accidental injury, certain coagulopathies, vascular diseases, infections, metabolic disorders, neoplastic diseases, certain therapies, and some congenital and dysplastic disorders. Infants who present with unexplained subdural and retinal hemorrhages most often are victims of child abuse. However, an autosomal recessive metabolic disorder, glutaric acidemia type 1, is a known cause of these findings in children.^{63,64} Urine organic acid testing will show a characteristic large peak of glutaric acid and 3-hydroxy glutaric acid. The diagnosis can be confirmed through testing of enzyme activity in cultured fibroblasts and leukocytes or through genetic mutation analysis.

Abdominal Trauma. Severe abdominal injury is an uncommon, but well recognized, manifestation of abuse.⁶⁵ The history almost always is misleading, and rarely includes a history of abdominal trauma. Less severe injury is under-recognized and underreported, because symptoms are non-specific and external indications of abdominal trauma are often lacking.²³

Most abusive abdominal injury is caused by blunt trauma, resulting in solid organ injury, perforation of hollow viscous, or shearing of mesenteric vessels.^{4,65-68} Isolated solid organ injuries are most common with both accidental and inflicted injuries,

although hollow visceral injuries more commonly are associated with abuse.⁴ Recent reports of abdominal trauma secondary to abuse reveal that liver and spleen injuries are most common, followed by duodenojejunal rupture, duodenal rupture, and pancreatic, vena cava, and renal trauma.^{66,67} These injuries are thought to be due to compression of abdominal viscera against the vertebral column following a punch or a kick.⁶⁶ The small size of the child's abdomen predisposes them to multiple organ injury. Children with severe liver or mesenteric injury usually present with signs and symptoms of acute bleeding, including hemorrhagic shock.⁶⁶ Children with intestinal perforation typically present with signs of peritonitis. Their presentation for medical care can be delayed by hours or days, but an accurate history (often lacking) should demonstrate progressive abdominal symptoms.⁶⁶ Mortality is extremely high owing to delays in presentation and the magnitude of injuries.⁶⁸

Abused children occasionally have asymptomatic abdominal injuries, which can be detected with evaluations of serum liver function tests (LFTs), amylase, and lipase.⁶⁶ Abdominal trauma is diagnosed by physical examination, screening LFTs, amylase, lipase, urinalysis, sonography and abdominal CT.⁶⁵⁻⁶⁸

Injuries involving the duodenum are a common finding in blunt trauma to the abdomen, and include duodenal hematomas or transection. Such injuries to the duodenum occur because the ligament of Treitz is a relatively fixed structure and allows compression of the duodenum against the vertebrae. (*See Figure 3.*)⁶⁵ It is not infrequently associated with injuries to the adjacent organs. Unfortunately, there are often delays in making the diagnosis because the retroperitoneum, in which part of the duodenum lies, offers some protection and this contributes to the morbidity and mortality of these injuries.

Life-threatening intraabdominal injuries can exist with few signs or symptoms. One research team describes a 2½-year-old child who presented with relatively few symptoms, who at post mortem examination was found to have peritonitis secondary to a duodenal rupture which was considered to have occurred 2-3 days before death.⁶⁹

Liver injuries also can be occult with no evidence of external injuries. One study found, in children suspected of nonaccidental injury who had no history or physical signs of abdominal trauma, evidence of occult liver lacerations on CT in 6% of cases.⁷⁰ Researchers also found that raised transaminases were associated with these cases and consider that this is a useful indicator of occult liver injury.⁷⁰

Nonaccidental trauma as a cause of pancreatic injury is not uncommon. One group reported one-third of their series of 49 cases of pancreatitis in children as being associated with nonaccidental injury.⁷¹ As in adults, pancreatitis in children is associated with considerable morbidity and chronic pancreatitis may develop.

Fractures. Fractures often are seen in physical abuse cases.⁷² They also are a common accidental childhood injury. As in the preceding cases, the clinician must ask, "Is the injury consistent with the history and developmental stage?"

Abusive fractures are more common in younger children (< 5 years of age), often present without a history of trauma, and

often are characterized by a delay in seeking medical care.⁷² Any fracture can be the result of abuse.³ It is the history, physical examination, and additional evaluation that are crucial in differentiating accidental from nonaccidental trauma. In children younger than 2 and selectively in children younger than 5 years of age, a skeletal survey is in order to look for other injuries, some of which may be occult.

A common type of history given in both abusive and unintentional injuries is a fall. Although a history of a fracture in a minor fall should be investigated, single unintentional fractures can occur from falls of fewer than two feet, and falls from fewer than four feet can result in injury to more than one bone.⁷³

Radiographically, some fractures are more suspect for abusive injury than others.^{24,72,74} Fractures that are highly specific for abusive injury in infants include the following: posterior rib fractures, scapular fractures, spinous process fractures, sternal fractures, and classic metaphyseal lesions. The classic metaphyseal lesions often are called bucket handle or corner fractures, and occur at the end of the long bones at the growth plate. Fractures with moderate specificity for abuse are complex skull fractures, digital fractures, vertebral body fractures, epiphyseal separations, fractures of different ages, and multiple fractures. Fractures common in childhood with low specificity for abuse are linear skull fractures, long bone fractures, and clavicular fractures. The appearance of subperiosteal new bone formation in infants also is common, but can be a normal variant. A pediatric radiologist may help with this evaluation when appropriate.

Linear parietal skull fractures are common whether unintentional or secondary to abuse.⁷² However, skull fractures that are multiple, depressed, diastatic more than 3 mm, bilateral, or cross suture lines are more suggestive of intentional injury, especially coupled with a suspicious history.^{24,72,73}

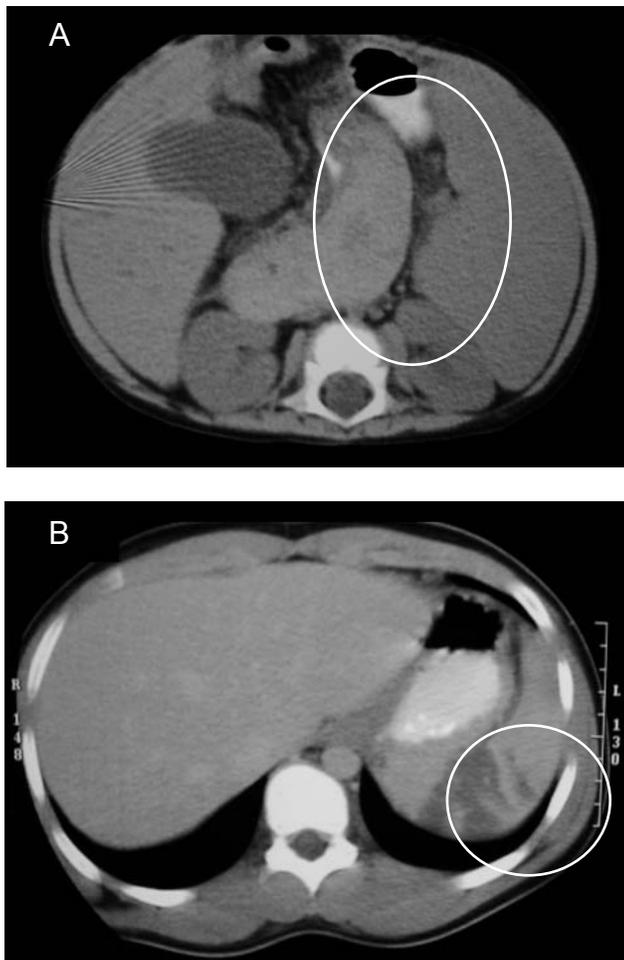
The humerus is the most commonly fractured bone in battered children.^{72,75} Several authors have reported that the majority of humerus fractures in infants younger than 15 months are intentional.⁷²

Rib fractures commonly are seen in abused children, with 90% of abuse-related fractures occurring in children younger than 2 years.^{72,76,77} In infants, rib fractures are the most frequent fracture of abuse.^{72,78} In general, rib fractures in children are much less common than in adults owing to their more compliant chest walls. Therefore, rib fractures, especially multiple fractures, are very suggestive for abuse in children younger than 2 years in the absence of major blunt trauma or prior bone pathology.⁷²

Abusive fractures typically occur when the infant is manually grabbed around the thoracic cage and violently squeezed and shaken. This anteroposterior compressive force results most frequently in multiple, symmetrical, posterior rib fractures where mechanical stress is at its greatest. With increasing force, lateral then anterior fractures occur.⁷⁹ Of importance, rib fractures from cardiopulmonary resuscitation are rare in infants and young children.⁷²

Diseases such as osteogenesis imperfecta, rickets, and osteomyelitis can mimic abusive injuries.⁷² Most have other clini-

Figure 3. Abdominal Trauma



A—Duodenal hematoma. **B**—Splenic lacerations.

cal manifestations that distinguish them from abuse, and may be diagnosed by simple blood tests.⁴

Bruises. A bruise is an area of skin discoloration caused by the escape of blood from ruptured underlying blood vessels after an injury. It is the process of hemoglobin degradation and its expression through the “window” of the skin that determines the color of a bruise.⁸⁰ They are a common injury in children and often are accidental. However, bruises may be a sign of physical abuse.⁸⁰⁻⁸⁵ To evaluate whether a bruise is abusive or accidental, it is important again to look at the history, the child’s developmental level, the pattern of the bruising, and other findings on physical examination.

In general, bruises are very difficult to age by appearance alone, especially in children. A yellow color to the bruise indicates that it is probably more than 18 hours old. However, red, blue, purple, and brown can be seen at any time. The healing of bruises is affected by the area of skin involved, the depth of the bruise, the amount of blood in the bruise, and other factors.⁸⁰ Therefore, the dating and aging of bruises is inexact.⁴

The history of the bruise is important—both from the caretaker

and the child, if obtainable. When was the first time the bruise was noted? What is the reported mechanism—fall, play, sports? Does the mechanism of injury match the bruise seen? Could the child do what is reported?

In the physical examination, it is important to look at all areas of skin and document any injuries. The area of the body affected is important because some areas are more suspect for abuse than others.⁸³⁻⁸⁵ Some areas of the body such as the back, buttocks, neck, cheek, ear, thighs, genitalia, and hands are atypical areas of accidental bruises. Grab marks sometimes are seen on the upper arms. Some bruises may appear patterned. Patterns of concern for abusive injury are looped cord marks, hand prints, and other patterns that could be matched to an object such as a shoe, belt, or other implement.² Patterns of abusive bruising also may be determined by the anatomy of the injured body part rather than the shape of the injuring object. Two examples include patterned abusive bruises of the buttocks and the pinnae.^{86,87}

Bite marks are lesions that may indicate abuse.³ Bite marks should be suspected when ecchymoses, abrasions, or lacerations are found in elliptical or ovoid patterns. Bite marks may have a central area of ecchymoses. The normal distance between the maxillary canine teeth in adult humans is 2.5-4.0 cm, and the canine marks in a bite will be the most prominent on deep parts of the bite.³ Bites produced by dogs and other carnivorous animals tend to tear flesh, whereas human bites compress flesh and can cause abrasions, contusions, and lacerations but rarely avulsions of tissue. If the intercanine distance is less than 2.5 cm, the bite may have been caused by a child. If the intercanine distance is 2.5-3.0 cm, the bite was probably produced by a child or small adult; if the distance is greater than 3.0 cm, the bite was probably by an adult.³ The pattern, size, contour and colors of the bite mark should be evaluated by a forensic odontologist or forensic pediatrician or pathologist if an odontologist is not available. A photograph, taken at a right angle to the bite should be taken with an identification tag and scale marker in the photograph. Because each person has a characteristic bite pattern, a forensic odontologist may be able to match dental models (casts) of a suspected abuser’s teeth with photographs of the site.

The differential diagnosis for bruises is long.^{2,82} Mongolian spots often are confused with bruises. Mongolian spots do not fade or change over days to weeks. A repeat examination can make the diagnosis if there are questions. Minimal accidental trauma may result in dramatic bruises suggesting nonaccidental trauma in some medical problems such as idiopathic thrombocytopenic purpura, hemophilia, and vitamin K deficiency.^{82,88} In settings of inappropriate bruising, it sometimes is appropriate to obtain a complete blood count and coagulation studies.

In some cultures, there are practices that can be confused with abusive bruising. These are cupping and coining.⁸² These cultural practices are done with the intent of helping the child, and some report that it feels good.

The key question remains, “Is this injury consistent with the history provided by the caretaker, and is it consistent with the child’s developmental abilities?” Several studies have looked at bruises in relation to development.^{83,84} Based on their research,

Sugar, et al., reported, “Those who cannot cruise don’t bruise.”⁸³ They found that those children who are not yet cruising (walking while holding onto furniture) do not have significant bruises on their bodies. There may be one or two isolated bruises over bony prominences (e.g., forehead, knee), but most of these children do not have bruises when examined. Bruises on the face and neck necessitate a good history owing to the concern for physical abuse.

Burns. Burns occur when tissue is damaged by heat, chemicals, sunlight, electricity, or nuclear radiation.⁸⁹ The history related to how burns occurred and how that correlates with the burn pattern is more important than the depth of burns. But in investigating burns, records must include specific details about pattern, location, and degree. Burns can be classified into first-, second-, third-, and fourth-degree, based on the depth and severity of the burn.

First-degree burns are the most common and rarely require hospitalization. There is superficial tissue damage often characterized by painful erythema without blisters. These usually heal without scarring. An example would be the common sunburn. Other than raising issues of possible neglect, this severity of burn usually is not related to abuse.

Second-degree burns are considered partial-thickness burns. They are characterized by clear fluid-filled blisters that are very painful and sensitive to temperature and air. The lesions often blanch with pressure. They usually heal within 1-2 weeks and sometimes scar.

Third-degree burns involve the full thickness of the skin. The injury is characterized by the finding of charring or translucent white tissue with mottling. Over time, the overlying tissues may develop a leathery, dry appearance. There is minimal pain in the charred tissue because the nerve endings have been damaged. There often is marked edema, and the color can vary from white to gray to red to black or charred. These burns always scar and often require excision and grafting.

Fourth-degree burns involve not only all layers of the skin, but also subcutaneous fat and deeper structures. They usually have a charred appearance. A unique situation seen in child abuse with fourth-degree burns is when a body (a child) is placed in an operating microwave oven.⁹⁰ There are only a handful of case reports in the literature, all involving children. In such cases, the tissue injury often is worse than it appears because of the way that microwave ovens cook. This type of burn will show relative layered tissue sparing where the skin and underlying muscle are burned with relative sparing of the subcutaneous fat.⁹¹ A child with this injury must be closely monitored for complications, preferably in a specialized burn unit.

Burns also can be classified as thermal, electrical, chemical, or radiation. The most commonly seen in abuse are thermal burns. Electrical burns can be seen in children when electrical cords are chewed (corners of the mouth) or outlets explored (fingertips). Chemical burns and radiation burns rarely are seen. Depending on severity and location of burns, some children do need to be transferred to the nearest burn facility.

In evaluating burns in children, there are several factors to

consider. These include the history, physical examination, the child’s developmental level, and the presentation of the injury to medical care.

When obtaining a history, the clinician first investigates the reported mechanism for the burn. It is important to note in the medical record the reported history and who reported it. In abuse cases, the history of the injury sometimes changes over time or with different witnesses. This can sometimes occur with accidental injuries, but such inconsistencies should raise a red flag for possible abuse.

The examiner also should look at the child’s developmental level, both reported and observed. The clinician should remember to observe whether details provided by the caretaker are similar to those observed in interactions with the child. In evaluating burns, the examiner must ask himself or herself such questions as could that child have reached up and grabbed that cup of hot tea? Is the history compatible with the child’s developmental level? CPS or law enforcement agencies usually can provide scene evaluations when necessary.

With possible child abuse, the physical examination is more than gathering information to assess the patient’s injuries and provide care; it is a source of very valuable information about mechanisms of injury and possible abuse. What is the pattern of the burn injury—immersion, flow, or contact? Does this pattern match with the reported history? As an example, the stocking-and-glove distribution seen in immersion burns is fairly specific for nonaccidental injury.⁴ These have a clear line of demarcation between the burned and unburned skin that looks like a sock line. There often are no splash marks. This is indicative of the limb being held forcefully in hot water. A donut distribution on the buttock area also can be seen with immersion burns. This is seen when the child is held in hot water in a tub (or sink). The donut appearance of central sparing and peripheral burns is related to the surface (usually of the tub) protecting the central skin, and the fluid in contact with the periphery resulting in second-degree burns. Skin in contact with other skin (e.g., between buttocks, behind knees) also is spared. By noting the burn pattern, the position the child was in at the time of the burn often can be recreated. As a protected area of the body, genital burns are uncommon accidental injuries. They often are seen in abusive situations, especially those involving toileting accidents.⁴

Burns may be inflicted by contact with hot solids, such as irons, radiators, stoves, or cigarettes.⁴ Inflicted burns are characteristically symmetrical, deep, and leave a clear imprint of the hot instrument. Dermatologic and infectious disease can mimic abusive burns, including toxin-mediated staphylococcal and streptococcal infections, impetigo (which can be mistaken for cigarette burns), and phytophotodermatitis.^{4,82}

How the child presented to medical care also is important. Did the child receive what appears to be a second-degree burn four days ago and is just now coming for treatment? Who is bringing the child for treatment? In abuse situations, there often is a delay in seeking appropriate medical care.

In completing the physical examination, the provider should be alert to other signs of trauma or neglect such as failure to

thrive or other injuries and scars. The physical examination should be fully documented with diagrams and pictures, if possible. This can help with longitudinally following healing of the burn and can assist greatly with recall in court if needed.

Conclusion

Neglect and abuse remain a difficult and emotionally charged topic. Occurring behind closed doors, it is unobserved and confessions are rare.⁹² There are myriad presentations, and abuse and neglect may mimic other disease processes. While there is significant morbidity and mortality, the diagnosis and treatment are intertwined with legal issues of parental rights and family preservation.

Identifying children who are victims of abuse is a difficult and unpleasant part of pediatric health care. However, it also can be rewarding in that it can serve as the first step in saving or improving a child's life. Health care professionals must keep in mind that children are the victims of these horrible acts and that they are often silent victims. They must count on us to identify and rescue them. Don't forget to keep child abuse on the differential diagnosis of all childhood injuries.

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CME/CE Questions

1. Which of the following sites of injury is the least specific for child abuse?
 - A. Scapular fractures
 - B. Rib fractures
 - C. Metaphyseal fractures
 - D. Clavicular fracture
2. All of the following skull fractures more commonly are encountered in abusive rather than in accidental injury *except*:

CE/CME Instructions

Physicians and nurses participate in this continuing medical education/continuing education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. **After completing this activity, you must complete the evaluation form provided and return it in the reply envelope provided in order to receive a certificate of completion.** When your evaluation is received, a certificate will be mailed to you.

- A. bilateral skull fractures.
 - B. fractures crossing suture lines.
 - C. isolated linear parietal skull fractures.
 - D. multiple skull fractures.
3. In a child with suspected physical abuse, the American College of Radiology recommends a full skeletal survey. This survey most appropriately is described by which of the following?
- A. A single frontal view of the entire child
 - B. Anteroposterior and lateral views of the upper and lower extremities
 - C. Multiple dedicated images of the axial and appendicular skeleton, including additional views as needed to document sites of injury
 - D. Anteroposterior and lateral views of the skull plus a single anteroposterior view of the chest and abdomen
4. A 1-year-old girl has a history of not moving her arm for one day. The family denies any history of trauma. The child is acting normally and has no other evidence of acute injury. An x-ray reveals a midshaft humeral fracture. The next step in the work up of this child would be:
- A. to order a CT scan of the head to rule out a chronic subdural hematoma.
 - B. to order liver enzymes to help rule out intra-abdominal injury.
 - C. to obtain a skeletal survey to rule out other fractures.
 - D. to apply a sling and swath and have the patient follow up with orthopedics.
5. Which one of the following statements concerning nonaccidental trauma is *not* true?
- A. Child abuse needs to be considered in all pediatric injuries.
 - B. Subdural hematomas frequently are seen in children who fall out of bed.
 - C. If the history does not seem to explain the identified injuries, the possibility of abuse should be considered.
 - D. An unexplained delay in seeking medical care in an injured child is an indicator of nonaccidental trauma.
6. Which one of the following statements concerning nonaccidental head injury is *not* true?
- A. Inflicted head injury is the most common cause of traumatic death in infancy.

- B. Children with intentional injuries have worse functional outcome than children with unintentional injury.
 - C. Infants will tolerate an acute brain injury better than adults because the fontanel is open.
 - D. Head injuries in infants can be difficult to diagnose because the symptoms often are nonspecific.
7. When physicians fail to recognize that the child's symptoms are secondary to nonaccidental head injury, the child is frequently re-injured or has serious complications of the unrecognized, untreated head injury.
- A. True
 - B. False
8. All of the following statements concerning imaging in nonaccidental pediatric head injury are true *except*:
- A. The most frequent presentation in nonaccidental trauma is a combination of subdural convexity and interhemispheric hematomas.
 - B. MRI is useful in detecting small hemorrhages in infants with equivocal CT findings.
 - C. The majority of subdural hematomas in children younger than 2 years are due to child abuse.
 - D. Epidural hemorrhage is a common finding in shaken-infant syndrome.
9. Which one of the following statements regarding bruising in infants and children is *not* true?
- A. The dating and aging of bruises is precise.
 - B. Some areas of the body such as the back, neck, and ears are atypical areas of accidental bruises.
 - C. Mongolian spots often are confused with bruises.
 - D. Children who are not yet walking do not have significant bruises on their bodies.
10. Severe abdominal injury is not a recognized manifestation of child abuse.
- A. True
 - B. False

CME/CE Objectives

- Upon completing this program, the participants will be able to:
- a.) Quickly recognize or increase suspicion for non-accidental trauma in a pediatric patient;
 - b.) Be educated about rapid stabilization and management of a child who has sustained non-accidental injury;
 - c.) Understand the various diagnostic modalities available to recognize non-accidental trauma, and know the appropriate use of each modality;
 - d.) Integrate the ability to recognize suspicious injury patterns for non-accidental trauma into their clinical practice.

Answer Key:

- 1. D 6.C
- 2. C 7.A
- 3. C 8.D
- 4. C 9.A
- 5. B 10.B

In Future Issues:

ED Thoracotomy