Nonaccidental Injury in Pediatric Patients: Detection, Evaluation, and Treatment

Abstract

Emergency clinicians are likely to encounter physical abuse in children, and they must be prepared to recognize its many manifestations and take swift action. Pediatric nonaccidental injury causes considerable morbidity and mortality that can often be prevented by early recognition. Nonaccidental injuries present with a wide array of symptoms that may appear to be medically inconsequential (such as bruising in a premobile infant), but are actually sentinel injuries indicative of child abuse. This issue provides guidance regarding factors that contribute to abuse in children, key findings on history and physical examination that should trigger an evaluation for physical abuse, and laboratory and radiologic tests to perform when child abuse is suspected.
Case Presentations

A mother brings her 3-month-old boy to the ED for vomiting and irritability. She says that the boy’s father told her the baby wouldn’t stop crying and had vomited several times. The mother states the baby had been fine when she left for work that morning. The patient’s medical history is significant for colic and an episode of blood from his mouth 1 month ago. On physical examination, the baby is irritable, his anterior fontanelle is full, and his pupils react bilaterally. The patient continues to vomit several times in the ED and remains irritable and afebrile. You are worried that the vomiting and irritability are signs of abusive head trauma and you consider how to approach brain imaging in this patient. You then wonder whether you should order laboratory tests and assess for other occult injuries with a skeletal survey. Would an ophthalmological examination be indicated in this patient? Finally, you consider how and when to approach the family about a child protective services referral.

A 2-month-old boy was transported to the ED by EMS. A neighbor had called 911 because of concerns of domestic violence between the parents. The mother denies domestic violence and says that the baby seems to be having some difficulty breathing. On physical examination, the patient is fussy but consolable. He is afebrile, but is breathing rapidly, with a respiratory rate of 70 breaths/min. There are bruises on his anterior and posterior torso and crepitus of his chest wall. When asked how the patient may have sustained the bruises, the mother states the baby may have “rolled” and hit the edge of the crib. You are concerned about physical abuse as a cause of your patient’s presentation. You wonder if domestic violence between caregivers is a risk factor for physical abuse in children. Should the developmentally implausible history provided by the mother make you more worried about abuse? You start to consider which laboratory, imaging tests, and consultations you should pursue to evaluate both for possible physical abuse and to exclude other diagnoses, such as a bleeding disorder.

A 3-year-old boy was sent to the ED from daycare after he refused to sit down due to pain in his buttock region. When his daycare teacher removed his pull-up diaper, she noted he had symmetric blistering in a circular region around his buttocks, with some central clearing. When asked how this happened, the boy said the bath water was too hot the day before. His father added that maybe a sibling pushed him into the water. Given the symmetry and donut-shaped appearance of this burn, you wonder if you should consider an intentional submersion burn in a young child of toilet-training age as a cause of this patient’s presentation? As you think about the differential diagnosis, you start considering which consultants could further assist you with this diagnosis. Finally, you start thinking about whether you should involve child protective services.

Introduction

In 2015, about 683,000 infants and children in the United States were determined by Child Protective Services (CPS) to have been maltreated and, of these, 17.2% were physically abused.¹ Based on self-reports by victims, the incidence of maltreatment, including episodes not reported to CPS, is likely much higher.¹⁻¹³ Most maltreatment-related fatalities occur in children aged < 3 years.¹ The majority of children with injuries concerning for abuse are seen in emergency departments (EDs).⁶⁻⁹ Notably, approximately 30% of children who died from abuse were previously evaluated by healthcare providers, often in the ED setting, for injuries that were not recognized to be the result of abuse.¹⁰⁻¹³

Even when there is uncertainty, the diagnosis of nonaccidental injury must be considered and evaluation initiated, as improvements in early detection and reporting of maltreatment could reduce morbidity and mortality. However, the presentations of nonaccidental injuries are variable and sometimes medically inconsequential and may thus be missed. This issue of Pediatric Emergency Medicine Practice provides a comprehensive, evidence-based review of the historical and physical examination findings that are concerning for abuse, injury patterns that are highly specific for abuse, and the use of screening tests and other available resources for diagnostic evaluation and management of cases when abuse is suspected.

Critical Appraisal of the Literature

A literature search was performed using the PubMed and Ovid MEDLINE® databases as well as the Cochrane Database of Systematic Reviews from their start until 2016. The following keywords were searched: child abuse, child maltreatment, nonaccidental trauma, and inflicted injury in various combinations with the key words epidemiology, diagnosis, evaluation, management, prognosis, emergency department, abusive head trauma, burns, bruising, intraoral injury, sentinel injury, abdominal injury, thoracic injury, eye injury, fractures, skeletal injuries, siblings, and domestic violence. References in the bibliographies of relevant review articles were also examined. Together, over 200 articles and websites were reviewed.

Literature on nonaccidental injuries consists largely of descriptive case series, retrospective case-controlled studies, and cohort studies. Additional limitations include a lack of prospective and epidemiological data, comparative studies that identify features between intentional and unintentional injuries, and data on abusive findings in children with disabilities.

The definition of the term child abuse varies across studies, and authors define abuse across a
spectrum that falls within the categories of confirmed abuse, suspected abuse, indeterminate cases, and excluded abuse. Even within each category, definitions vary. Variability also exists in the inclusion criteria by injury severity, as many studies include only injuries that require hospital admission, intensive care unit admission, trauma registry inclusion, or injuries that cause death. Some studies include patients only when there is a consultation to a child abuse specialist. Thus, though researchers have performed systematic reviews on many topics associated with physical abuse (oral injuries, bruising, burns, abusive head trauma [AHT], fractures, retinal findings, and visceral findings), they struggle to draw conclusions on true associations between various factors and physical abuse.

**Epidemiology**

In 1974, the Child Abuse Protection and Treatment Act provided funding for the prevention, identification, and treatment of child maltreatment. It established mandated reporting of suspected child maltreatment in the United States. Minimum standards for defining child abuse and neglect were defined as “any recent act or failure to act on the part of a parent or caretaker, which results in death, serious physical or emotional harm, sexual abuse or exploitation, or an act or failure to act which presents an imminent risk of serious harm.”14 Within these guidelines, however, each state maintains the authority to define maltreatment within its own legal statutes, which causes variability in reporting practices throughout the country.14

Each year in the United States, CPS agencies receive roughly 3 million reports of suspected child maltreatment; of these, about 60% are accepted and investigated. In 2014, there were 702,000 children for whom maltreatment was substantiated (9.4 victims per 1000 children). Children aged < 1 year had the highest rates of victimization (24.4 victims per 1000 children). Seventeen percent of all maltreated children suffered from physical abuse, 75% suffered from neglect, and 8.3% suffered from sexual abuse. Every year, nearly 1500 child deaths are from maltreatment; the majority are children aged < 3 years. However, based on self-reports of maltreatment by victims and parents, the annual rates of reported cases likely significantly underrepresent the true extent of maltreatment in the United States.13,5,15

In the United States, the majority of children who seek care in the acute setting are evaluated in general EDs where general emergency clinicians evaluate and treat both children and adults.15,16,17 Due to the lack of recognition of nonaccidental injuries, child abuse may be missed in the ED.18-20 Efforts to improve early detection and reporting of nonaccidental injuries in the ED setting are critical, and implementation of evidence-based interventions must take into consideration both general and pediatric ED settings.

**Etiology**

Schmitt identified 7 developmental phases in children that are challenging periods for caregivers and may trigger abuse: colic, nighttime awakening, separation anxiety, exploratory behavior, negativism, poor appetite, and toilet-training resistance.21 Indeed, caregivers often take children to the ED for evaluation of some of these complaints. Crying is the most common trigger of AHT, based on both epidemiological data that show that the age-specific incidence curve of AHT has a similar starting point and shape to the crying curve in infants (the peak occurs 4 to 6 weeks later) as well as from data on perpetrator confessions.22-25 Acknowledging that parenting can be frustrating, normalizing behaviors in children and providing alternative coping strategies, even during an ED visit, may prevent maltreatment.

Another opportunity to identify children at higher risk of being maltreated comes from understanding the interplay of factors related to the child, the caregiver, and the environment.26 Factors that may predispose the child to maltreatment include emotional or behavioral difficulties, chronic illness, physical or developmental disabilities, preterm birth, multiple gestation births, and being unwanted or unplanned.26-28 Characteristics that may reduce a caregiver’s ability to cope with the stresses of parenting include low self-esteem, poor impulse control, substance and alcohol abuse, young maternal/paternal age, presence of mental illness, having poor knowledge of child development characteristics or unrealistic expectations for the child, having negative perceptions of normal child behaviors, and being abused themselves as children.28-32 Finally, social isolation, poverty, unemployment, low maternal education, a single-parent home, a nonbiologically related male living in the home, and family violence or intimate partner violence all increase the likelihood of maltreatment.28,33-36

Nevertheless, the absence of risk factors does not preclude a diagnosis of abuse if suspicion is high, such as when a patient presents with a sentinel injury. National data illustrate biases in the evaluation of abusive injuries.35 In fact, in the landmark study by Jenny et al, the cases of AHT that were missed were more likely to be young white children from 2-parent households.11

**Differential Diagnosis**

The differential diagnosis of nonaccidental injury is broad and varies based on the child’s presenting signs and symptoms. Screening for dermatologic,
hematologic, or infectious diseases that may mimic presentations of abusive burns or bruises may be required. The greater challenge for the front-line provider may be in differentiating accidental or birth injury from nonaccidental injury. Table 1 summarizes some medical conditions that may be in the differential diagnosis of nonaccidental injuries.

**Bruises and Burns**

Mimics of bruising due to child abuse may result from accidental trauma, bleeding disorders, connective tissue diseases, cultural practices, benign congenital lesions, and artifacts. Children with bleeding disorders (eg, Von Willebrand disease) or neoplastic processes (eg, leukemia) may present with unexplained and more numerous bruises compared with healthy children. Benign congenital lesions such as Mongolian spots and hemangiomas must also be excluded prior to diagnosis of bruising due to abuse. Finally, if an ink stain from new clothing is a possibility, the bruise should be rubbed with an alcohol wipe.

Abusive burns must be differentiated from friction blisters, hypersensitivity reactions, impetigo, phytophotodermatitis, dermatitis herpetiformis, dermatitis of the buttocks due to accidental ingestion of laxatives, and cultural practices. Differences between bruising and burns due to accidental injury and nonaccidental injury are discussed in the “Sentinel Injuries” section, pages 6-8.

**Fractures**

Conditions that mimic abusive fractures include disorders that predispose children to fractures. These include disease processes that affect collagen or impair bone mineralization, inborn errors of metabolism, prematurity, infection, and neoplastic processes.

Osteogenesis imperfecta incorporates a spectrum of conditions that vary in severity of symptoms and are caused by genetic mutations that control collagen synthesis. Osteogenesis imperfecta is the most common inherited disease that predisposes children to fractures. Classic features (eg, blue sclera) may be absent in some cases, and molecular genetic testing can help identify osteogenesis imperfecta.

Rickets, most commonly due to vitamin D deficiency, leads to failure of new bone mineralization and predisposes a child to fractures. Infants with rickets should have radiographic and laboratory evidence of the disease. Importantly, rickets is not typically associated with fractures that are most specific for abuse, such as classic metaphyseal lesions, multiple fractures, and rib fractures.

Fractures from birth injury can go unrecognized initially, but must be differentiated from abusive fractures. The clavicle and skull are the bones most commonly fractured during delivery, though physeal and diaphyseal injuries of the humerus and femur as well as rib fractures have been described. However, delivery-associated fractures usually have radiologic evidence of healing by 10 days, starting with subperiosteal new bone formation, followed by the development of a callus.

**Intracranial Hemorrhage**

When evaluating children with intracranial hemorrhage, consider injuries from accidental trauma, birth trauma, coagulopathy, congenital vascular malformations, spontaneous subdural hematoma, and metabolic deficiencies such as glutaric aciduria type I.

**Table 1. Differential Diagnosis of Nonaccidental Injuries**

<table>
<thead>
<tr>
<th>Sign</th>
<th>Differential Diagnosis</th>
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<tbody>
<tr>
<td>Bruising</td>
<td>Mongolian spots (congenital dermal melanosis)</td>
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<tr>
<td></td>
<td>Bleeding disorders</td>
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<td></td>
<td>Hemangiomas</td>
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<td></td>
<td>Phytophotodermatitis</td>
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<td></td>
<td>Malignancy</td>
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<td></td>
<td>Connective tissue disorders (Ehlers-Danlos syndrome)</td>
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<td></td>
<td>Healing practices (eg, coining and cupping)</td>
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<tr>
<td></td>
<td>Osteogenesis imperfecta</td>
</tr>
<tr>
<td></td>
<td>Vasculitis (Henoch-Schönlein purpura)</td>
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<tr>
<td></td>
<td>Ink stains (eg, those caused by new clothing)</td>
</tr>
<tr>
<td>Burns</td>
<td>Hypersensitivity reactions</td>
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<tr>
<td></td>
<td>Friction blisters</td>
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<tr>
<td></td>
<td>Impetigo (may be confused with cigarette burns)</td>
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<tr>
<td></td>
<td>Phytophotodermatitis</td>
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<tr>
<td></td>
<td>Dermatitis herpetiformis</td>
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<tr>
<td></td>
<td>Accidental laxative ingestion</td>
</tr>
<tr>
<td></td>
<td>Healing practices (eg, coining, cupping, and moxibustion)</td>
</tr>
<tr>
<td>Fractures</td>
<td>Normal variants of bone structures</td>
</tr>
<tr>
<td></td>
<td>Rickets</td>
</tr>
<tr>
<td></td>
<td>Congenital syphilis (can cause periosteal elevation)</td>
</tr>
<tr>
<td></td>
<td>Birth trauma</td>
</tr>
<tr>
<td></td>
<td>CPR (rarely causes rib fractures and very rarely causes posterior rib fractures)</td>
</tr>
<tr>
<td></td>
<td>Osteogenesis imperfecta</td>
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<tr>
<td></td>
<td>Caffey disease</td>
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<tr>
<td></td>
<td>Osteomyelitis</td>
</tr>
<tr>
<td>Subdural hematomas</td>
<td>Bleeding disorders</td>
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<tr>
<td></td>
<td>Vascular malformations</td>
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<tr>
<td></td>
<td>Glutaric aciduria type I</td>
</tr>
<tr>
<td></td>
<td>Benign extra-axial fluid</td>
</tr>
<tr>
<td></td>
<td>Menkes disease</td>
</tr>
<tr>
<td>Retinal hemorrhages</td>
<td>Vasculitis</td>
</tr>
<tr>
<td></td>
<td>Vascular obstruction</td>
</tr>
<tr>
<td></td>
<td>Vaginal delivery (generally disappear by 4 weeks of age)</td>
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<tr>
<td></td>
<td>CPR (retinal hemorrhages are rare after chest compressions and, if present, are usually in the presence of other risk factors for hemorrhage)</td>
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Abbreviation: CPR, cardiopulmonary resuscitation.
type 1. Glutaric aciduria type 1 is an autosomal recessive disorder, in which accumulation of glutaric acids lead to hypotonia, acute striatal necrosis, frontotemporal atrophy, and neurological deterioration. Spontaneous subdural hematomas are thought to be related to enlargement of the subdural space that usually begins with an increasing head circumference at 2 to 3 months of age and results in a head circumference > 95th percentile at 3 years of age. Infants can present with macrocephaly and bilateral subdural hematomas.

Retinal Hemorrhage

Retinal hemorrhages may be present in about 30% of infants after vaginal delivery and tend to be localized around the optic discs and in the posterior pole; most resolve within 4 weeks. Retinal hemorrhages after cardiopulmonary resuscitation (CPR) are rare and usually occur in the presence of other risk factors for hemorrhage.

Prehospital Care

The acute nature of nonaccidental injuries may lead abuse victims to use emergency medical services (EMS) for care. In addition to stabilizing the airway, breathing, and circulation in critically injured patients, prehospital care providers are in a unique position to recognize and report abuse because they may be able to provide first-hand information about the household scene in which a child was injured or neglected. Prehospital care providers are also mandated reporters of abuse in many states and should report any suspicion of abuse to CPS in addition to emergency clinicians. CPS workers may also bring children to the ED directly for a medical screening. These children could be victims or may have witnessed violence in the home.

Emergency Department Evaluation

History

Emergency clinicians face challenges in recognizing maltreatment in children. First, child maltreatment frequently occurs in young, nonverbal children who are unable to provide a history or in older children who may be too scared or feel loyal to their abusers and may not disclose the abuse. Second, caregivers may intentionally provide a false history or no history of trauma, which can mislead clinicians who often rely on the history provided by a caregiver to guide their diagnostic evaluation. Third, biases of the clinician may prevent consideration of abuse in the differential diagnosis. Finally, traumatic injuries due to abuse can be occult and present as medical chief complaints such as fussiness or vomiting.

Taking a complete history is necessary to distinguish accidental from abusive injury. It is important to let caregivers provide a full history, without interruption, to assure it is not influenced by clinician interpretations and questions; clarifying questions should follow the initial history. It is vital to document the mechanism of injury described by caregivers, the onset of symptoms, and the child’s developmental abilities. Asking about the last time a child was at his/her baseline state may help determine the timing of the injury. If there is no history of a traumatic injury, the emergency clinician should ask how the child may have sustained the injury, noting if the history provided is an implausible cause of the presenting injury or is inconsistent with the child’s developmental capabilities.

The following historical factors are useful when evaluating a child for suspected maltreatment: (1) information about recent injuries and information about the child’s temperament; (2) social history, including recent stressors and methods of discipline used in the home; (3) family history; (4) history of previous abuse in the family or CPS involvement; and (5) substance abuse, mental health problems, or domestic violence history in the family. The emergency clinician can utilize other services such as social workers, CPS, the child’s primary care provider, and child abuse specialists to help them collect this information. For children with bruising or a history of bleeding, emergency clinicians should ask about symptoms suggestive of a pre-existing coagulopathy, such as excessive bleeding from the umbilical stump, after venipuncture, circumcision, immunizations, or dental procedures; medications that can predispose to bleeding (nonsteroidal anti-inflammatory drugs, aspirin); and whether there is a family history of coagulopathies.

The emergency clinician should note any red flags in the caregiver’s report of the history (eg, a child presenting with a serious traumatic injury without any reported history of trauma, or a child who has a history of “misbehaving” who presents with burns from a suspected submersion injury). Significant delays in care can also be a concerning sign, as are changes in the caregiver’s report of the history. Emergency clinicians should document any of these historical red flags in their notes and report them to CPS.

Physical Examination

The physical examination alone will rarely determine whether an injury was from an accidental or abusive mechanism. However, combining the history with a thorough physical examination will help determine whether abuse should be considered as part of the differential diagnosis. Though abuse may be diagnosed when a child is brought in for an evaluation for a specific injury, findings such as bruising may be discovered on a routine physical examination conducted for other presenting complaints. Regardless of the presenting chief complaint,
the examination of a young child and/or infant should always include a thorough examination of the entire body, which requires undressing the child. This is particularly important when a child presents for evaluation of an injury.63

As physical abuse and neglect may occur concurrently, look for signs such as malnutrition, falling off the growth curve, dental caries, healing injury/injuries, or poorly controlled chronic disease (eg, asthma or diabetes). The skin is the most commonly injured organ system in abuse and the examination may show burns, bruises, bites, or lacerations that should be documented and photographed. Injuries to areas such as the ears, neck, torso, genitals, buttocks, thighs, mouth, frenum, palate, or lip, especially in a premobile infant or occurring as patterned injuries, should raise concern for physical abuse.

A full neurological examination, including assessment of mental status, reflexes, tone, cranial nerves, motor/sensory abilities, and assessment of the fontanelle should be performed, as abnormalities may be due to AHT. However, a normal neurologic examination in an infant does not exclude significant neurological injury.60,61 An eye examination may reveal scleral hemorrhages in the setting of blunt facial trauma.62 A dilated eye examination performed by an ophthalmologist is critical for detecting retinal hemorrhages in the setting of significant intracranial injury and suspicion of AHT.63

A thorough musculoskeletal examination with palpation of all extremities, the chest, and the head may reveal crepitus or other concerning findings due to acute or healing fractures; however, a normal musculoskeletal examination does not exclude the presence of fractures, especially old, healing fractures.

The evaluation of children for abusive intra-abdominal injury can be difficult, due to uncertainties in the history and physical examination. In children who are being evaluated for the possibility of abuse and suspected intra-abdominal injury, while performing the physical examination, it is recommended to start with laboratory liver function tests. When either the alanine aminotransferase or aspartate aminotransferase level is > 80 IU/L, abdominal computed tomography (CT) should be considered in children with signs of potential abuse.64,65 The emergency clinician should not depend on the PECARN (Pediatric Emergency Care Applied Research Network) Pediatric Head Injury/Trauma Algorithm abdominal trauma rules48 alone, as abdominal injuries in children who are physically abused may be missed because their injuries might be older than 24 hours and the history is often unclear.65

The American Academy of Pediatrics (AAP) clinical report “The Evaluation of Suspected Child Physical Abuse” outlines the following 7 parameters of the physical examination that are concerning for abusive injury67:

1. ANY injury to a young, pre-ambulatory infant, including bruises, mouth injuries, fractures, and intracranial or abdominal injury;
2. Injuries to multiple organ systems;
3. Multiple injuries in different stages of healing;
4. Patterned injuries;
5. Injuries to nonbony or other unusual locations, such as over the torso, ears, face, neck, or upper arms;
6. Significant injuries that are unexplained; and
7. Additional evidence of child neglect.

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Sentinel Injuries
Sentinel injuries are relatively minor injuries such as bruises, scleral hemorrhages, or intraoral injuries that are inadequately explained and are therefore concerning for abuse. (See Figure 1, page 7.) These injuries are not expected in the normal care of an infant who is premobile.68-71 Sheets et al performed a retrospective study of abused infants and matched controls to determine how often abused infants had a previous history of a sentinel injury compared to the healthy controls. In their study, 27.5% of 200 abused infants had previous sentinel injuries, while none of the healthy controls had previous sentinel injuries.72 Sentinel injuries included bruising in 80% of the cases and intraoral injury in 11% of the cases; in 42% of the cases, medical providers were previously aware of these injuries.73 Other studies have similarly described missed sentinel injuries in abused children.73-77

Bruises
Bruising is the most common detectable injury in maltreatment; it is missed as a sentinel injury in about one-third of fatal or near-fatal abusive injuries.11,72 Bruising is uncommon in children who are premobile or not yet crawling, walking (generally, children aged < 6 months).58-71 One study evaluated bruising in infants aged < 12 months who presented to a large pediatric ED and found that bruising was present in 1.3% of all infants aged < 5 months, and the majority of these bruises were associated with a traumatic mechanism. Only 0.2% of these infants with a medical chief complaint had any bruising.70 In contrast, bruising from normal activity is often seen in preschool and school-aged children.78 Accidental injuries in mobile children are often present on the front of the body and over bony prominences such as the anterior tibia, knee, and forehead.58,69,78

In premobile children, abusive bruising was most commonly seen on the head and neck (especially the face), followed by the buttocks, trunk, and arms.
Compared to accidental bruises, abusive bruises were more likely to be patterned, multiple, occur in clusters, and large in size.\cite{78} Pierce et al examined bruising characteristics that differentiated abused from nonabused children in the intensive care unit. Although they did not find that head and facial bruising reliably predicted nonaccidental injury, bruising on the torso (T), ears (E), and neck (N) in any child aged < 4 years or any bruising in infants aged < 4 months was predictive of abuse. (See Figure 2.) This clinical decision rule (called TEN-4) had a sensitivity of 97% and specificity of 84% for predicting abuse.\cite{79} Another study showed that bruising to the buttocks/genitalia, trunk, cheeks, neck, front of the thighs, or upper arms, with associated linear petechiae or distinct patterns and bruises that were clustered was highly associated with physical abuse.\cite{80} (See Figure 3, page 8.)

Maguire et al performed a systematic review to determine whether it was possible in clinical practice to determine the age of bruises in children. Results of the included studies revealed that any color could be present in fresh, intermediate, and old bruises. Additionally, the accuracy with which clinicians correctly aged a bruise to within 24 hours of its occurrence was < 40%. The authors concluded that the age of a bruise cannot be accurately determined from clinical assessment in vivo or from photographs and that the practice of estimating the age of a bruise from its color has no scientific basis.\cite{81}

Young children with bruising in the locations described and premobile infants (aged < 6-9 months) with any bruising in the absence of an underlying bleeding disorder or known witnessed trauma, have a higher risk of concurrent or future severe and fatal abuse, and warrant further investigation.\cite{11,72,77}

**Figure 1. Sentinel Injuries**

Unilateral scleral hemorrhage in an infant.

Healing labial frenum injury in an infant.

Facial bruising in a 10-month-old developmentally delayed premobile infant.

Images courtesy of Kirsten Bechtel, MD.

Scan the QR code with an enabled device to view figures in color or go to: www.ebmedicine.net/PEMP-7-17-figures

**Figure 2. Example of an Ear Bruise Included in the TEN-4 Decision Rule**

Facial bruising on the back side of the pinna of a 2-year-old.

Image courtesy of Kirsten Bechtel, MD.
Oral Injuries
Several studies have shown an association between oral injuries and physical abuse. In a case series of 300 abused children, Naidoo found that 59% of the patients had orofacial trauma and 11% of the patients had mouth injuries, which included lacerations to the lips, frenulum, and tongue; fractured or avulsed teeth; and mandibular fractures. In a study by Sheets et al, 11% of the abused cohort with sentinel injuries had injuries to the mouth. A torn frenulum, though a trivial dental injury often explained by an accidental fall in an older child, is highly associated with physical abuse in premobile children, and is the most common abusive oral injury. Abusive mechanisms for torn frenula include forceful feeding, gripping, or direct blows to the mouth. Maguire et al evaluated the association of torn frenula and physical abuse and found that, in most cases, no injury mechanism is provided, and in rare cases, the only mechanism described was a direct blow to the face. They also found an association between torn frenula and fatal abuse, with the majority of fatalities in children aged < 5 years. Other reported oral injuries were lacerations or bruising to the lips, mucosal lacerations, dental trauma (including fractures, intrusion, and forced extraction), tongue injuries, and gingival lesions. A recent comparative study that examined oral, jaw, and neck injuries found that only 0.9% of children sustained an oral injury from endotracheal intubation, whereas oral, jaw, and neck injuries were significantly associated with abuse. However, the authors of a small study of mobile children with frenulum tears concluded that this injury was common in falls in ambulatory children who had other facial trauma. While there is a lack of data supporting the view that a torn labial frenulum is diagnostic of physical abuse, an unexplained torn frenulum or other oral injuries in premobile infants should be considered suspicious for abuse.

Burns
While the majority of burns in children presenting to the ED occur from accidental injury, some are the result of abuse. The prevalence of burns due to abuse is approximately 6% to 24% of all children admitted for burns. Patients with abusive burn injuries have longer hospital stays and higher mortality than those with unintentional burns. Maguire et al examined factors that distinguished abusive burns from unintentional scald burns. They concluded that intentional scalds were most commonly immersion injuries (caused by hot tap water) that affected the extremities, buttocks, or perineum. They were also more likely symmetrical, with clear upper margins, and were associated with old fractures or other unrelated injuries. (See Figure 4, page 9.)

In a study published in 2016 that evaluated burn patients referred to child abuse pediatricians, scald burns accounted for 53% of the burns referred, while contact burns (eg, cigarette burns) accounted for 28%. Factors associated with a higher likelihood of abuse included hot water as the scalding agent, an immersion scald, a bilateral/symmetric burn pattern, total body surface area > 10%, full-thickness burns, coexisting injuries, children with reported inflicted injury, and absent or inadequate explanation for injury. Abusive contact burns have clearly demarcated margins defined by the configuration of the burning object, are often deeper and on the back,
children with abusive burns, a significant number will also have occult fractures; thus, children aged < 24 months should undergo a skeletal survey.96,99

Abusive Head Trauma
The AAP Committee on Child Abuse and Neglect recommends use of the term *abusive head trauma* rather than the older term, *shaken baby syndrome*, as it includes the range of abusive head injury (inertial, contact, and hypoxic-ischemic), their respective clinical presentations, diagnostic imaging findings, and outcomes.100-102 In most cases, the presence of a subdural hematoma involving one or both cerebral convexities or the interhemispheric fissure (without a clear history of trauma or a history of minor trauma) is a key diagnostic feature. Subdural hematoma, retinal hemorrhage, and rib fractures are frequently seen together in cases of AHT; however, the diagnosis of AHT does not require the presence of all 3 of these types of injury.103

For children aged < 4 years, the annual rate of AHT in the United States is approximately 13 cases per 100,000 children.104 Children aged < 1 year accounted for most AHT cases (60.6%). In general, morbidity and mortality from AHT is greater than head trauma from accidental mechanisms.101,105,106 AHT is the leading cause of death in abused children aged < 2 years.104,107

Recognition of AHT can be difficult. In a landmark retrospective study of infants with AHT, 31% of abuse cases were not recognized on first presentation to healthcare providers. Missed cases were more likely to occur in very young infants, white infants, infants whose parents were living together, and infants without seizures or apnea. Fewer cases of AHT were missed in minority infants and when the parents were not living together. The authors of the study surmised that up to 4 of 5 deaths could have been prevented if AHT had been recognized on

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**Figure 4. Abusive Versus Accidental Scald Burns**

Abusive hot water immersion burn in a 2-year-old boy. Note the clearly demarcated areas and symmetrical bilateral involvement.

Accidental scald burn from pulling hot soup off a counter. Note the irregularly demarcated areas of the burn.

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**Figure 5. Cigarette Burn on a School-aged Child**

Image courtesy of Kirsten Bechtel, MD.
initial presentation.\textsuperscript{11}

Caregivers who perpetrate AHT are predominantly male. In one study, in 60% of cases of AHT, fathers, stepfathers, and mother’s boyfriends were the perpetrators, while female babysitters accounted for 17.3%, and mothers were responsible for 12.6%; all but one of the confessed abusers were with the child at the time of onset of symptoms.\textsuperscript{108} Other studies have demonstrated that caregivers who provide a history of shaking often describe violent and repeated shaking; impact of the infant’s head was noted in a minority of confessions, and symptoms were immediate after these episodes.\textsuperscript{109,115} Most often, infants do not have a lucid interval after an episode of shaking.\textsuperscript{112} Because most perpetrators admitted to shaking without impact, along with the relative lack of skull and scalp injury found in the majority of these infants, it is most likely true that shaking alone can produce the signs and symptoms seen in children with AHT.\textsuperscript{115} The cervical spine injury found in children with AHT suggests that repetitive shaking causes flexion-extension injury to the brain and spinal cord.\textsuperscript{113}

In cases of AHT, parents may describe a relatively minor traumatic event, such as a household fall (eg, off the couch/bed or from a caregiver’s arms) or no history of a traumatic event.\textsuperscript{114,115} Biomechanical studies have evaluated potential theoretic outcomes to gauge the likelihood and range of injuries caused by household falls. One study evaluated the injury potential from falls from beds and other household surfaces onto different impact surfaces using an anthropomorphic model of a 12-month-old infant. Linoleum over concrete had the greatest potential for head and neck injury compared to other evaluated surfaces (linoleum over wood, carpet, wood, playground foam); however, the potential for severe head and extremity injuries was low for most evaluated surfaces.\textsuperscript{116} Retrospective reviews of short-distance falls, such as those from a bed or down the stairs, suggest that they are not terribly injurious to young children.\textsuperscript{117,118} Infants with traumatic brain injury with the following histories are also more likely to have AHT: a history of trauma, persistent neurological abnormalities at hospital discharge, brain injuries blamed on home resuscitative efforts; or a changing history of the injury mechanism.\textsuperscript{115}

Household falls in infants can result in scalp lacerations or contusions. In 3% of household falls in which the infant is taken in for medical evaluation, a skull fracture may occur, and in these instances, the infant or young child may not have a significant change in mental status.\textsuperscript{119} Reece et al retrospectively reviewed cases of both abusive and accidental head injury in young infants from reported household falls. They found that, for short-distance falls (< 4 feet) in the accident group, 8% had a subdural hematoma and 2% had subarachnoid hemorrhage; among those in the definite abuse group, 38% had a subdural hematoma and 38% had subarachnoid hemorrhage.\textsuperscript{120}

There are clinical signs that are helpful in distinguishing abusive mechanisms from accidental mechanisms for brain injury. Children with AHT may present more often with abnormal mental status and seizures, whereas children with accidental head injury will more likely have scalp hematomas.\textsuperscript{121} A meta-analysis by Piteau et al found the following clinical and radiographic variables were significantly associated with AHT: subdural hematoma, cerebral ischemia, retinal hemorrhages, skull fracture with intracranial injury, metaphysial fractures, long bone fracture, rib fractures, seizures, apnea, and inadequate history of the injury. They found that characteristics more often associated with accidental mechanisms included epidural hemorrhage(s), scalp swelling, and isolated skull fractures.\textsuperscript{122} Finally, up to 2% of brief resolved unexplained events (BRUE) may be due to AHT.\textsuperscript{123,124} When there is also a history of vomiting, irritability, or a call to EMS in cases of brief resolved unexplained events, there is an increased risk of AHT.\textsuperscript{124}

Clinical Prediction Rules for Abusive Head Trauma

Several investigators have evaluated clinical prediction rules to diagnose AHT. Hymel et al evaluated the utility of 4 variables (acute respiratory compromise before admission; bruising of the torso, ears, or neck; bilateral or interhemispheric subdural hemorrhages or collections; and any skull fractures other than an isolated, unilateral, nondiastatic, linear, parietal fracture) in patients with acute head injuries admitted to the intensive care unit. This clinical prediction rule had a negative predictive value of 93% when none of these variables were present.\textsuperscript{125} Similarly, Cowley et al evaluated a predictive tool (PredAHT) to detect AHT in children aged < 36 months who were hospitalized with intracranial injury. This decision rule was based on the presence of the following physical signs: retinal hemorrhage, unexplained rib and/or long bone fractures, apnea, seizures, and head or neck bruising. When ≥ 3 features were present in a child aged < 36 months with intracranial injury, the estimated probability of AHT was > 81.5%.\textsuperscript{126} Further study is needed to confirm the usefulness of such clinical prediction rules for AHT in the ED setting.

Berger et al developed a clinical decision rule, the Pittsburgh Infant Brain Injury Score (PIBIS) to determine which high-risk infants should undergo CT of the head. The 5-point PIBIS included abnormality on skin examination (2 points), age > 3 months (1 point), head circumference > 85\textsuperscript{th} percentile (1 point), and serum hemoglobin < 11.2 g/dL (1 point). At a score of 2, the sensitivity for abnormalities found on cranial CT was 93.3% and the specificity was 53%. However, the authors cautioned that further study was needed before the PIBIS could be incorporated into routine clinical practice.\textsuperscript{127}
**Retinal Hemorrhages**

Retinal hemorrhages are a frequent feature of AHT, especially when seen in infants aged < 6 months with brain injury. Retinal hemorrhages seen in AHT are often bilateral and involve the preretinal layer (See Figure 6.) In a study by Bechtel et al, children with AHT were more likely to have retinal hemorrhages that covered the macula and extended to the periphery of the retina, whereas unilateral retinal hemorrhages were more often seen in children with accidental head injury. Maguire et al demonstrated that, in cases of AHT, large numbers of retinal hemorrhages in both of the eyes were present in all layers of the retina and they extended into the periphery. This review confirmed that retinal hemorrhages are rare in accidental trauma and, when present, are usually unilateral, confined to the posterior pole, and few in number. Other investigators have found that infants with AHT who present with alteration in mental status along with brain injuries (subdural hematoma, cerebral ischemia, diffuse axonal injury, hydrocephalus) are also more likely to have retinal hemorrhage; infants with skull fractures without intracranial hemorrhage most often do not have retinal hemorrhage.

**Consultation With an Ophthalmologist**

When AHT is suspected, consultation with an ophthalmologist should be initiated early in the evaluation (typically within 48 hours) to identify and document retinal findings. Photographic documentation using a hand-held fundus camera is helpful in documenting the presence, type, and extent of retinal hemorrhages. The presence of intraretinal hemorrhages that are too numerous to count suggests that the trauma occurred within a few days prior to examination, whereas the presence of preretinal hemorrhages with no or few intraretinal hemorrhages is suggestive of days to weeks since the trauma. The treatment for retinal hemorrhages is most often observation, as intraretinal hemorrhage clears rapidly; preretinal hemorrhage may persist for many weeks.

**Abusive Thoracoabdominal Injury**

While abusive thoracoabdominal trauma may be a less common form of maltreatment, it has significant morbidity and mortality. It is second only to AHT as a cause of abuse fatalities. Most abusive thoracoabdominal injuries result from a direct blow or from rapid deceleration and impact when a child is thrown. Because perpetrators or unsuspecting caregivers may not appreciate the severity of the injury until the child becomes severely ill, care is often delayed. In general, children sustaining abusive abdominal trauma are younger than those with accidental mechanisms, and they suffer greater morbidity and mortality. Excluding witnessed events (such as motor vehicle crashes), blunt thoracoabdominal injury in children aged < 4 years should be concerning for abuse. Other factors more likely to be associated with a nonaccidental injury mechanism include young age, pancreatic injury, bowel injury, concomitant brain injury, and death. Simple household falls, including stairway falls, rarely result in significant thoracoabdominal injury in children. Clinically significant injury to the lungs and heart (beyond multiple rib fractures) is rare in maltreated children. Thus, case reports and case

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**Figure 6. Multiple Preretinal and Intraretinal Hemorrhages Extending to the Periphery**

White arrow indicates an intraretinal hemorrhage. Black arrow indicates a preretinal hemorrhage. Image courtesy of Kirsten Bechtel, MD.
Clinical Pathway For Evaluation of Nonaccidental Injuries in Children

Child presents with an injury that was due to reported trauma or an injury discovered upon evaluation of an alternate chief complaint

Is the injury concerning for abuse?
Does the child have any of the following findings:

History:
- Absent, inadequate, changing, or inconsistent explanation for injury (Class I)
- Developmentally implausible explanation for injury (Class II)
- Different witnesses provide different explanations (Class II)
- Injury occurred as a result of family/domestic violence incident (Class II)
- Social stressors present (Class II)
- History of previous abuse or Child Protective Services involvement (Class II)
- History of substance abuse or mental illness in caregivers (Class II)

Physical examination:
- Burns: symmetric, bilateral, immersion mechanism, clear upper limits (Class II)
- Bruises: ear, head, neck, torso, buttocks, arms, pattern marks (Class II)
- Additional evidence of child neglect (eg, failure to thrive or poor dentition) (Class II)

Injuries suggestive of abuse (Class II):
- Any injury in a premobile infant (bruises, mouth injuries, fractures, intracranial or intra-abdominal injuries) (Class II)
- Injuries to multiple organ systems
- Multiple fractures
- Fractures to ribs, long bones in children aged < 6 months, metaphyseal fractures, scapula, vertebra, sternum, hands and feet, and face
- Subdural hematoma with or without a skull fracture, unexplained intracranial injury
- Any illegal drug exposure

Perform the following studies:
- Cranial CT in all children with neurological abnormalities (Class II)
- Consider cranial CT for occult injury and dilated retinal examination in children aged < 1 year, even without neurological abnormalities (Class II)
- Skeletal survey in children aged < 2 years; follow-up survey in 2 weeks (Class II)
- Transaminases in children aged < 5 years with suspicion of abusive abdominal injury; if AST or ALT > 80 IU/L, obtain an abdominal CT (Class II)
- Abdominal CT if any signs of abdominal trauma (Class II)

Involve consultants:
- Consult social work and child abuse specialists, if available
- Consult trauma surgery for evaluation, if indicated (Class II)
- Consult other subspecialties to screen for other diseases that can mimic signs of physical abuse, as indicated
- Refer to Child Protective Services

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; CT, computed tomography.
For Class of Evidence Definitions, see page 13.
series have primarily provided the descriptions of such nonaccidental injuries. Pulmonary contusions, diffuse alveolar injury, pneumomediastinum, chylothorax, pneumothorax, and multiple rib fractures have been described in young infants with intentional forceful compression of the chest. Nonaccidental cardiac injuries such as abusive lacerations to the right atrium, ventricular septum, and left ventricle as well as commotio cordis are rare, but can be fatal. Repeated episodes of unresponsiveness and poor feeding have been described in a 4-month-old infant with multiple rib fractures and a history of forceful squeezing by a caregiver that likely led to restriction of respiration and reduced cardiac output.

When evaluating preschool-aged children with any hollow viscus or pancreatic injury, consider abusive injury. Perforation of the small intestine is overrepresented in abusive abdominal trauma; it is often caused by a blow to the anterior abdominal wall, causing a rapid increase in intraluminal pressure or shearing of opposing intestinal surfaces, and it most often occurs in preschool children. In the absence of a significant unintentional mechanism (eg, a motor vehicle crash), duodenal trauma in a child aged < 5 years is highly suggestive of an abusive etiology. Rapid deceleration after a child is thrown against an object may cause injury to the mesentery and disruption of the intestinal vascular supply. Pneumatosis intestinales, portal vein gas, and lacerations of the hepatoduodenal ligament have been described as the results of abusive abdominal trauma from this mechanism. Up to 10% of all cases of traumatic pancreatitis in children may be due to child abuse. Pancreatic fracture has also been reported to result from abusive injury. Although serious accidental abdominal trauma most often involves the spleen and kidneys, splenic and renal injuries may be seen in up to 30% of cases of abusive intra-abdominal injury.

When children die from fatal abusive abdominal injuries, it is frequently from intra-abdominal hemorrhage or peritonitis from a ruptured hollow viscus. In some cases, the fact that the child died from abusive abdominal trauma may only be determined at autopsy.

**Fractures**

There are several fracture patterns that are highly specific for maltreatment, including rib fractures and classic metaphyseal lesions. Rib fractures account for up to 29% of all fractures in maltreated children and up to 51% of all fractures in infants with fatal maltreatment. Posterior rib fractures are caused by levering of the posterior rib neck over the transverse spinous process as the rib cage is vigorously squeezed. Fractures of the scapula, sternum, and spinous processes without a history of trauma are also highly specific for child abuse. Because of the compliant nature of an infant’s chest, sternal fractures are rarely seen in routine infant care, such as chest physiotherapy or after CPR. In the rare cases where CPR leads to rib fractures, the fractures are usually anterior, along the sternum.

**Diagnosis and Management**

**Cutaneous Injury**

Because bruising is a common manifestation of maltreatment, careful consideration of the presence of a coagulopathy is warranted as a component of a comprehensive evaluation in children with bruising. The presence of a coagulopathy does not always exclude abuse as the cause of bruises or bleeding, nor does the presence of either accidental or abusive trauma exclude the likelihood of a coagulopathy. There are clinical situations in which the evaluation of a bleeding diathesis may not be necessary, such as when the abusive event that led to the bruising is independently witnessed or the child provides a clear history of the event, or when the bruises are in the configuration of an object, such as a belt. If there is a clinical suspicion of bleeding diathesis, such as petechiae along pressure sites (eg, clothing line or from a tourniquet), then the...
et al suggests that an MRI screening protocol including axial T2, axial gradient-echo, and coronal T1-W inversion recovery sequences is highly sensitive for intracranial hemorrhage and may be useful as a screening tool to detect AHT; however, the feasibility of this approach in clinical practice has not yet been studied.\textsuperscript{185} While diagnostic imaging such as MRI has been thought to be helpful to identify the age of an injury, the significance of and the range for dating these injuries may be wide.\textsuperscript{110,186}

There are several clinical signs and laboratory abnormalities that are helpful to gauge prognosis in AHT. Leeper et al found that an international normalized ratio (INR) of 1.3 at the time of hospital admission was strongly predictive of mortality. They recommended that patients with AHT and an elevated INR should be targeted for early aggressive interventions and monitored for trauma-induced coagulopathies.\textsuperscript{187} Several investigators have demonstrated that apnea, need for CPR and/or endotracheal intubation, early posttraumatic seizures, or status epilepticus are associated with poorer developmental outcomes.\textsuperscript{188-190}

**Abusive Head Trauma**

The initial diagnostic imaging for suspected AHT is unenhanced cranial CT, which is highly sensitive in detecting acute subdural and subarachnoid hemorrhage.\textsuperscript{182} (See Figure 7.) In addition, 3-dimensional (3D) cranial CT may be more helpful for evaluation of skull fractures. Orman et al found that the combination of 2-dimensional and 3D cranial CT had better sensitivity and specificity to detect skull fractures in children aged < 2 years, as 3D CT can distinguish skull fractures from cranial sutures at no added cost or radiation exposure.\textsuperscript{183} (See Figure 8.) Thus, it may be helpful to obtain 3D reconstruction when obtaining cranial CT in children aged < 2 years.

While CT may be readily available in the ED setting, MRI can better identify shear injury and hypoxic-ischemic injury.\textsuperscript{184} A recent study by Flom et al suggests that an MRI screening protocol including axial T2, axial gradient-echo, and coronal T1-W inversion recovery sequences is highly sensitive for intracranial hemorrhage and may be useful as a screening tool to detect AHT; however, the feasibility of this approach in clinical practice has not yet been studied.\textsuperscript{185} While diagnostic imaging such as MRI has been thought to be helpful to identify the age of an injury, the significance of and the range for dating these injuries may be wide.\textsuperscript{110,186}

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**Thoracoabdominal Injury**

**Laboratory Testing**

Laboratory testing may be useful to exclude abusive intra-abdominal injury in otherwise asymptomatic children. Several studies have found that liver transaminases may be useful in identifying occult abusive intra-abdominal injury in asymptomatic children.

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**Figure 7. Intracranial Hemorrhages on Computed Tomography**

Subdural hemorrhage over the right convexity (top arrow). Subarachnoid hemorrhage over the right cerebellar tentorium (bottom arrow). Image courtesy of Kirsten Bechtel, MD.

**Figure 8. Cranial Computed Tomography With 3-Dimensional Reconstruction**

Arrow indicates the left parietal fracture. Image courtesy of Kirsten Bechtel, MD.
is administered, because extravasation of the contrast material rarely occurs.\textsuperscript{198,199}

At present, the role of ultrasonography in screening for abusive intra-abdominal injury is unclear. A consensus statement from the AAP Section of Radiology stated that sonography has little use in the detection of intra-abdominal injury in seriously injured children, including those with abusive injury; CT should be the modality of choice.\textsuperscript{193} However, a study published in 2014 demonstrated that pediatric patients with unintentional blunt abdominal trauma with a low or moderate clinician suspicion of intra-abdominal injury may be less likely to undergo CT if they receive a FAST (focused assessment with sonography in trauma) examination.\textsuperscript{200} Contrast-enhanced ultrasonography may also be as sensitive as CT in the identification and characterization of solid-organ lesions in unintentional blunt abdominal trauma and, thus, might be considered useful in the assessment and monitoring of blunt unintentional abdominal trauma in children.\textsuperscript{201} While promising, these modalities have yet to be rigorously evaluated to detect intentional intra-abdominal injury in children. It is important to remember that while the outcome of interest in unintentional trauma is clinically significant intra-abdominal injury, the outcome of interest in cases of suspected physical abuse is the presence of any intra-abdominal injury, regardless of its clinical significance. Thus, at present, abdominal CT would be the best modality to detect these injuries in children with suspected physical abuse.

**Skeletal Injury**

While occult skeletal injuries are rarely life-threatening to a child, they are often strong indicators of abuse. Children aged < 2 years with suspicion of or with obvious physical abuse should have a skeletal survey to evaluate for suspected abuse.\textsuperscript{64,191,192} For children with a serum alanine aminotransferase or aspartate aminotransferase > 80 IU/L, or with significant signs and symptoms of abdominal trauma, CT is the best initial diagnostic modality to evaluate for abusive intra-abdominal injury.\textsuperscript{65}

**Imaging**

Plain radiographs are perhaps the best modality to detect rib fractures; however, rib fractures are often not visible until there is callus formation, which occurs between 7 and 14 days after the injury.\textsuperscript{193} (See Figure 9.) Low-dose CT scanning of the chest may help to identify rib fractures not seen on initial radiographs in children aged < 2 years, since the majority of rib fractures are nondisplaced and located posteriorly or anteriorly.\textsuperscript{194} Abusive pulmonary contusion results from direct trauma to the pulmonary vessels, often resembles infiltrates on radiographs shortly after injury, and can be detected by chest radiographs in most patients.\textsuperscript{148} In most children with blunt cardiac rupture, cardiomegaly is present on plain radiographs of the chest.\textsuperscript{195} Ultrasonography, echocardiography, and angiography can also be employed to determine the extent of blunt cardiac injury.

Findings on CT suggestive of abusive small-bowel or mesenteric injury include free intraperitoneal fluid, a thickened bowel wall, and extraluminal air. If free intraperitoneal fluid is found in more than one location in the abdomen, there is a 50% likelihood of intestinal injury.\textsuperscript{196} Killeen et al found that helical CT scans with oral and intravenous contrast material had a sensitivity of 94% and a specificity of 96% in detecting mesenteric injury in adults with blunt accidental abdominal trauma.\textsuperscript{197} However, other authors believe that CT is not reliable for diagnosing intestinal injury in children with blunt abdominal trauma, even when oral contrast medium is administered, because extravasation of the contrast material rarely occurs.\textsuperscript{198,199}

Follow-up skeletal surveys done within 2 weeks of the initial study will frequently demonstrate additional occult skeletal injuries, such as healing rib fractures.\textsuperscript{205,206} The risk of the effective radiation dose in skeletal surveys using digital radiography is low and should not be an overriding concern in determining the need for skeletal surveys in children with possible physical abuse.\textsuperscript{207} Skeletal surveys should be obtained in the siblings of injured abused children who are aged ≥ 2 years, regardless of physical examination findings.\textsuperscript{208} Twins are at high risk for abusive fractures when compared to nontwin household contacts.\textsuperscript{208}

**Figure 9. Rib Fractures on Chest Radiography**

Acute fractures of the left posterior rib (black arrow) and healing fractures with callus (white arrows) of the lateral ribs in a 2-month-old. Image courtesy of Kirsten Bechtel, MD.
Special Circumstances

Children With Special Needs

Multiple studies have shown that children with disabilities are at greater risk of being victims of abuse and neglect compared to children without disabilities.27,206 Up to 18% of children in the United States aged < 18 years have disabilities and up to 54% of children served by CPS have some form of disability.209,210 Some children with special needs are also more likely to sustain injury in the course of their normal activities, especially if decreased mobility leads to decreased bone density. Emergency clinicians should have a lower threshold to consider abuse, and to consult a child abuse pediatrician for children with special needs.

Cultural, Complementary, and Alternative Medical Considerations

There are some cultural practices that can mimic child physical abuse, such as traditional practices of skin scraping, cupping, and moxibustion.211,212 Skin scraping, also called coin or spooning, is a common practice in Chinese and Vietnamese cultures in which oiled skin on the back is rubbed in linear strokes (typically in a “pine-tree” distribution) with a coin or porcelain spoon. This can present as linear erythema and progresses to petechiae or purpura that is thought to be a sign of efficacy.212 Cupping can be seen in Asian, Middle Eastern, Latin American, and Eastern European cultures and is performed by placing a heated cup on the skin. The cup is placed over acupuncture points, and cooling of the air inside the cup creates suction that is thought to draw out stagnant blood, toxins, and vital energy for improving circulation. Cupping can cause erythema that can become edematous and ecchymotic from the suction.211 Moxibustion is less commonly seen, with 2 methods practiced. The first method is where pieces of moxa herb are rolled into small balls and placed on the skin, ignited, and burned. This can lead to target-like burns that resemble cigarette burns. The indirect method is where the practitioner holds a lit moxa stick near the skin until the area turns red or sets the stick on top of acupuncture needles. This method rarely leads to scarring and is often used to treat atopic dermatitis.211

When evaluating children with unusual bruising or burns suggestive of these practices, ask the family if they practice any alternative and complementary medicine. Emergency clinicians must be mindful of cutaneous injuries in immigrant families and ask about the source of anything atypical. A good history will clarify any of the above practices that are not considered to be abusive in nature.

Female genital cutting and mutilation is a cultural practice that was outlawed in 1996 by United States federal statute as being abusive in persons under the age of 18.

Intimate Partner Violence

Children who live in violent households are often inadvertent victims of violence between adult family members.213,214 Intimate partner violence in the household increases the risk for emotional, psychological, physical, and sexual abuse.215,216 Children who live in households with intimate partner violence are also at risk for developing adverse health, behavioral, psychological, and social disorders later in life.218 Children exposed to intimate partner violence are more likely to engage in health-compromising behaviors during adolescence and adulthood such as cigarette smoking,220 drug use and abuse,215 and risky sexual behaviors.221,222 Some studies suggest a possible correlation between the frequency of intimate partner violence exposure and frequency of adverse health behaviors.219,223-225 Some studies have also shown that children exposed to intimate partner violence do not function well socially or academically,226,227 with some of these children becoming abusers themselves.215,226 Whether witnessing intimate partner violence leads to perpetrating intimate partner violence remains controversial, and direct causation is not yet supported by research.220

Not all states require mandated reporting for children exposed to intimate partner violence. Inter-
vening on behalf of the caregiver experiencing the intimate partner violence may be a means of preventing child abuse and neglect.228

Controversies and Cutting Edge

The field of child abuse is distinct from most other medical fields because there is a group (defense attorneys and witnesses) with a vested interest in creating controversy. This means that there are 2 layers of differentials: real (osteogenesis imperfecta, rickets, accidental trauma) and invented (infantile rickets, temporary brittle bone disease, hypoxia). Some of these invented controversies and how they have been debunked are discussed in the following sections.

Subdural Hematoma and Retinal Hemorrhage in Relation to Hypoxic-Ischemic Events

Geddes et al published a series of articles that compared the pathology of infants who died from AHT with those who died from hypoxic-ischemic causes.229-231 They proposed that infants with the combination of severe hypoxia, brain swelling, and raised central venous pressure develop blood leaks from intracranial veins into subdural spaces and report that a similar mechanism could account for retinal hemorrhage. Further studies were conducted to counter the idea that hypoxia and ischemia in the brain leads to subdural hematoma and retinal hemorrhage. One such study was a retrospective chart review of 156 pediatric patients presenting after submersion injury; CPR was performed on the majority of the cases. None of the patients had a subdural hematoma.232 Another study examined 50 cases of children aged < 4 years presenting after nontraumatic cardiorespiratory arrest and found that none had significant intracranial hemorrhage either on diagnostic imaging or on autopsy.233 Finally, a multicenter study of catastrophic cardiorespiratory arrest from nontraumatic causes found no children with intracranial hemorrhage.234 There have also been studies refuting retinal hemorrhage after CPR for nontraumatic causes, except in the presence of significant coagulopathy, where the patient had unilateral retinal hemorrhage.235

Retinal Hemorrhage and Seizures

There have been multiple studies evaluating the incidence of retinal hemorrhage after seizures in children.236-239 The most recent study examined 182 children (all aged < 2 years) admitted to the hospital following a seizure. Two patients (1.1%) were found to have retinal hemorrhage, and both were ultimately diagnosed as being abused.239 In the discussion section of that article, the authors pooled the results of their cohort with other studies evaluating the prevalence of retinal hemorrhage after convulsions in children aged < 2 years236-238 These authors then calculated a combined prevalence of retinal hemorrhage in the setting of seizure to be 0.26% and concluded that retinal hemorrhage found after convulsions are extremely rare and should trigger careful evaluation for other causes, especially child abuse.

Fractures and Rickets

In 2008 Keller and Barnes published a controversial article entitled “Rickets vs. abuse: a national and international epidemic.” In this article, the authors implied that multiple fractures occur spontaneously in young infants with subclinical vitamin D deficiency/insufficiency, even in the absence of radiologic findings of rickets. Because of this possibility, they concluded that subclinical vitamin D deficiency should always be included in the differential of infants with multiple fractures, as these can be mistaken for nonaccidental injuries.240

Rickets, however, is a deficiency of bone mineralization that requires radiographic findings for the diagnosis. Merely having insufficient/deficient vitamin D levels in the blood does not constitute rickets.246-241 To further refute the likelihood of subclinical vitamin D deficiency as a cause of multiple fractures, Chapman et al evaluated children with radiographically evident rickets and documented the frequency and types of fractures these children sustained.46 In this cohort, none of the infants had fractures prior to 6 months of age. The fractures that were observed in mobile infants aged > 6 months resembled structural insufficiency fractures; were either present in the face of florid rachitic changes or were accompanied by moderate radiological abnormality; and were consistent with the history of injury mechanisms. No fracture types that are more often seen in abuse (eg, classic metaphyseal fractures or posterior medial rib fractures) were seen in this cohort. The authors concluded that fractures occur in mobile infants/toddlers with radiologically overt nutritional rickets, but these fractures do not resemble those of nonaccidental injuries.46 Another paper that examined vitamin D status in abused and nonabused children aged < 2 years with fractures showed that there was no difference in fracture risk between those with and those without vitamin D deficiency.242 The authors of that study concluded that child abuse remains the most common cause of multiple fractures in young children.

Documentation

Emergency clinicians should ask open-ended, nonleading questions of both the parent or caregiver and any verbal children about “what happened,” whenever abuse is suspected or an injury is unexplained. If possible, it can be helpful to interview the
1. “I thought bruising on the lower extremities could be a normal finding in a 3-month-old infant.”
Bruising is the most common detectable injury in maltreatment; it is missed as a sentinel injury in about one-third of fatal or near-fatal abusive injuries. Though bruising to anterior lower legs in mobile children can commonly occur from accidental injuries, bruising is uncommon in children who are premobile (in general, children aged < 6 months).

2. “I thought I had to wait until I was certain that some form of abuse had occurred before I reported to CPS.”
All medical providers are considered mandated reporters and should report any concern for the possibility of abuse to CPS as soon as suspicion arises. A local child protection specialty physician can also be contacted to discuss concerns. Reporting to CPS facilitates the investigation and the mobilization of resources to help the child, and does not automatically trigger removal of the child from the home.

3. “I did not consider AHT on my differential because the infant had a seizure and vomiting and had no external signs of injury.”
Recognizing AHT can be difficult, as it can present with subtle signs and symptoms. However, shaking without impact may result in no external signs of injury. AHT is important to consider in the differential diagnosis, especially when the history does not point to a clear cause or does not explain the presentation.

4. “This infant has mild vitamin D deficiency; therefore, this must be the cause of his fractures.”
Insufficiency/deficiency of vitamin D levels in the blood does not constitute rickets. Fractures in patients with rickets resemble structural insufficiency fractures and are present in the face of florid rachitic changes in the bones. Fractures associated with rickets are also consistent with the injury mechanism. They tend to be seen in mobile infants aged > 6 months. They are not associated with classic metaphyseal fractures, posterior medial rib fractures, vertebral fractures, or skull fractures.

5. “A 2-month-old child could have bleeding from his mouth from hitting himself with a toy.”
Always consider the developmental stage of the child and whether the injury makes sense with that developmental stage. Premobile infants presenting with inadequately explained oral injuries must be evaluated for abuse.

6. “I got the chest x-ray to look for aspiration pneumonia. I was not looking for rib fractures.”
Always assess radiographic studies in a systematic manner. For example, look at image quality, soft tissue and bones, the airway and mediastinum, lungs, heart, diaphragm, etc. Rib fractures are not typically visible until there is callus formation, which occurs approximately 7 to 10 days postinjury. Among children with abusive fractures, approximately 20% were missed initially, including a large fraction that were present but missed on initial imaging studies.

7. “This family is so nice and the parents are very wealthy, they couldn’t have abused their baby.”
Abuse can happen to children of all social and ethnic demographics. Abuse cases are more often missed on first presentation to the ED due to provider biases and the misconception that abuse only happens in certain populations.

8. “The bruising pattern on this boy makes me concerned for child abuse. I will make him an appointment with his pediatrician and she can decide if there needs to be a referral to CPS.”
Emergency clinicians are considered mandatory reporters of abuse. It is inappropriate to wait for a follow-up appointment with a pediatrician to make a CPS referral. It might not be safe for this child to go home with the family and wait for the appointment. The patient could be lost to follow-up and may be further harmed.

9. “This child probably has multiple fractures because she was born prematurely.”
Children with chronic medical problems are a uniquely at-risk population and have higher rates of abuse than the general pediatric population. Children with chronic illness or disability often place higher emotional, physical, financial, and social demands on their caregivers. Caregivers with limited support and poor coping skills may feel overwhelmed by the responsibility of caring for a child with special needs.

10. “The patient has loop-shaped bruises on his torso, but his platelets and coagulation studies are normal. I will arrange for follow-up with a hematologist.”
Coagulopathies may cause petechiae and ecchymoses, but bruises that are patterned, multiple, or occurring in clusters may occur from physical abuse.
parent/caregiver separately, away from the child, so that their responses are not suggestive to the child. Document words and statements in quotation marks when possible. For example, when asked what caused the old scars on his arms, the patient stated, “daddy hit me with the cable cord because I spilled my dinner.” Conducting separate interviews can be time consuming, and social work may need to assist in the midst of a busy shift in the ED. The child should not be left alone while interviewing the parent/caregiver; have another family member or volunteer sit with the child to provide comfort.

**Disposition**

Because emergency clinicians are mandated reporters, a report should be filed with CPS when there is concern for possible child maltreatment. This critical step often affects the disposition of the patient as well as those living in the home. If a child abuse specialist is available, he or she can also aid in the planning of the child’s disposition and can answer questions the emergency clinician may have. Child abuse specialists can evaluate the child in the hospital (if admitted) and can also perform follow-up in their clinic, as needed.

Forensic interviews often take place in the outpatient setting. A forensic interview is a structured conversation with a child, intended to elicit detailed information about possible event(s) that the child may have experienced or witnessed. Pediatric trauma centers are required to have a child protection team available. Emergency clinicians who do not work in a center with a child abuse pediatrician should be aware of possibilities for referral or consultation outside their own center.

Social workers can be another helpful resource, if available, and they can help link children and families to needed resources and, at times, help clinicians with reporting to CPS. CPS will help coordinate a plan to ensure the child’s safety, and they often decide who is able to stay with and/or visit the child if the child is admitted to the hospital. CPS will also decide who will have custody of the child after he or she is deemed medically stable for discharge. Some hospitals have a policy for 1:1 observation, beginning in the ED setting, when there is heightened concern of nonaccidental injury.

Finally, in all cases of suspected maltreatment, it is helpful (when possible) to contact the primary care providers prior to discharge to make them aware of the situation and to coordinate further outpatient care. These are the providers who have a previous relationship with the family and patient, and they may have further details about the family dynamics.

**Cost-Effective Strategies**

Abused and/or neglected children have greater morbidity, higher hospital charges, and are more likely to die during hospitalization compared with nonabused children. Early identification of abuse may lead to significant cost and resource savings. Using an exploratory Markov model, Campbell et al evaluated the cost-effectiveness of a universal cranial CT protocol to detect AHT in well-appearing infants with unexplained scalp bruising. The authors concluded that from a medical payer perspective, CT screening is cost-saving in infants with unexplained scalp bruising. In contrast, the authors found a higher societal cost from head CT screening, which reflects the high cost of child protection. While this study supports a low medical threshold for CT screening for AHT, there are other considerations that can be made to lower medical expenditure. Emergency clinicians should avoid inadequate skeletal surveys that will need to be repeated. If a center is unfamiliar with and does not perform skeletal surveys regularly, the child should be transferred to a center that does. Also, it is probably cost-effective to perform a routine electroencephalogram in children admitted for AHT, given the high rates of occult seizures.

In addition to the medical decision-making listed above, there is also a need for programs that prevent abuse from occurring, rather than solely improving its detection. There are several promising interventions to prevent maltreatment. Poole et al performed a systematic review of universal maltreatment prevention programs. After implementation, several of these programs demonstrated significant reductions in dysfunctional parenting, child behavior problems, and parental anger, as well as increases in parental self-efficacy and knowledge of concepts and actions relevant to preventing child abuse. One study from this review showed the preventative impact of a program called Triple P (Positive Parenting Program). In this population trial, 18 counties were randomly assigned to either a services-as-usual control group or the Triple P intervention group. There were significant reductions in the rates of substantiated child maltreatment, child out-of-home placements, and hospitalizations or ED visits for child maltreatment injuries for those families who received the intervention. There are other promising programs (eg, Nurse Family Partnership, a home visitation program for at-risk families) that have also shown evidence to decrease future maltreatment.
Summary

Contact with an emergency clinician may be the first and only opportunity for abuse to be recognized. Physical abuse may manifest in a wide spectrum of findings, and it is critical for emergency clinicians to consider abuse in the differential when the caregiver history does not provide a clear mechanism for the type and severity of injuries detected on physical examination or diagnostic workup. When abuse is considered, initiation of a complete evaluation, which may include laboratory testing; radiological imaging; consultation with experts in child abuse, trauma, and ophthalmology; and referral to CPS, will aid in assuring that the diagnosis of abuse is appropriately made.

Case Conclusions

You decided to order a cranial CT scan for the 3-month-old vomiting, irritable boy. The results revealed a subdural hematoma. Given these results and a lack of history to explain the patient’s findings, you called CPS. You transferred the infant to a tertiary-care pediatric center for further monitoring, a dilated eye examination by an ophthalmologist to look for retinal hemorrhages, a skeletal survey to evaluate for other occult fractures, and an MRI of the brain and cervical spine to further delineate any other injuries.

Given the implausible history given by the mother of the 2-month-old boy with bruises, you had a heightened concern for abuse. You ordered a chest x-ray, which revealed multiple posterior rib fractures, some acute and some with signs of callus formation. Liver function tests and a cranial CT scan were performed in the ED and were found to be normal. The patient was admitted and a skeletal survey was completed. The results of the skeletal survey revealed multiple metaphyseal corner fractures. Taken together, you were convinced that this patient’s injuries were not accidental. Upon further questioning, the father eventually confessed to aggressively squeezing the baby to try to stop his crying.

For the boy brought from daycare with a circular burn on his buttocks, given the pattern of the burn and the age of the child, you considered alternative diagnoses, such as a burn from accidental laxative ingestion, infectious etiologies such as bullous impetigo and staph-scaled skin, and other diaper dermatitis. You decided to consult with the available child abuse physician. After reviewing the case, the child abuse physician had a high suspicion for inflicted injury. The social worker learned of previous CPS involvement when a sibling presented with multiple bruises. You made a report to CPS for further investigation into this case, and the patient was admitted for burn care and disposition planning.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study is included in bold type following the references, where available. The most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.


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1. Approximately what percentage of children who died from nonaccidental injuries were previously evaluated by healthcare providers for injuries that were not recognized to be abusive?
   a. 5%
   b. 10%
   c. 20%
   d. 30%

2. What behavior on the part of a child is the most common trigger for abusive head trauma?
   a. Toilet-training accidents
   b. Spilling food on the floor
   c. Crying
   d. Not eating dinner

3. Which of the following household characteristics puts a child at higher risk for being maltreated?
   a. A nonbiologically related adult male living in the household
   b. Both parents living together in the household
   c. A father with no high school diploma
   d. More than 3 children living in the household

4. Which of the following scenarios is highly specific for maltreatment?
   a. Any injury to a premobile infant
   b. A frenulum injury in 13-month-old infant
   c. A nondepressed, stellate temporal skull fracture in a 9-month-old infant
   d. A spiral fracture of the tibia in a 12-month-old infant


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5. Which of the following locations of bruises is highly specific for maltreatment?
   a. The pinna
   b. The olecranon
   c. The anterior superior iliac spine
   d. The lateral malleolus

6. Which child needs a retinal examination?
   a. A child with multiple fractures
   b. A child with an unexplained subdural hematoma
   c. A child with multiple patterned bruises
   d. A child with symmetric lower extremity burns

7. This question has been deleted.

8. What is the most common cause of death in cases of abusive abdominal trauma?
   a. Acute renal failure
   b. Acute liver failure
   c. Peritonitis
   d. Sepsis

9. Which of the following fracture types is highly specific for maltreatment?
   a. A torus fracture of the distal radius
   b. A spiral fracture of the proximal tibia
   c. A classical metaphyseal lesion of the proximal humerus
   d. A stellate nondepressed fracture of the occipital bone

10. Which is the most appropriate initial imaging for a child with concern for abdominal injury?
    a. FAST examination
    b. Abdominal CT with intravenous contrast
    c. MRI
    d. Formal ultrasound performed by a radiologist

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EB Medicine would like to thank Adam E. Vella, MD, FAAP, for his service as Editor-in-Chief of Pediatric Emergency Medicine Practice.

Since 2012, Dr. Vella has led the journal to new heights, devoting countless hours to ensuring that pediatric emergency medicine clinicians are better informed, ready, and able to provide the highest quality of care for their patients. During his tenure as Editor-in-Chief, PEMP has become recognized as an authoritative, evidence-based publication and a valuable source of high-impact specialty CME. Dr. Vella will continue to support as a member of the Editorial Board.

One of Dr. Vella’s many contributions in the past five years is his recruitment of an exceptional group of practicing clinicians to serve on PEMP’s Editorial Board, including Ilene Claudius, MD. Effective July 1, 2017, he passes the baton to Dr. Claudius, PEMP’s new Editor-in-Chief.

Please join us in thanking Dr. Vella for his leadership and contribution to the field of pediatric emergency medicine and congratulating Dr. Claudius on her new opportunity to make her mark at the helm of PEMP.

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CME Objectives: Upon completion of this article, you should be able to: (1) explain the variable presentations of nonaccidental injuries in infants and children; (2) determine which laboratory and diagnostic tests to obtain when abuse is suspected; and (4) review the evidence-based practice of abuse in children.

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