

# Radiological Features of Nonaccidental Injury

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**ABSTRACT:** Nonaccidental injury (NAI) is a leading cause of traumatic brain injury with significant morbidity and mortality in young children. Radiology plays a vital role in the diagnosis and management of NAI. It also helps in assessing the prognosis of various injuries and dating the injuries. Important radiological features of NAI including recent advances in imaging particularly involving magnetic resonance neuroimaging of abusive head trauma will be discussed. Important differential diagnoses and their imaging features will also be discussed. (J Radiol Nurs 2013;32:3-9.)

**KEYWORDS:** Nonaccidental injury; Abusive head trauma; Pediatric imaging; Child abuse.

## INTRODUCTION

Abusive head trauma (AHT) as a result of nonaccidental injury (NAI) is the leading cause of traumatic brain injury with significant morbidity and mortality in young infants. The mortality is approximately 15% to 23% with moderate to severe neurological and physical disability seen in two-third of the survivors (Sieswerda-Hoogendoorn, Boos, Spivack, Bilo, & van Rijn, 2012). The rate of victimization is highest from birth to 1 year of age at 20.6 per 1,000 children according to the US Department of Health and Human Services 2010 survey. In 2010, there were 1,537 fatalities with nearly 80% of these fatalities in children younger than 4 years (United States Children's Bureau, 2010). The Federal Child Abuse Prevention and Treatment Act defines child abuse 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." It is a difficult diagnosis to make because the injuries are most often unseen by someone other than the caretaker, and often there is no explanation for the injuries. The lack of history or history not consistent with clinical findings should alert the health care provider to the possibility of NAI. The differential includes true accidental injury as well as rare metabolic and genetic disorders. The medicolegal implications are significant for the young infants, their siblings, parents, caretakers, and also medical personnel taking care of the infants. Missing the diagnosis can potentially be lethal to the infant or their siblings, and making a wrong diagnosis of AHT/NAI can be devastating to the family. As such, the diagnosis is frequently challenged in the court. The nomenclature of AHT has evolved over time, and other terminologies include battered baby syndrome, whiplash shaken infant syndrome, and abuse. The current nomenclature of AHT adopted by the American Academy of Pediatrics reflects the overall nature of the injury rather than a mechanism of injury (Sieswerda-Hoogendoorn et al., 2012). The diagnosis of NAI/AHT is established by a multidisciplinary team approach. Radiology plays an important role in the diagnosis. It helps to raise the possibility of the diagnosis or exclude it, define the extent and nature of the injury, date the injury, and predict the prognosis. Dating the injury when possible is important in the medicolegal process to establish a definite time line to ensure that the perpetrator of the crime is identified. Reporting to the social services department responsible for child protection is the obligation of all professionals who work with children, such as physicians, nurses, schoolteachers, and guidance counselors (Hilton & Edwards, 2006).

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There are different types of child abuse: physical (nonaccidental trauma), neglect, sexual, and emotional. Our discussion will mainly focus on physical or nonaccidental trauma and the role of imaging in identifying these cases as the present and future well-being of our children relies on early recognition and prompt initiation of protective services.

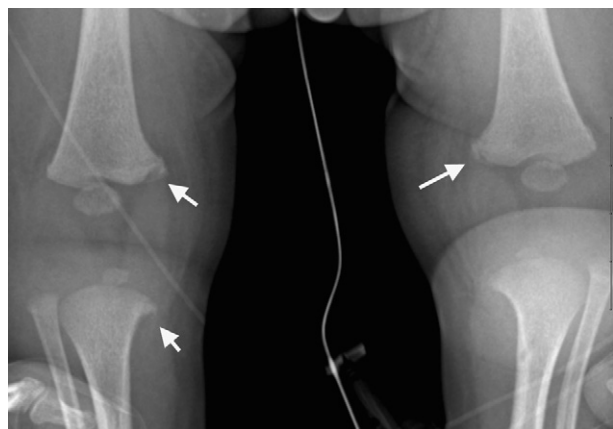
### SKELETAL INJURIES

The skeletal survey is the primary imaging study for suspected physical nonaccidental trauma. At our institution, these routine views are obtained as a baseline: anteroposterior (AP) and both obliques of the chest, AP and lateral skull, lateral cervical spine, AP and lateral views of thoracolumbar spine, AP pelvis including lower extremities through the knees, bilateral AP views of the lower legs, AP feet, frog leg lateral view of both legs including hip through foot/ankle, and bilateral AP upper extremities including hands. Additional views to supplement will be obtained to clarify questionable findings. Correlating the provided history with the imaging findings is crucial. A pediatric radiologist checks the images to decide whether additional views are required. In positive cases, and in cases without definite abnormality but a high degree of suspicion, a repeat study, usually limited to the chest and extremities, is obtained 10 to 14 days after the initial survey. The follow-up survey is very helpful in better dating of the fractures and frequently identifying fractures that were acute or occult on the original survey. The clinical benefit to the limited survey outweighs the radiation risk to the patient.

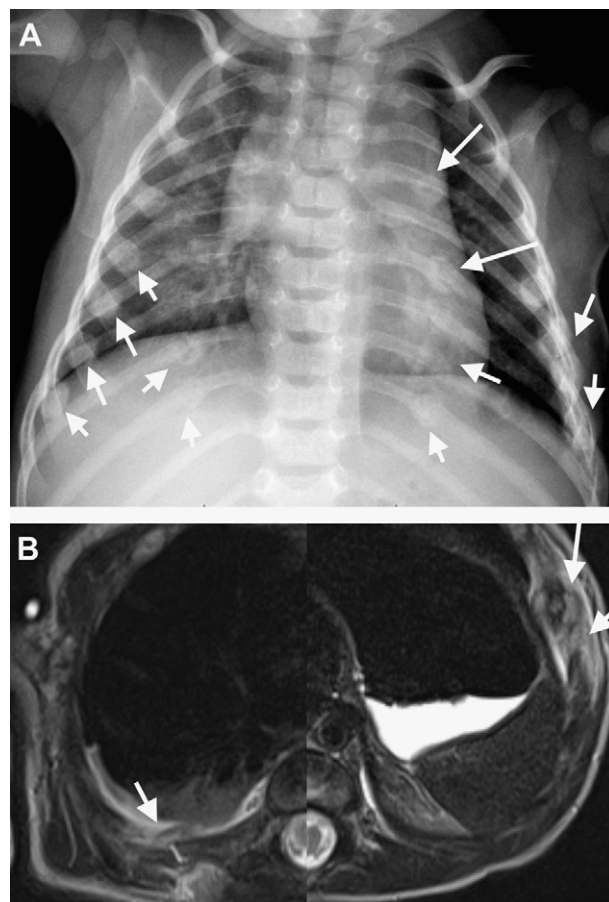
The specificity of various fractures has been the subject of numerous publications. Kleinman (1998) has sug-

gested that abusive skeletal trauma can be subdivided into three categories: high, moderate, and low specificity.

High-specificity fracture includes classic metaphyseal lesion of long bone metaphysis, which is postulated to be caused by vigorous pulling, twisting, and grabbing of extremities (Figure 1). Rib fractures in otherwise healthy infants are also included in high-specific category. These fractures often occur around the costovertebral junction secondary to excessive compression force with shaking, as if the infant was grasped about the thorax (Figure 2). Because it is secondary to AP compression force, there is always a question about whether cardiopulmonary resuscitation (CPR) can cause rib fractures. In a systematic literature review of 923 children, rib fractures after CPR were rare (3/923) and if present was anterior in location (Maguire, Mann, John, Ellaway, Sibert, & Kemp, 2006). Other



**Figure 1.** A 5-month-old female patient presented with unexplained cardiac arrest at home and was found to have diffuse hypoxic-ischemic encephalopathy of the brain with multiple healing rib fractures. Radiograph of the bilateral femur demonstrates metaphyseal fractures of the bilateral distal femur and right proximal tibia (arrows).



**Figure 2.** A 2-month-old male patient presents with a witnessed history of shaking and punching injury. (A) Twenty-nine healing rib fractures were identified on the chest radiograph. Some of the rib fractures are arrowed. (B) Magnetic resonance imaging of the spine juxtaposing two different levels of the chest demonstrated the healing rib fractures with callus formation bilaterally (arrows).

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