Diagnostic Imaging of Child Abuse

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Our Patient

- OD, a 4 month old female, begins day care.
- 1st week “irritable, fussy, and inconsolable.”
- 2nd week “somnolent more than usual”
- Pediatrician notes regression in milestones and bulging fontanelles
- Sent to South Shore ED because of fear of meningitis
Our Patient

- South Shore LP found to have normal WBC, RBC, protein
- Retinal hemorrhages found on fundoscopic exam
- Head CT performed
- Findings on CT lead to a general skeletal survey

From Children’s Hospital
Our Patient: Skeletal Survey

Chest X-ray demonstrated healing posterior rib fractures from ribs 3-10 on the right side and ribs 6-10 on the left side.

From Children’s Hospital
Our Patient: Skeletal Survey (cont)

- Widened coronal sutures suggested that there was an acute increase in intracranial pressure

From Children’s Hospital
Skeletal survey also revealed a fracture of the right distal femur.
Child Abuse Incidence

- In 1999, data from state child protective service agencies nationwide found the incidence of abuse and neglect to be 11.8 per 1000.
- In 1999, an estimated 1,100 children died of abuse and neglect, a rate of approximately 1.62 deaths per 100,000.
- The 3rd National Incidence Survey (NIS 3) in 1993 estimates the true incidence to be 42 per 1000 with 2,815,600 children harmed or endangered by maltreatment per year.
- The NIS 3 estimated that, in 1993, 269,700 children were harmed by physical abuse.
Skeletal Injury in Abuse

• Frequency of fracture in cases of abuse estimated at 11 to 55%
• Most fractures found in children under 3 years old
• Children under 1 year of age found to be a biggest risk of fracture.
• Abusive skeletal injury is rarely life threatening, but may signal a serious threat to a child
Specificity of Radiologic Findings

High Specificity
- Classic Metaphyseal Lesions
- Rib Fractures
- Spinous Process Fractures
- Scapular Fractures
- Sternal Fractures

Moderate Specificity
- Multiple Fractures
- Fractures of different ages
- Epiphyseal separations
- Vertebral body fractures
- Digital Fractures
- Complex Fractures

Common, but low specificity
- Subperiosteal new bone formation
- Clavicular fracture
- Long bone shaft fractures
- Linear skull fractures

Location and types of fractures in non-accidental (A) vs. accidental (B) trauma in infants less than 18 months old.

Classic Metaphyseal Lesions

• Fracture of the infant metaphysis resulting from traction and torsion on the extremities

• Classic “bucket handle” or “corner” fractures

• Most commonly seen in femur, tibia, and proximal humerus

• With healing, may see focal metaphyseal lucency representing extension of the growth plate cartilage into metaphysis

• Subperiosteal new bone is uncommon with these lesions

Bucket handle fracture of distal radius of a 2 month old. Fracture viewed obliquely. If tangential view obtained fracture would appear as corner fracture.

From Children’s Hospital Dept. of Radiology Teaching File
Examples of Classic Metaphyseal Lesions

From Children’s Hospital Dept. of Radiology Teaching File
Rib Fractures

- In infants, unusual in any setting except abuse
- Incidence of rib fractures in abuse between 5-29%
- Acutely may be invisible, later see callus and subperiosteal new bone
- Most frequently posterior and middle ribs
- Multiple levels at similar points
- Often symmetric

Spine Fractures

- Spinal injuries have been found in 0-3% of physical abused children
- Injuries are due to hyperflexion and hyperextension
- Vertebral body fractures are the most common
- Spinous process fractures are highly specific for abuse

Spinous process avulsion fractures (arrows above) are due to increased tension on the supraspinous ligament during hyper flexion.

Shaken Baby Syndrome (SBS)

- Extreme rotational cranial acceleration induced by violent shaking +/- impact
- Clinical features include subdural and/or subarachnoid hemorrhages, retinal hemorrhages, and CMLs.
- Most often in children younger than 2 years old, Seen in children up to 5 years old

Younger infants will often be grabbed by the rib cage leading to associated rib fractures (left). Heavier children may be grasped by extremities (right) leading to periosteum contusion and SPNB formation.

From Children’s Hospital Department of Nuclear Medicine Teaching File
Shaken Baby Syndrome

• History of poor feeding, vomiting, lethargy, and/or irritability for days or weeks.
• Severe injury and delayed seeking of medical attention can lead to seizure, coma, apnea, and/or bradycardia on presentation
• Symptoms similar to meningitis; Can not assume blood in LP is due to traumatic tap
• CT is the diagnostic test of choice if suspected increased intracranial pressure
Our Patient shows classic signs of SBS

While never proven the belief was that one of the workers at her new day care center must have abused her.
Skeletal Survey Guidelines

Recommendations for skeletal survey

0 to 12 mo
Skeletal survey
Follow up skeletal survey (2 wks)

12 mo to 2 y
Skeletal survey or scintigraphy

2 to 5 y
Skeletal survey or scintigraphy in selected cases where physical abuse strongly suspected

5 y and older
Radiographs or individual sites of injury suspected on clinical grounds

Components of Skeletal Survey

AP skull
Lateral skull
Lateral C Spine
AP Thorax
AP Pelvis
Lateral lumbar spine
AP Humeri
AP forearms
Oblique hands
AP Femora
AP Tibias
AP feet

Avoid Babygrams: X-rays that try and get the entire skeleton onto one plain film miss subtle findings!!!
Characteristic bone scan in child abuse

- Important complementary modality
- Detects many areas that would be hard to identify radiographically
- Some centers use it as the primary global screening tool for children over 1 year old

“diffusely increased uptake in the skull, increased focal uptake in the lateral left clavicle, multiple foci in adjacent anterior and posterior ribs on the left and in several anterior ribs on the right, focal uptake in the distal radius and ulna bilaterally more prominent on the right, bilateral diffuse increased uptake in the femoral shaft, diffuse uptake to a lesser extent in the shafts of the tibiae and diffuse increased uptake in the iliac bones bilaterally.”

Scan and report from Children’s Hospital Department of Nuclear Medicine Teaching File.
Important Differentials

- Unintentional and Obstetric Trauma
- Normal Variants
- Osteogenesis Imperfecta
- Other Genetic and Metabolic Bone Diseases
Unintentional or Accidental Trauma

- After age 2, long bone fractures are more likely to be due to unintentional injury.

- Femoral spiral, oblique, and transverse fractures in infants less than 1 y.o. are usually secondary to abuse.

- Humeral fractures other than subcondylar in infants and young children are highly suggestive of abuse.

- Toddler, spiral, and hyperextension fractures of tibia in a nonwalking or cruising child also suggest abuse.

- Extremity and rib fractures due to falls from a normal height crib or beds are unusual (see figure).

- Falls from greater heights, down stairs, and with, or from the arms of, caretakers are more likely to produce extremity or skull fracture.

Examples of Obstetric Trauma

- Clavicular fractures are the most common
- Long bone fractures (humeral more than femoral) are less common
- Rib fractures are rare
- Exuberant callus formation is a common
- Absence of callus formation in long bone, clavicular, or rib fracture after 11 days of age suggests that a fracture is not of obstetric origin

From Children’s Hospital Dept. of Radiology Teaching File
Normal Variants

- There are a number of normal metaphyseal variants during the first year of life that can be mistaken for CMLs.

Normal Variants

- Physiologic subperiosteal new bone formation is phenomenon seen in 40% of healthy infants
- Occurs during first six months of life
- Always symmetric
- Rarely thicker than 2 mm
- Predilection for long bones particularly the femur and tibia
Osteogenesis Imperfecta

• Only Types I and IV are mild enough to be confused with child abuse.

• Osteogenesis Imperfecta is rare (1 in 20,000 births) while unfortunately child abuse is common

Metaphyseal fractures with confirmed OI. There appear to be metaphyseal corner fractures (thin arrows). A mature callus has formed from a healing femoral shaft fracture (fat arrows). Generalized demineralization is also present.

OI vs Child Abuse Algorithm

*Evaluation of OI includes examination for wormian bones, blue sclera, abnormal skin texture, abnormal teeth, hearing loss, and joint laxity

Metabolic Bone Disease of Prematurity

• Premature infants often suffer from metabolic bone disease that leaves them at increased risk for fracture.
• Believed to be due to low intake of calcium and phosphorus although these lab values may be normal.
• Osteopenia is usually present
• Rib and long bone fractures common

Healing posterolateral rib fractures (arrows) in a 4 month old premature infant that occurred prior to discharge from the hospital

Other conditions that can simulate abuse

- Congenital indifference to pain
- Myelodysplasia
- Osteomyelitis
- Congenital syphilis
- Rickets
- Scurvy
- Vitamin A intoxication
- Caffey’s Disease
- Leukemia
- Prostaglandin E₁ therapy
- Methotrexate therapy
- Menke’s Syndrome
- Copper deficiency
- Metaphyseal and spondylometaphyseal dysplasia
Fake out lesions

Widened coronal sutures (above) and subperiosteal new bone formation (right) in a patient with Vitamin A intoxication

(above) Corner metaphyseal fracture in a child recovering from rickets

References


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