Orthopedic Aspects of Child Maltreatment
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Disclosure Statement
Jamie Hoffman-Rosenfeld, MD, has no financial relationships with any commercial interests.

Objectives
The learner will be able to:
* Articulate the concepts involved in the evaluation of orthopedic injuries and their relationship to child abuse.
* Explain the appropriate workup of an infant and a young child with suspicious orthopedic injuries.
* Review specific orthopedic radiologic findings associated with child abuse.
Fractures account for 10%-25% of childhood injuries. About 25% of fractures in children less than 1 year old are attributed to abuse. The percent diminishes with increasing age of the child.


Specificity of Radiographic Findings

High Specificity
- Classic metaphyseal lesions
- Rib fractures, especially posterior


The CML
- Cannot be dated.
- May not be symptomatic.
- Disappears in 4-8 weeks.
- The most common fracture identified in fatally abused infants!
Description of Fracture is Key!

- The specific fracture location along the bone (e.g., epiphyseal, diaphyseal, metaphyseal)
- The fracture type (e.g., transverse, oblique, spiral, buckle, CML)
- Whether there is displacement, separation, or comminution of the fracture
- Whether the fracture is open or closed
- Whether there is more than one fracture along the bone or more than one bone
- The extent of callus formation, if present

Types of Loading Leads to Predictable Fracture Patterns

Biomedical Condition: Torsion
Fracture Type: Spiral/Long Oblique

Bones of children fail more readily under torsion than bending.

*Child Abuse and Neglect: Diagnosis, Treatment and Evidence*, editor Carole Jenny, MD
Chapter on Fracture Biomechanics, Gina Bertocci, PhD
More than 80% of metaphyseal fractures had no associated bruising!

The absence of associated bruising does not imply that the force required to produce the fracture was trivial.
Abstract

To determine whether the presence or absence of bruising can be used to differentiate between abusive and nonabusive fractures, a retrospective study was conducted of patients with acute fractures referred to a child abuse team. A bruise and fracture were considered associated if both occurred on the same body site. Chart summaries, excluding information on bruising, were reviewed by 2 abuse experts to assign cause of injury. Of the 150 participants, fractures of 93 (62%) were categorized as abusive and 57 (38%) as nonabusive. Bruising associated with a fracture was found for 26% of abused and 25% of nonabused children. Most children (61%) had no bruises anywhere on the body, and this did not differ significantly by cause of injury. The sensitivity of a bruise associated with a fracture to predict abuse was only 26%.

The presence or absence of bruising was not useful to differentiate between abusive and nonabusive fractures.

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Transverse Metadiaphyseal Fracture

- 8 month old; chubby baby
- Left on bed while mother was in bathroom; she heard a thump and returned to find the baby on the floor.
- Irritable, noted swelling of leg.
- Promptly brought the baby to the ED.
- X-ray revealed femur fracture.

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Types of Loading Leads to Predictable Fracture Patterns

Biomedical Condition: Compressive
Fracture Type: Buckle/Impaction

Child Abuse and Neglect: Diagnosis, Treatment and Evidence, editor Carole Jenny, MD
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6 day old infant noted by family to have extreme irritability after the visit to the pediatrician. Pain with touching and movement of right leg, swelling. Brought to community hospital where swelling and bruising noted. X-ray reveals proximal femur fracture. Scheduled C-section for breech presentation. Delivery hastened when non-stress test monitoring detected decreased fetal movement. Father peeked over the drapes in the DR and noted that rump was delivered first. Nuchal cord X3 and cord around torso. Apgars 9 and 9.
Review of DR and Nursery Records

- No snap or pop recorded
- No details of delivery maneuver
- Normal entry and discharge nursery exam

Pediatric Visit on Day #6

Pediatrician reports that lower extremity and hip exam was normal.

Parent History

- Since birth, seemed to cry only during diaper change.
- Crying stopped when he was swaddled.
- Father noticed more movement on the left side; “I think he’s going to be a lefty.”
Fractures can happen from delivery, including femur fractures. C-section is not necessarily protective! Presentation of parturitional femur fracture might be delayed. Even good doctors can miss things. Use all sources of information available to put the puzzle pieces together – in this case, the family’s photo and video clip were essential.


Father notified by the babysitter that the shoulder is swollen and arm not moving. Generally healthy. Five day history of fever and fussiness. Mother noted that he wasn’t moving as much as usual for several days but did not notice any particular limb injury.
Physical Exam
- Pain with movement
- Swelling and tenderness at left shoulder
- Bruise on right mandible
- Dried blood in left ear concha

Other Evaluations and Laboratory Tests
- Ophtho exam normal
- Head CT normal
- Skeletal survey normal

Left Shoulder Salter 1 Fracture/Dislocation of the Proximal Humerus
- Epiphyseal separation injury
- Moderate specificity for child abuse according to Kleinman
- Considerable traction forces required
“suggest that a continuum exists between the CML and the epiphyseal separation of the proximal humerus”

“the degree of force required to cause epiphyseal separation is likely to be greater than those causing the cml”

“It is reasonable to assume that the traction, torsion, acceleration and deceleration forces commonly applied during infant assaults result primarily in osseous disruption without significant epiphyseal displacement…when massive injury occurs, a mainly cartilaginous injury with epiphyseal separation results”

Six year old son of babysitter reported seeing the babysitter’s husband swing the baby like a teddy bear because he wouldn’t stop crying.
Possible is not the same as plausible; must consider all features of the history.

What is the particular type and magnitude of loading required for the particular type of fracture?

Is the history described in a clear and consistent fashion with details?

What was the child’s response, symptoms, etc.?

Was there an appropriate caretaker response or was there a delay in seeking medical care?

Twins were in the crib together.

This baby cried and father reached over other twin to lift this baby from the crib.

Heard a snap; thought his bracelet had hit the crib side rail.
Could this be an accident??

- Healing left distal femur fracture
- Left tibial spiral fracture with periosteal reaction
- Right humerus periosteal reaction along diaphysis
- Toddler brother – thick periosteal reaction around distal right humerus

Conclusions
- Children who have been physically abused often sustain bony fractures.
- Different fracture types have been described as having a high probability for abuse while others are more nonspecific.
- No one fracture in isolation is specific for physical abuse.
- The details are in the history!
5 Month Old with Marks on Skin

- 5 month old brought to the ED because of bruises to the buttocks.
- Previously healthy without chronic health conditions
- One prior ED visit at 2 months of age because of bruises to buttocks; the father said he fell while holding the baby and she fell against the foot of the bed.
- The mother works and leaves the baby in the care of the father; they live with the maternal grandmother.
- The grandmother reports that the father spends many hours in the bedroom with the baby; bedroom door closed and baby crying.

Findings

- Healing left metacarpal fracture
- Healing right posterior 11th rib fracture
- Edema of gluteal soft tissue and anus inflammation
- Right parietal skull fracture

OBJECTIVE: To develop guidelines for performing initial skeletal survey (SS) in children 24 months old with fractures, based on available evidence and collective judgment of experts from diverse pediatric specialties.
Osteogenesis Imperfecta
Prematurity
Vitamin D Deficiency Rickets
Osteomyelitis
Disuse Osteopenia
Scurvy, Menkes, Copper Deficiency
Accidental Injury
Temporary Brittle Bone Disease

Infant with Knee Pain and Fever

Pain noted when placed in exersaucer.

Seen by pediatrician and diagnosed with soft tissue injury.

Developed high fever and taken to an urgent care center; X-rays and blood tests done.

Called back and told to go to CCMC because of + blood culture and fracture seen on X-ray.
Metaphyseal fracture not well seen; minimal irregularity and sclerosis noted.

Subperiosteal fluid collection/abscess

Heterogenous disorder with defects in Col1A1 and Col1A2, the genes that encode for Type 1 collagen which supports the framework of bone.

Denovo mutations and autosomal recessive variants may account for absent family histories.

Diagnosis suggested by family history, blue sclera, dentinogenesis, short stature, and radiographic evidence of osteopenia.
Most common fracture type is transverse diaphyseal fractures of long bones.

Unusual to have multiple long bone fractures or rib fractures in infancy without other stigmata, either radiographic or clinical.

If fractures continue in a protected environment, consider additional workup.

Abuse is more common than OI.

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Prematurity

Decreased bone mineralization at birth which normalizes after the first year of life.

Particular risk: <1500 grams, <28 weeks, prolonged TPN (>4 weeks), BPD, steroids and diuretics.

Osteopenia presents between 6 and 12 weeks of life.

Premature babies are at risk for abuse.

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Vitamin D Deficiency

Vitamin D insufficiency (<30 ng/ml) is common in otherwise healthy infants and toddlers.

Despite this, Rickets is uncommon.

The claim that Vitamin D insufficiency or deficiency is commonly mistaken as abuse is unsupported.

Studies of patients with Vitamin D deficiency without evidence of Rickets does not show increased fracture prevalence.

Fractures in Rickets are in older, mobile infants = insufficiency fractures.
Laboratory Evaluation: The clinical evaluation should guide the laboratory evaluation. In children with fractures suspicious for abuse, serum calcium, phosphorus, and alkaline phosphatase should be reviewed, although alkaline phosphatase may be elevated with healing fractures. The physician should consider checking serum concentrations of parathyroid hormone and 25-hydroxyvitamin D, as well as urinary calcium excretion (e.g., random urinary calcium/creatinine ratio) in all young children with fractures concerning for abuse, but these levels should certainly be assessed if there is radiographic evidence of osteopenia or metabolic bone disease.

4 Month Old with Multiple Fractures

- 4 month old, grandmother points out to mother that she is not moving her arm.
- After 4 days, taken to outside hospital.
- Humerus fracture diagnosed.
- Skeletal survey done but other fractures not identified.
- Admitted to CCMC.

History

- Maternal cholestasis of pregnancy
- Induced and delivered at 36 6/7 weeks
- Tight nuchal cord
- Delayed transition with TTN, transfusion, phototherapy
- Defense expert opines: metabolic bone disease of prematurity, maternal cholestasis, Hypophosphatemic Rickets
Defense Witness Hypothesis

- Hypophosphatemic Rickets
- Prematurity
- Maternal Cholestasis
- Chest Physiotherapy

Toddler with Facial Injuries Brought for Evaluation

- Left 10th posterior rib fracture
- Compression fracture of lumbar vertebrae
- Lumbar compression fractures
- Right posterior acetabular fracture
- Head CT with soft tissue swelling

Investigation

- Child too young to be interviewed.
- Mother maintained he fell in the bathtub.
- Mother arrested for endangering but nobody could be charged with the abuse/assault.
- Newborn baby removed once the mother delivered.
Mother informed her attorney of domestic violence.

She said her boyfriend would slam the boy’s head against the bathtub and slam him onto his butt.