# Imaging Basics of Child Abuse

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# Definition

"Child abuse is the portion of harm to children that results from human action that is proscribed, proximate, and preventable."

Finelhor & Korbin. *Child Abuse and Neglect* 1988.

# Types of Abuse

- Neglect
- Emotional Abuse
- Sexual Abuse
- Physical Abuse

# Physical Abuse

World Health Organization (WHO): Inflicting injury upon a child, such as burning, hitting, punching, shaking, kicking, beating or otherwise harming a child. The parent or caretaker may not have intended to hurt the child.

Kacker et al. Study on Child Abuse: India 2007. Government of India. 2007.

# Epidemiology-Worldwide

- Data is limited due to lack of proper documentation. Thus, existing data is likely underestimating the extent of this problem.
- Per a WHO study on child maltreatment around the world, 25-50% of all children report being physically abused depending on the country.

Preventing Child Maltreatment: a guide to taking action and generating evidence. World Health Organization. 2006.

# Epidemiology-Worldwide

- Every year, globally, there are an estimated 34,000 homicide deaths in children under 15.
  - Infants and pre-school children are at greatest risk.
  - Risk of fatal abuse is 2-3x higher in low and middle-income countries than in high-income ones.
  - Most common cause of death is head injury. 2nd is abdominal injury.

Preventing Child Maltreatment: a guide to taking action and generating evidence. World Health Organization. 2006.

# Epidemiology-Worldwide

- Reasons for abuse being underreported:
  1. Fear: children and family members are afraid to report a more powerful family member
  2. Society accepts certain forms of physical abuse as 'discipline' or 'punishment.'
  3. Lack of trust in police system, social services, and other authority figures in a country

Report of the Independent Expert for the United Nations Study on Violence against Children. Promotion and protection of the rights of children. United Nations General Assembly, Sixty-first session. A/61/299. 2006.

# Epidemiology—United States

- Neglect makes up 62.4% of confirmed cases[1]
- Physical abuse is second making up 17.5%[1]
- By the age of 1 year, approximately 1 in every 50 children suffers some form of abuse or neglect[2]
- Studies show a range of 1200 to 2000 deaths in children per year from physical abuse alone[3,4]
  - The youngest are at greatest risk for fatality in the U.S: about 45% are younger than the age of 1[1]


[1]Boal, Danielle K.B. "Child Abuse." *Caffey's Pediatric Diagnostic Imaging*. Ed. Thomas L. Slovis. 11th ed. Vol. 2. USA: Mosby, 2008. 2816-830. Print

[2]U.S. Department of Health and Human Services, Administration for Children and Families. Administration on Children, Youth and Families, Childrens' Bureau (2010). *Child Maltreatment 2009*.

[3]Lonergan et al. *Radiographics* 2003.

[4]Nimkin & Kleinman. *Pediatr Radiol* 1997.

# Physical Abuse—
# Statistics in the US and UK

- Data is limited even for the US on the exact prevalence of abuse injuries in children.
- Based on data from the US and the UK, here are some statistics on the breakdown of injuries :
  - **Skeletal** : 35 to 88% (In one study, 66% had multiple fractures)
  - **CNS**: 12 to 24%
  - **Visceral**: 2 to 9%


Carty and Pierce . *Eur Radiol* 2002.

Day et al. *J Clin Forens Med* 2005.

Lane et al. *Pediatrics* 2009.

Leventhal et al. *Pediatrics* 2008.

Roaten et al. *Am J Surg*. 2005.

# Role of Diagnostic Imaging

- Three-fold:
  1. Recognize characteristic lesions of physical abuse to support a diagnosis or raise suspicion
  2. Serve as evidence of the mechanism and pattern of healing of injuries in a court of law
  3. May help exclude a diagnosis of child abuse

Boal, Danielle K.B. "Child Abuse." *Caffey's Pediatric Diagnostic Imaging*. Ed. Thomas L. Slovis. 11th ed. Vol. 2. USA: Mosby, 2008. 2816-830. Print

# Imaging Protocol for Skeletal Injury

- Fractures are the second most common finding after cutaneous injury, such as bruises and contusions.[1]

- SKELETAL SURVEY is the primary radiological exam in cases of suspected child physical abuse

[1]Offiah et al. *Pediatr Radiol* 2009.

# Skeletal Survey

- Per the 2011 ACR-SPR guidelines, it is a 'systematically performed series of radiographic images that encompasses the **entire** skeleton.' [1]

- Per the 2009 AAP guidelines, **ALL** children < 2 years, where physical abuse is suspected, should have a skeletal survey done.[2]

[1]ACR-SPR Practice Guidelines for Skeletal Surveys in Children. Revised 2011. <http://www.acr.org/~/media/9bdcdbee99b84e87baac2b1695bc07b6.pdf>.

[2]Diagnostic Imaging of Abuse. *Pediatrics* 2009.

# Skeletal Survey Imaging

## Whole body: Appendicular & Axial

- Axial
  - Ribs (AP, lateral, left and right obliques)
  - Pelvis (AP)
  - Lumbosacral spine (AP and lateral)
  - Cervical spine (AP and lateral)
  - Skull (AP and lateral)
- Appendicular
  - Humeri (AP), forearms (AP), hands (PA), femurs (AP), lower legs (AP), feet (AP)

ACR-SPR Practice Guidelines for Skeletal Surveys in Children. <http://www.acr.org/~/media/9bdcdbee99b84e87baac2b1695bc07b6.pdf>.

# Skeletal Survey

Lateral Cervical Spine

Lateral Skull

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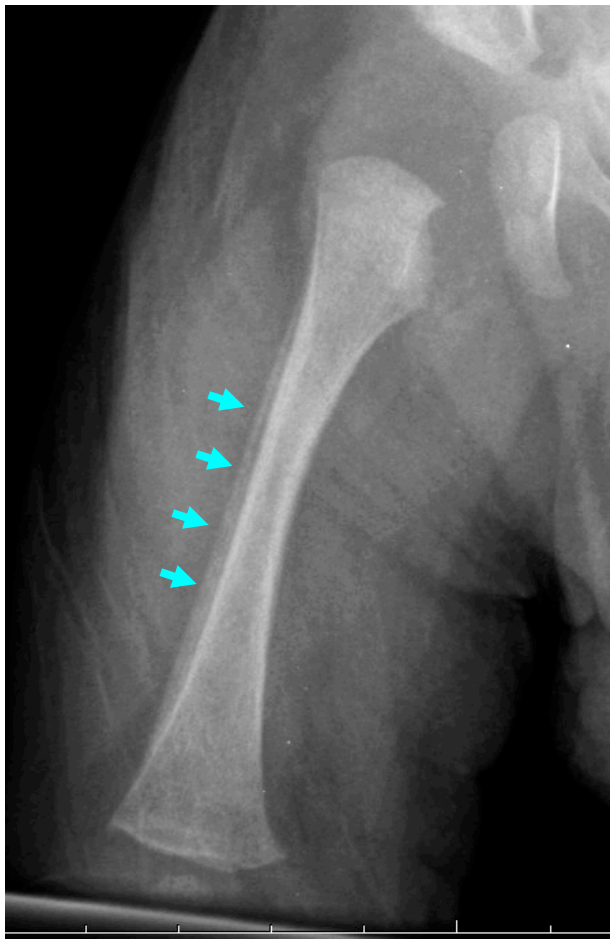
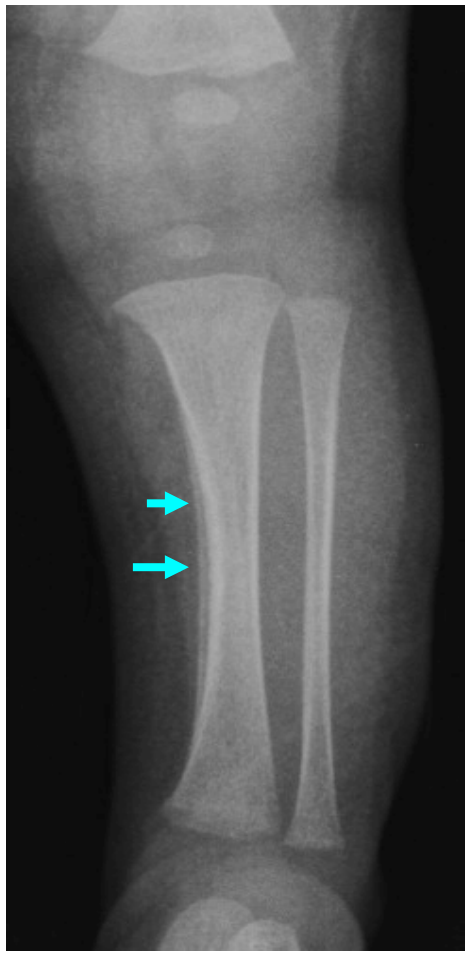
# Skeletal Survey



AP
Femur

Note:
Normal physiologic periosteal reaction (arrows).



AP Leg

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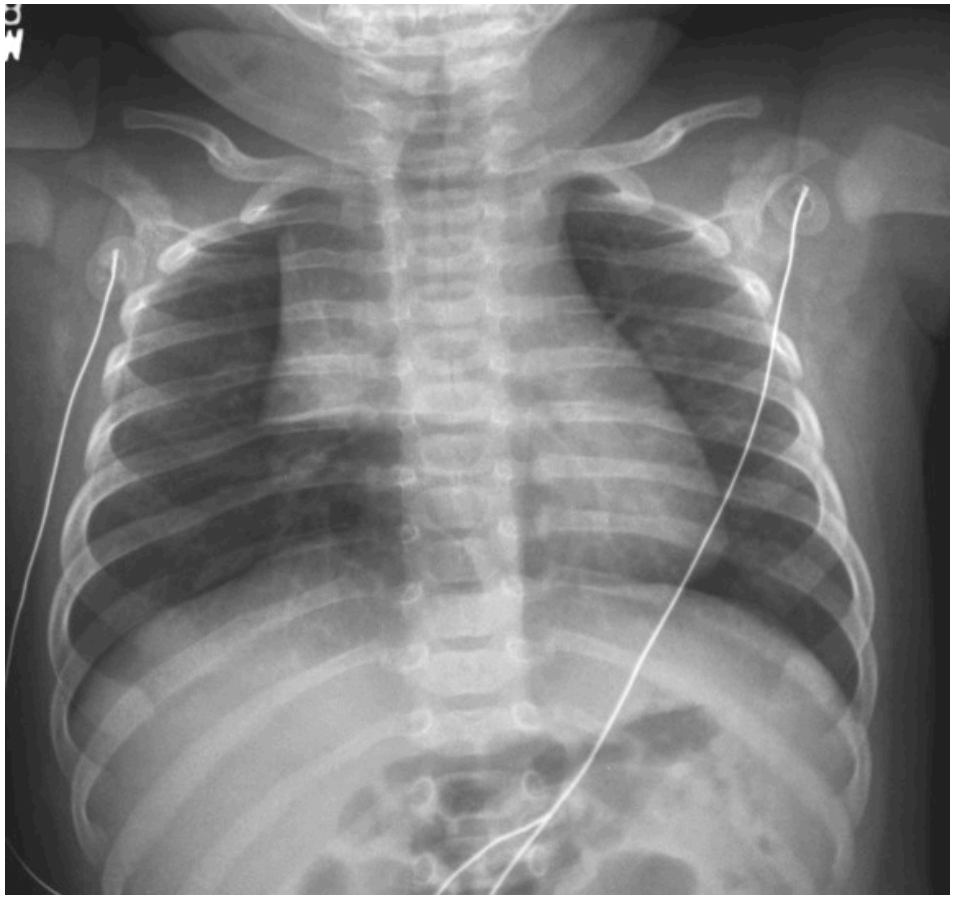
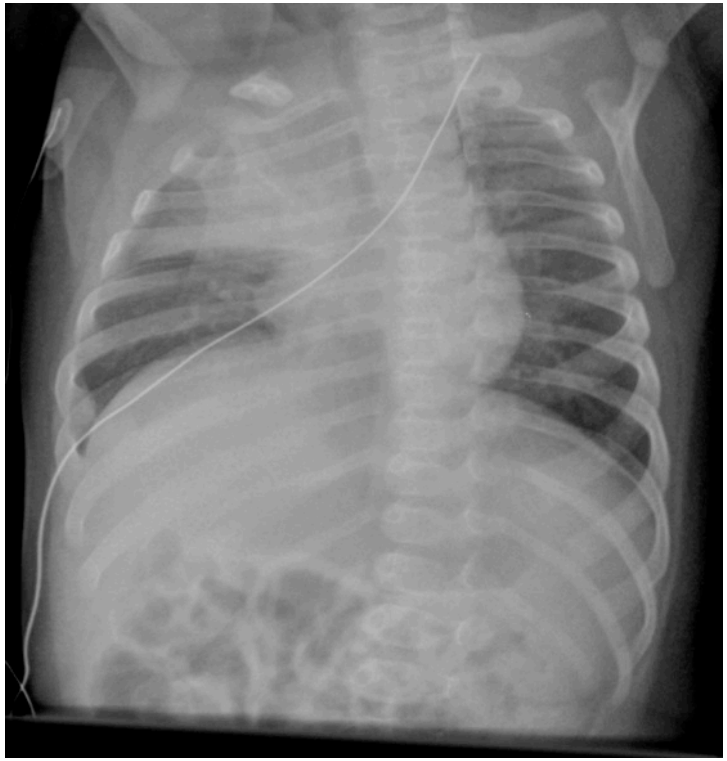
# Skeletal Survey-Ribs



AP Ribs

# Skeletal Survey-Ribs

- Rib fractures are the most commonly missed on skeletal surveys so it is important to include oblique views of the chest
  - Studies show that these views increase the sensitivity of detecting rib fractures by 17% and specificity by 7%.[1]



Right Posterior Oblique view of the ribs

[1]Offiah et al. *Pediatr Radiol* 2009.

# Specificity of Fracture Locations of Abuse

**High specificity**

Classic metaphyseal lesions
Rib fractures, especially posterior
Scapular fractures
Spinous process fractures
Sternal fractures

**Moderate specificity**

Multiple fractures, especially bilateral
Fractures of different ages
Epiphyseal separations
Vertebral body fractures and subluxations
Digital fractures
Complex skull fractures

**Low specificity**

Subperiosteal new bone formation
Clavicular fractures
Long bone shaft fractures
Linear skull fractures

Kleinman PK. Diagnostic Imaging of Infant Abuse, ed 2. St. Louis, Mosby, 1998.

# Common Fracture Patterns of Abuse

**Common**
-Multiple fractures (unsuspected and/ or varying in age)
-Classic metaphyseal lesion (CML)*
-Multiple rib fractures*
-Diaphyseal fractures (non-ambulatory infant)
-Skull fractures
-Subperiosteal new bone formation

*Indicates high specificity for abuse

**Less Common**
-Spine
-Small bones of hands and feet
-Clavicular fractures
-Dislocations and epiphyseal separations

**Uncommon**
-Scapular fractures*
-Pelvic fractures
-Sternal fractures
-Facial and mandibular fractures

Boal, Danielle K.B. "Child Abuse." *Caffey's Pediatric Diagnostic Imaging*. Ed. Thomas L. Slovis. 11th ed. Vol. 2. USA: Mosby, 2008. 2816-830. Print

# Clinical History

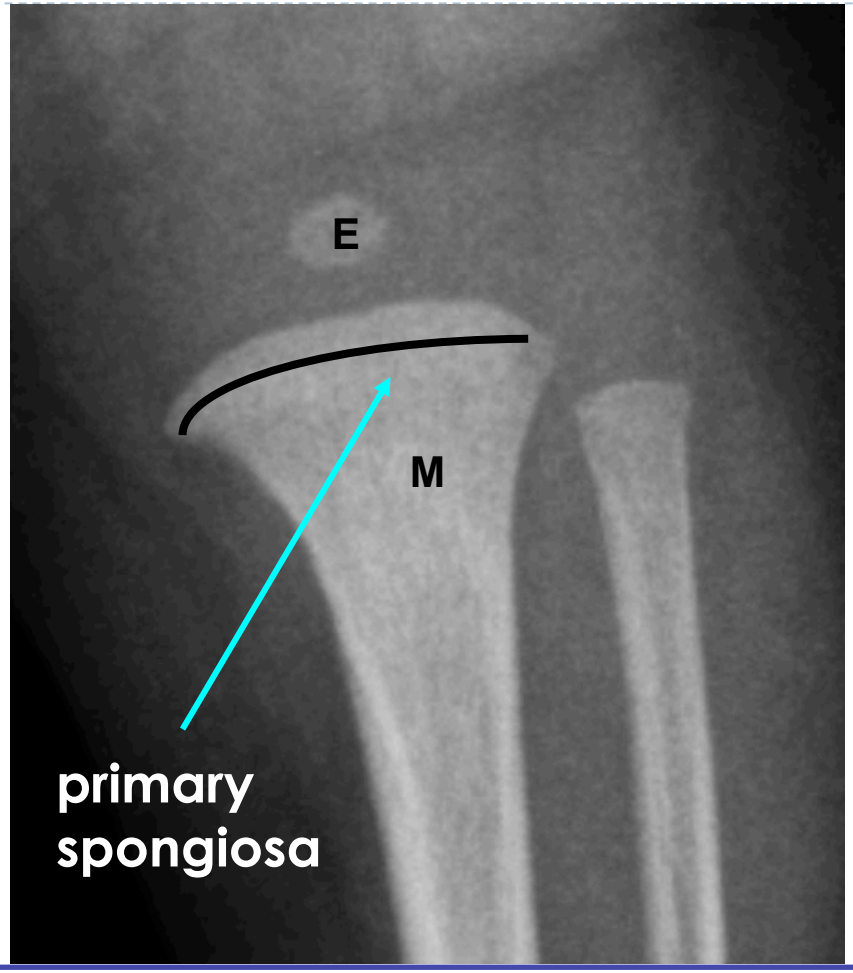
- While skeletal surveys are crucial in providing objective evidence, it is important to remember the significance of a good clinical history.
- Comparing the history given with the likely mechanism of injury is the first and most important clue to a diagnosis of non-accidental or abuse injuries.

# Skeletal Injuries associated with Abuse

Classic Metaphyseal Lesion (CML)
Rib
Long Bone Diaphysis
Scapula
Spine

# Classic Metaphyseal Lesion (CML)

- Term coined by Paul Kleinman, MD.
- Metaphyseal fracture is virtually pathognomonic of abuse
- Series of microfractures in the primary spongiosa of bone, which is the most immature area of mineralized matrix in the growing metaphysis
- Most common location is the lower extremities, especially the knees.

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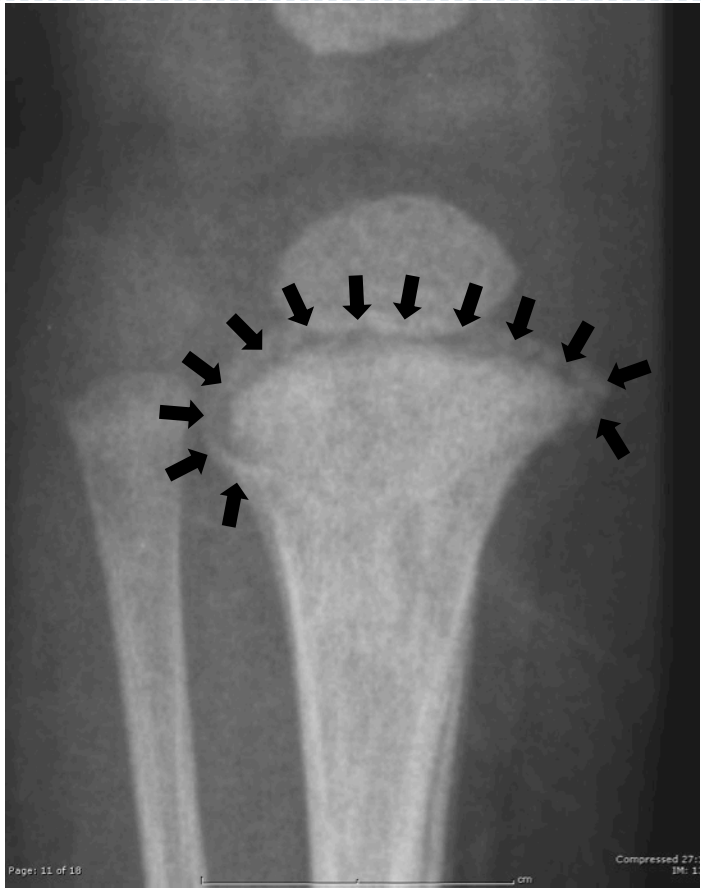
# CML-Mechanism

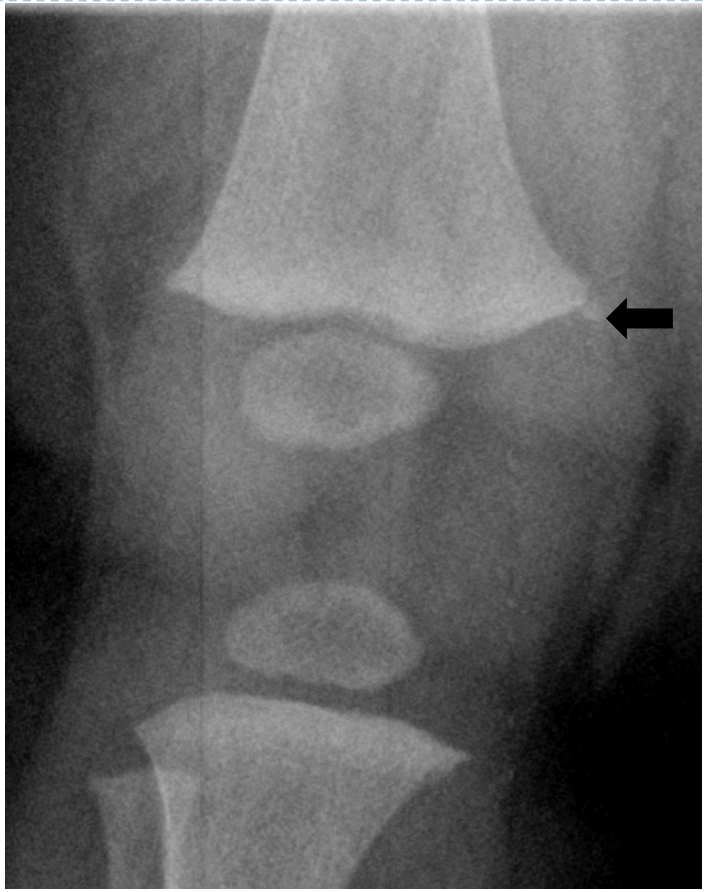
- Precipitating force: shearing injury in a horizontal direction across the metaphysis
- Thus, mechanism of injury:
  - Torque force on the extremity
  - Manual to-and-fro motion of the extremities
    - Example: shaking an infant by the feet or hands, or whiplash back-and-forth of extremities when child is held around chest
- **No outward sign of injury** is seen with CML.

# CML-Radiology

- When complete, it is a disk with a broad, thin center and a thick circumferential rim
- On radiography, the thicker rim is more visible and appears as a triangular fragment (commonly called a 'corner fracture')
- CMLs may have the appearance of 'bucket handles.' On a view obtained through beam angulation, the subepiphyseal area of lucency goes all around giving the fragment a 'bucket handle' appearance.



Bucket handle fracture



Corner fracture

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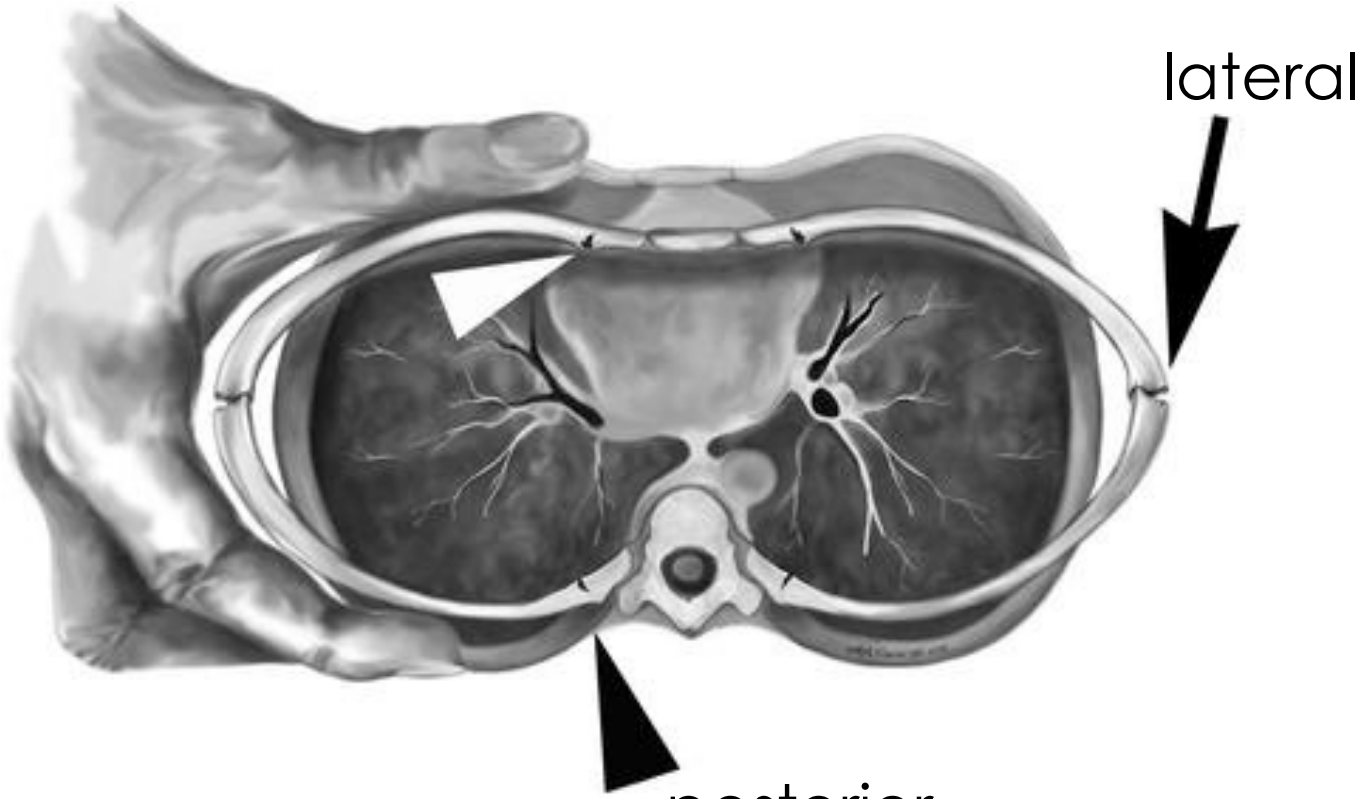
# Rib Fractures

- In infants, they are strongly correlated with abuse because the mechanism of injury is specific.
- Acute rib fractures are difficult to visualize since fractures are often incomplete and nondisplaced, and/or in an area with multiple superimposed structures.

# Rib Fractures-Mechanism

- Mechanism of injury:
  - Squeezing force from adult hands wrapped around an infant's chest → **anterior-posterior compression of the ribs** → fractures of the posterior, lateral, and anterior aspects of the rib

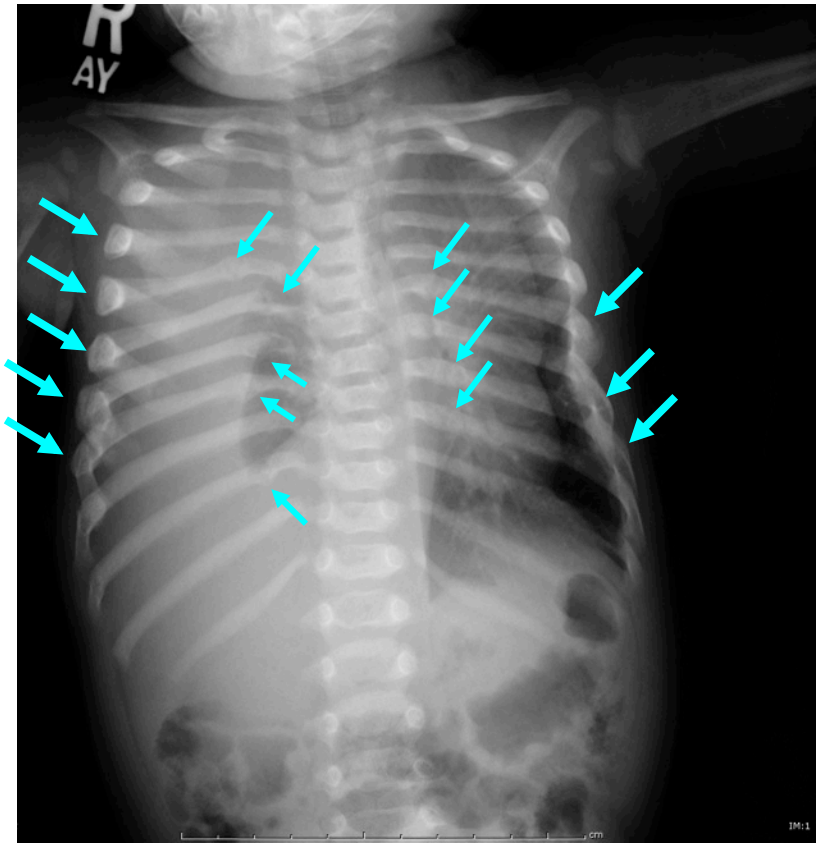



Lonergan et al. Child Abuse: Radiologic-Pathologic Correlation. *Radiographics* 2003.
Used with permission of Dr. Gail Lonergan. All Rights Reserved

# Rib Fractures-Radiology

- They occur most commonly in the posterior and lateral aspects of the ribs.
- Also, they often occur in multiple ribs and are often bilateral.

- With healing, most fractures become more visible due to subperiosteal new bone and callus formation.
  - Thus, a follow-up skeletal survey 2 weeks after the initial increases sensitivity of initial study and should be considered when abuse is strongly suspected
  - Oblique views of the chest can also improve sensitivity of detecting rib fractures.




AP ribs

Left posterior oblique

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# CPR and Rib Fractures

- Unlike adults, CPR almost never causes fractures in infants
  - One study showed that out of 446 infants who received CPR, 3 had CPR-related fractures. All 3 were of the anterior rib[1].
- While posterior rib fractures can occur from from CPR, they are rare.
  - Posterior rib fractures are **highly specific** for abuse

[1]Lonergan et al. *Radiographics* 2003.

# Skeletal Fractures

- Long bone, diaphyseal fractures: can be transverse, oblique, or spiral
  - A spiral fracture is NOT specific for abuse
    - Common in ambulatory infants (e.g. spiral tibia fractures or "toddler's fracture) and studies have shown accidental spiral fractures in nonambulatory infants.
    - Spiral fractures require torsional force as when infants are grabbed by the extremities and shaken. Thus, it is important to compare radiological findings with the clinical history given.

***Remember to compare radiologic findings with developmental stage of the child

Humerus, spiral fracture--Acute

Humerus, spiral fracture--Healing

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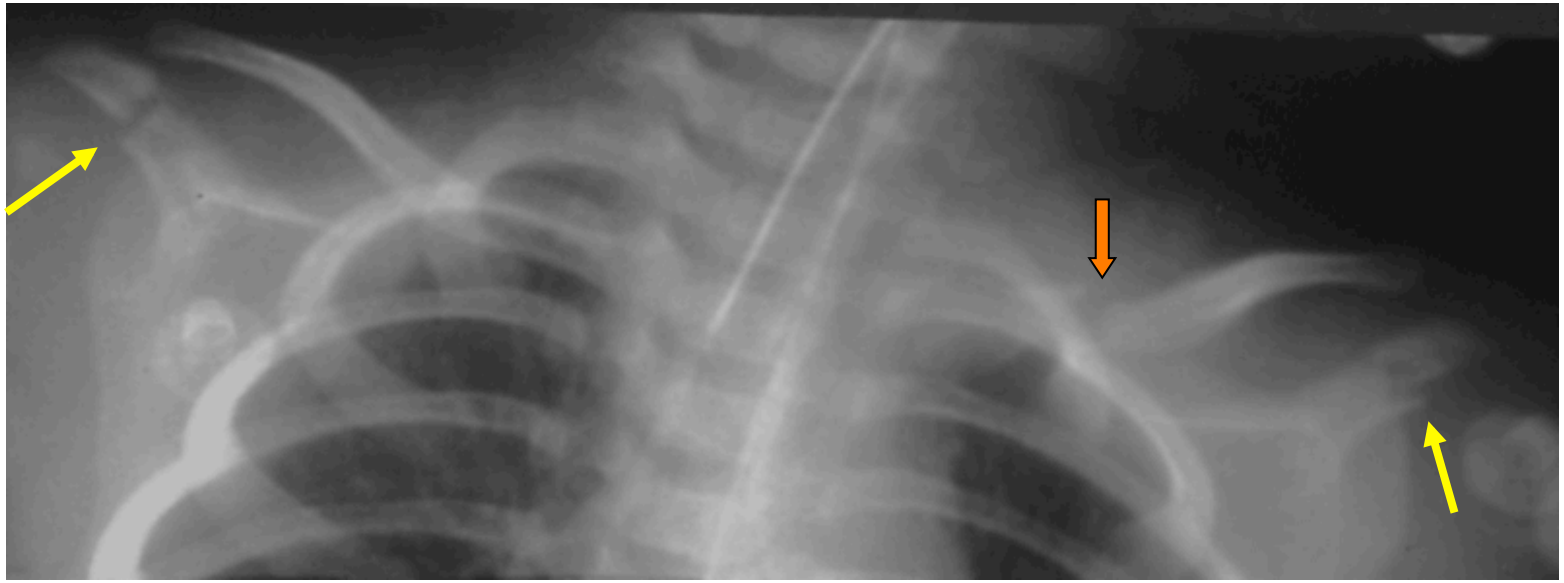
# Other Skeletal Fractures

- Scapular fracture: although uncommon, it is highly specific for abuse, particularly when it occurs at the acromion
  - *Mechanism*: Shaking an infant → stretching of deltoid muscle → avulsion of acromion

- Spinal fracture: rare.
  - *Mechanism*: hyperflexion and hyperextension. Called an "axial loading injury" because patient is thrown down on a hard surface with the spine perpendicular to the surface
  - *Imaging*: manifest as compression deformities of the vertebral bodies (most commonly near the thoracolumbar junction)
  - "Hangman's fracture": severe fracture-dislocation of the C2 verebra



Bilateral acromion and left clavicular fracture

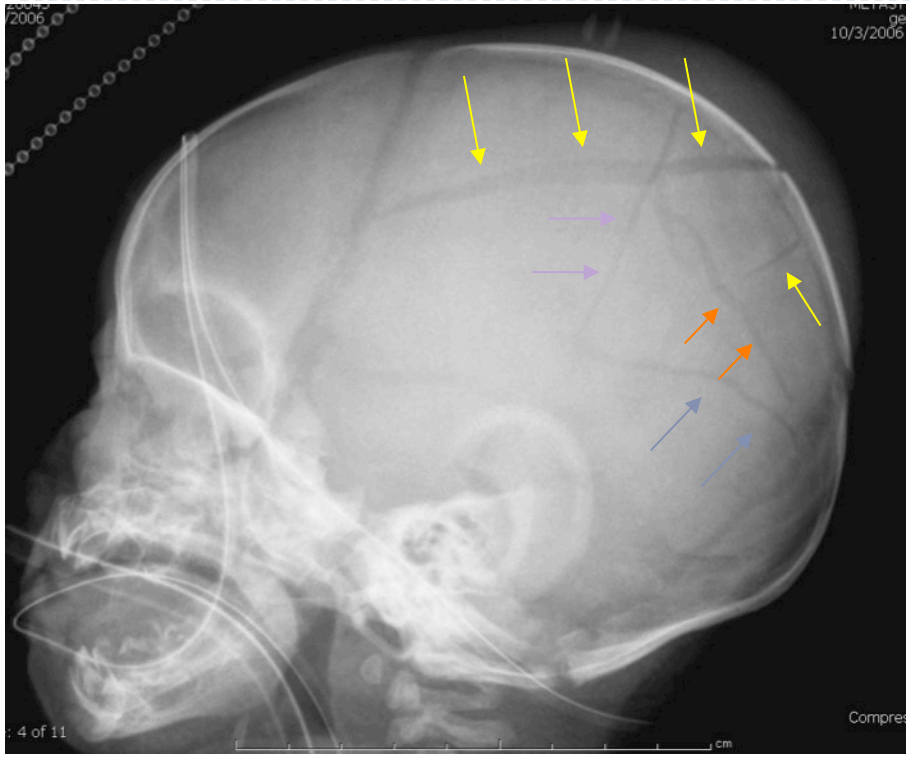
# Skull Fracture

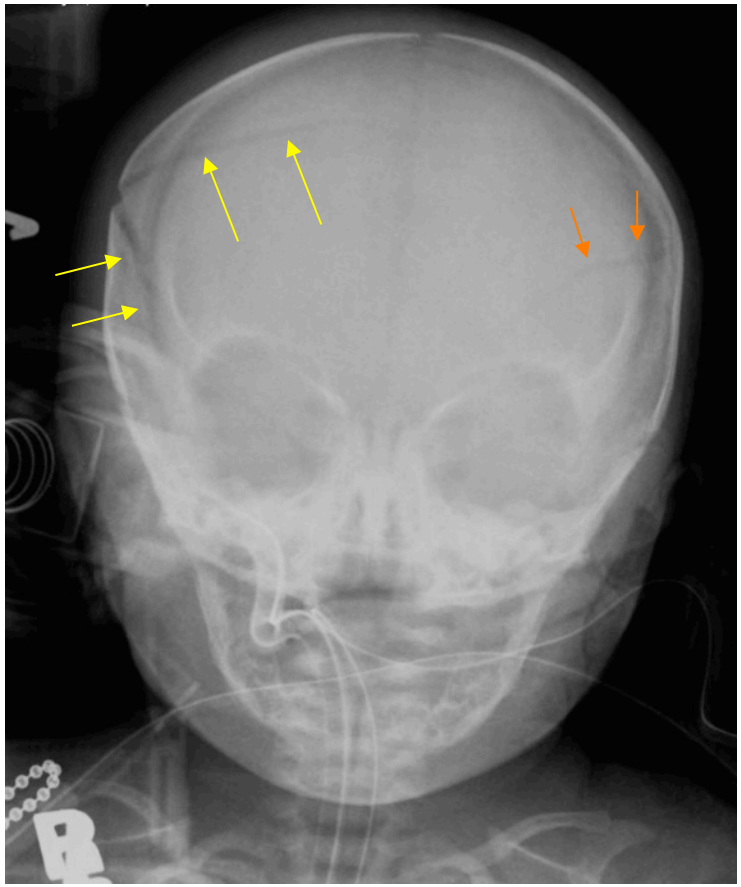
- Account for 8-13% of fractures among all abused children and about one-third in abused children under the age of 2.[1]
- Unlike sutures, fractures appear as linear or branching lucent areas with sharp margins
- However, NO skull fracture pattern correlates highly with abuse.[2]
  - Fractures *suggestive* of abusive head trauma:
    - Multiple, bilateral, ones that cross suture lines[1,3]
    - Fracture diastasis and asymmetric suture diastasis[2,3]


[1]Lonergan et al *Radiographics* 2003.

[2]Fernando et al. *Pedatr Radiol* 2008.

[3]Boal, Danielle K.B. "Child Abuse." *Caffey's Pediatric Diagnostic Imaging*. Ed. Thomas L. Slovis. 11th ed. Vol. 2. USA: Mosby, 2008. 2816-830. Print



# Complex skull fractures

# Skull Fracture-Radiology

- Radiography is preferred over CT because fractures that are roughly parallel to the section orientation may be missed on CT

- Complete skull radiographic series includes 4 views[1]:
  - AP
  - both lateral
  - Towne view

[1]Lonergan et al *Radiographics* 2003.

# Stairway Falls

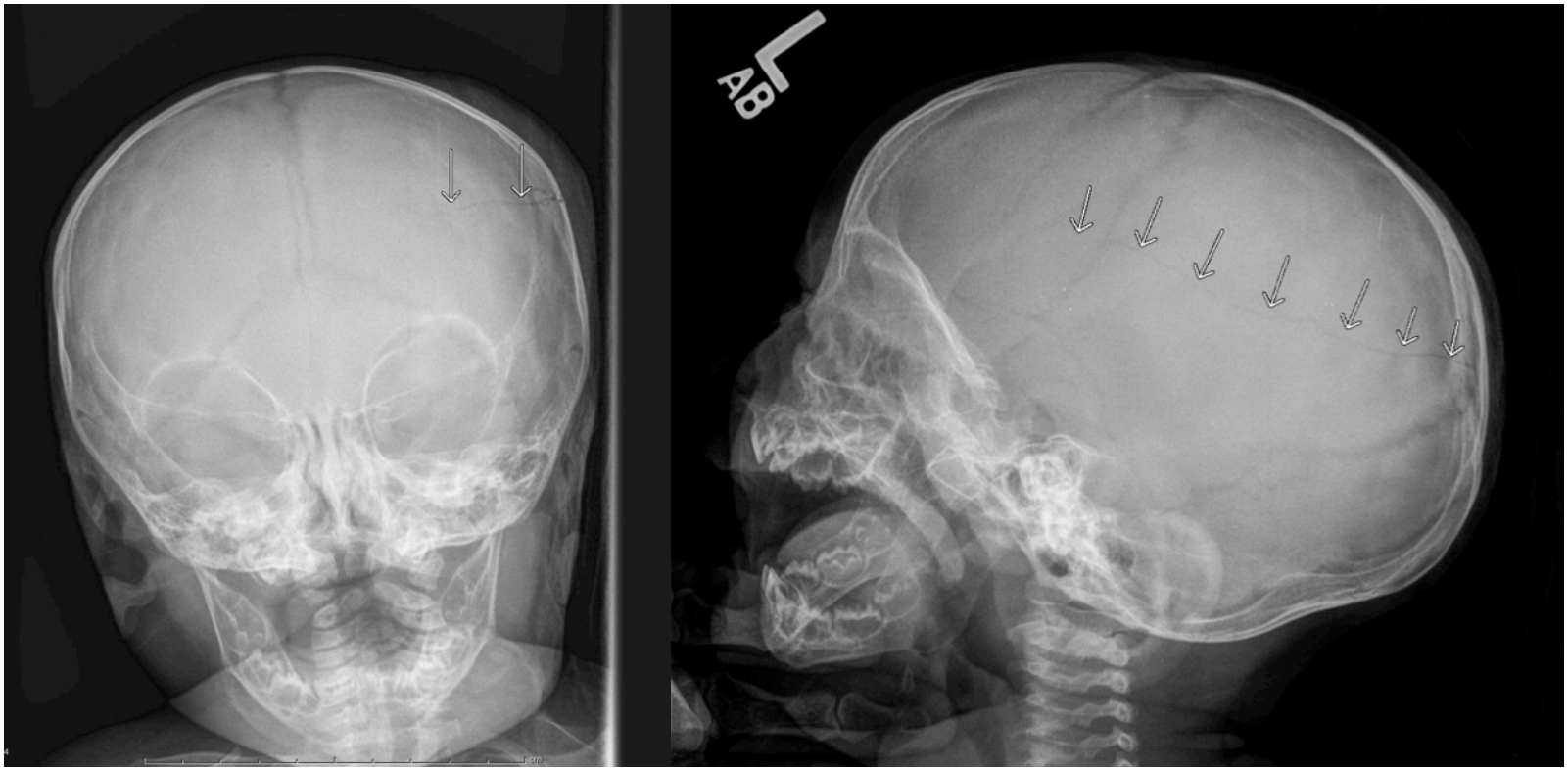
- Often offered as explanation for abusive head trauma
- Head injury is most commonly seen

- However, injury is mild to moderate because stairway falls, unlike free falls, have an initial fall of moderate impact followed by short, low impact falls down the remaining stairs
  - Linear, non-diastatic, frontal and parietal skull fractures, concussion, and brain contusion can be seen
  - Falls can result in severe injury if child falls down stairs from arms of an adult or while in a walker

- Injuries sustained must be compared to clinical history given
- Suspicion for abuse increases when there is more than one area of injury, such as a femur fracture and a skull fracture.

Lonergan et al *Radiographics* 2003.

WFPI




Linear, non-diastatic skull fracture

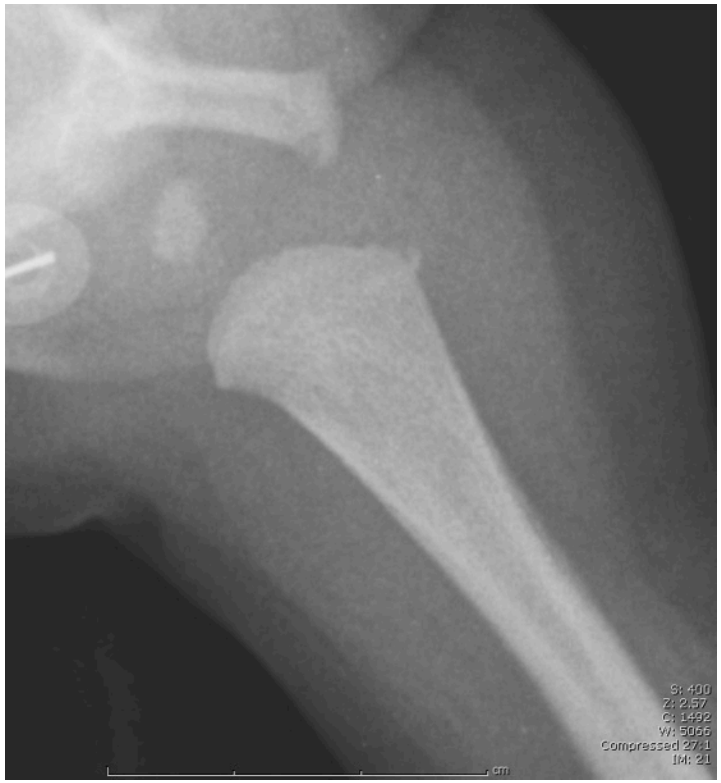
# Follow-Up Skeletal Survey

- In a follow-up skeletal survey, skull, spine, and pelvic films can be omitted.
  - This is because studies show that the majority of additional fractures found are of the ribs and long bones of the extremities.

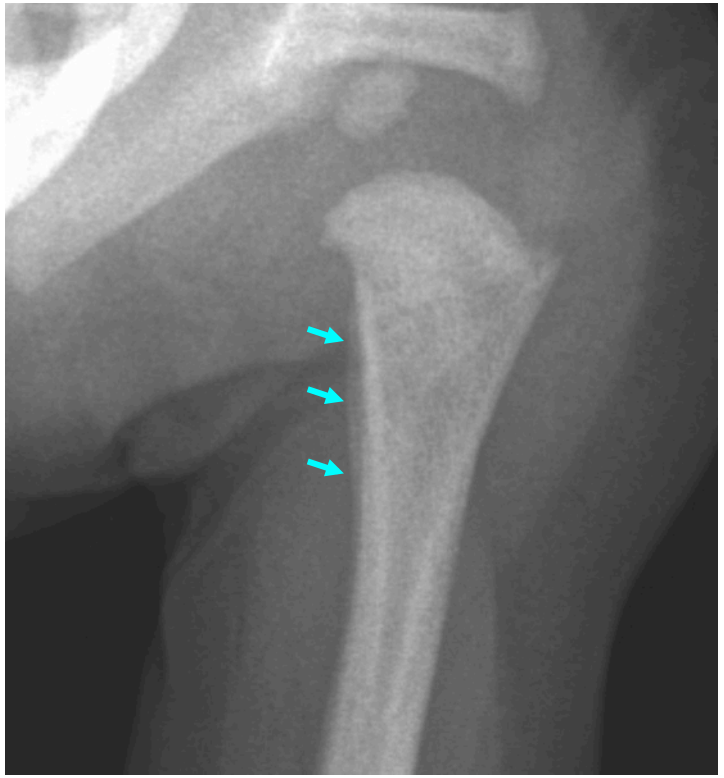
- Separate studies have shown that follow-up skeletal surveys provide additional information in 38% to 61% of cases regarding the age and number of fractures.

Kleinman et al. *Am J Radiol* 1996
Zimmerman et al. *Child Abuse and Neglect* 2005
Harlan et al. *Pediatr Radiol* 2009

# Follow-Up Skeletal Survey



Initial skeletal survey



Follow-up skeletal survey
13 days later

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# Follow-Up Skeletal Survey

Initial skeletal survey

Follow-up skeletal survey
13 days later

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# Dating of Fractures

- There is no consensus in the literature for the precise dating of fractures.
- Of note, an infant's fractures heal faster than older children and adults.
- As a general rule[1]:
  - Resolution of soft tissue swelling 4-10 days
  - Periosteal new bone formation 10-14 days
  - Soft callus formation 14-21 days
  - Hard callus formation 21 to 42 days

[1]Offiah et al *Pediatr Radiol* 2009.

# Imaging Recommendations for Skeletal Injury


- O-24 months:
  - Skeletal survey
  - Follow-up skeletal survey (done 2 weeks later)

- > 2 years of age:
  - Skeletal survey at the discretion of examining pediatrician
  - Radiographs of individual sites of injury per clinical history and exam if physical abuse strongly suspected

Kleinman PK. Diagnostic Imaging of Infant Abuse, ed 2. St. Louis, Mosby, 1998.

# CNS Injuries associated with Abuse

Subdural Hemorrhage
Subarachnoid Hemorrhage
Cerebral Edema and other Parenchymal Injury

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# Statistics

- In children under 2, non-accidental head injury, also known as abusive head trauma, accounts for 80% of deaths from head injury.
- In children under 1, 64% of all head injuries are a result of abuse.
- Abusive head trauma is the leading cause of morbidity and mortality in abused children.

Lonergan et al *Radiographics* 2003.

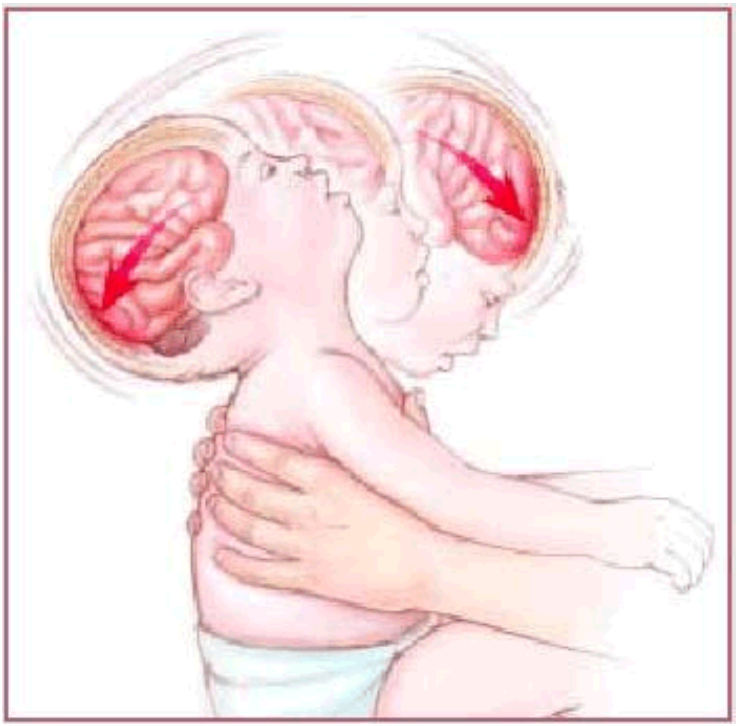
# Mechanism of abusive head trauma

- Biomechanics involve movement either by the child's head, an object, or both.
- *Direct* injury: occurs when the head strikes a stationary object, vice versa, or both colliding.
  - Results in distortion or fracture of the skull, intracranial hemorrhage (ICH), and brain injury.
- *Indirect* injury: occurs when head is shaken causing sudden acceleration and deceleration of the brain relative to the skull.
  - Results in shearing strain between tissue interfaces → parenchymal brain injury, hemorrhage.

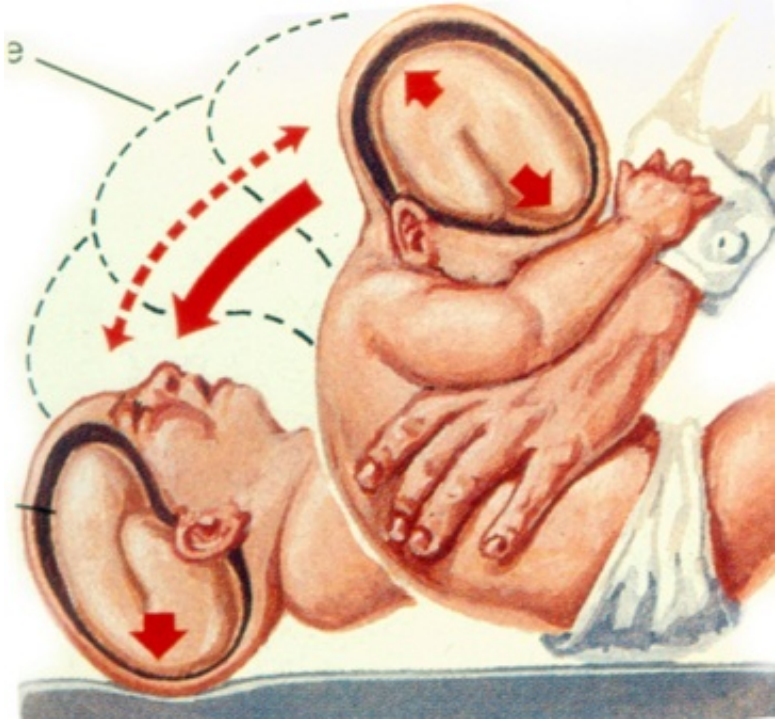
Fernando et al. *Pedatr Radiol* 2008.

WFPI

## Indirect Injury



## Direct Injury



"Shaken Baby Syndrome." Peoria Illinois Brain Injury Group Foundation. <http://braininjurygroupfoundation.sharepoint.com/Pages/ShakenBabySyndrome.aspx>.

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# Skull Fracture

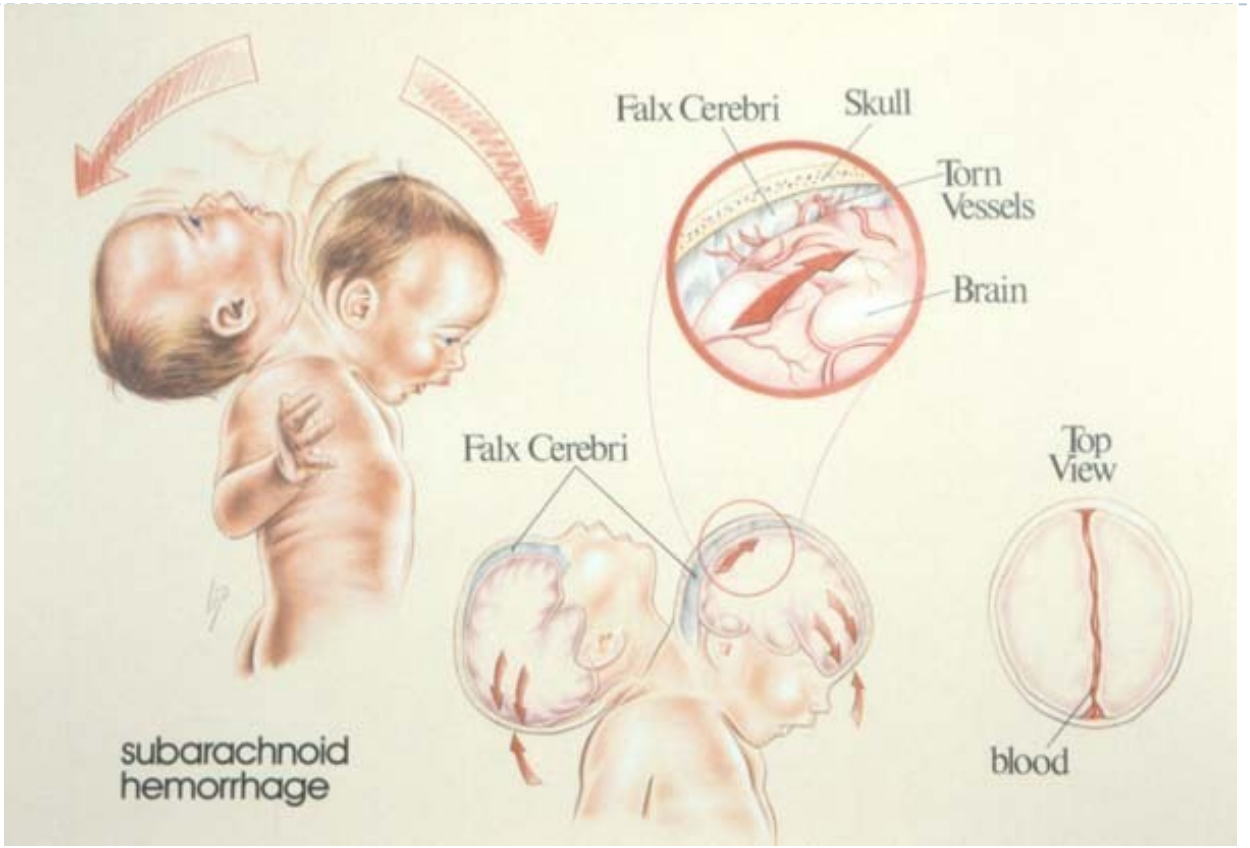
- The presence of a skull fracture is NOT predictive of intracranial injury.[1]

- Often, in an infant, deformation of the skull injures the underlying brain and meninges without causing a fracture.[2]

[1]Fernando et al. *Pedatr Radiol* 2008.
[2]Lonergan et al *Radiographics* 2003.

# Intracranial Injury

- Most deaths from child abuse are secondary to intracranial injury, especially among infants.
- Subdural hemorrhage (SDH) and subarachnoid hemorrhage (SAH) are two common abusive, intracranial injuries.
  - SDH occurs due to tearing of the bridging cortical veins that bleed into the potential space between the dura mater and arachnoid membrane
  - SAH occurs when vessels beneath the arachnoid membrane tear causing bleeding between the arachnoid membrane and pia mater




"Diagram of what happens to the brain." Nevershake Foundation. <http://nevershake.webs.com/apps/photos/photo?photoid=34294399>.

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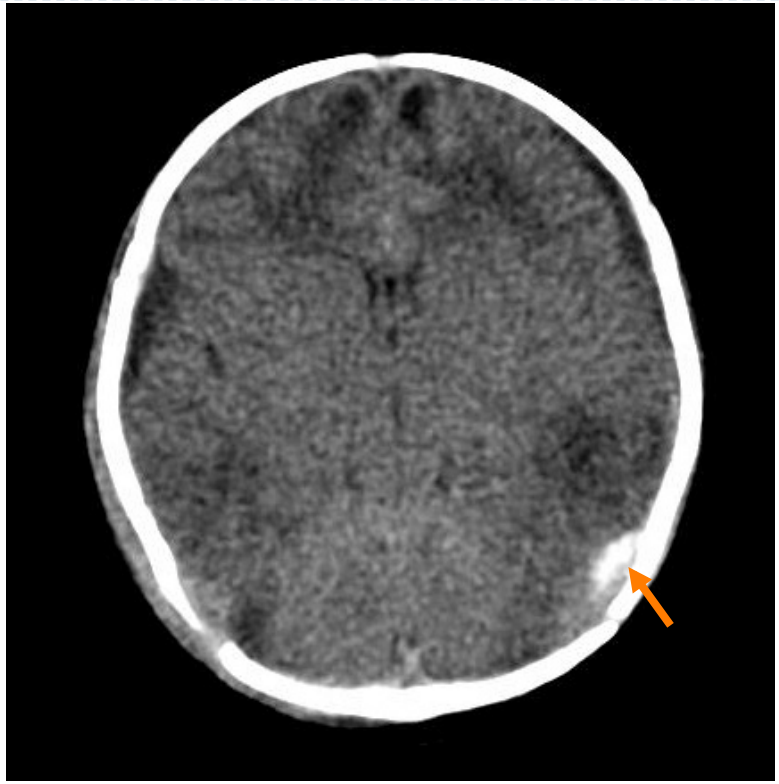
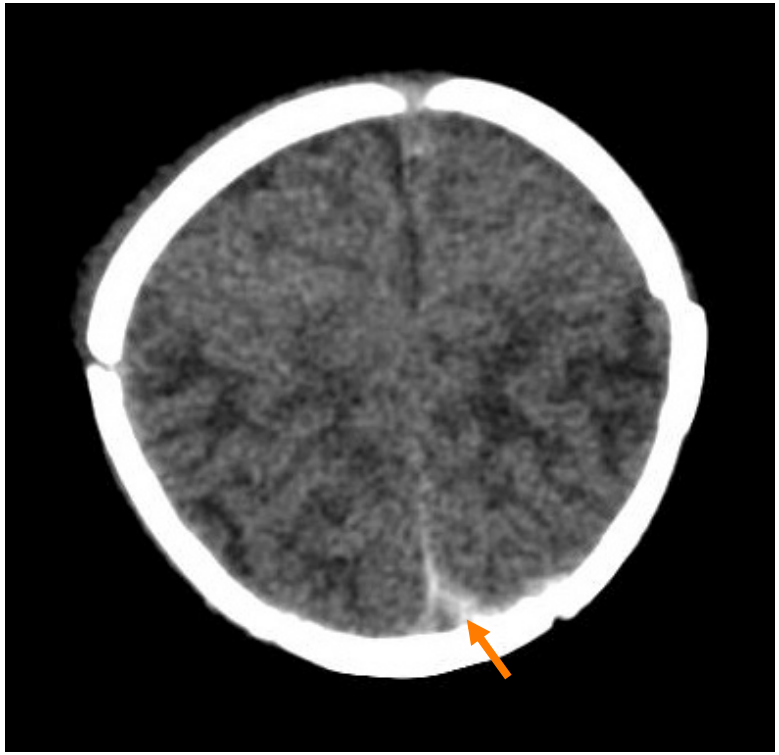
# Intracranial Injury-Radiology

- In an acute setting, non-contrast head CT is the first study of choice when intracranial injury is suspected.
  - On CT, SDH appears as a "crescent-shape" convexity.
    - High attenuation when acute hemorrhage; becomes isoattentuating relative to brain and then hypoattenuating as the SDH ages over days to weeks.
  - CT contrast enhancement can show membranes which would suggest that a SDH is a week or more old.





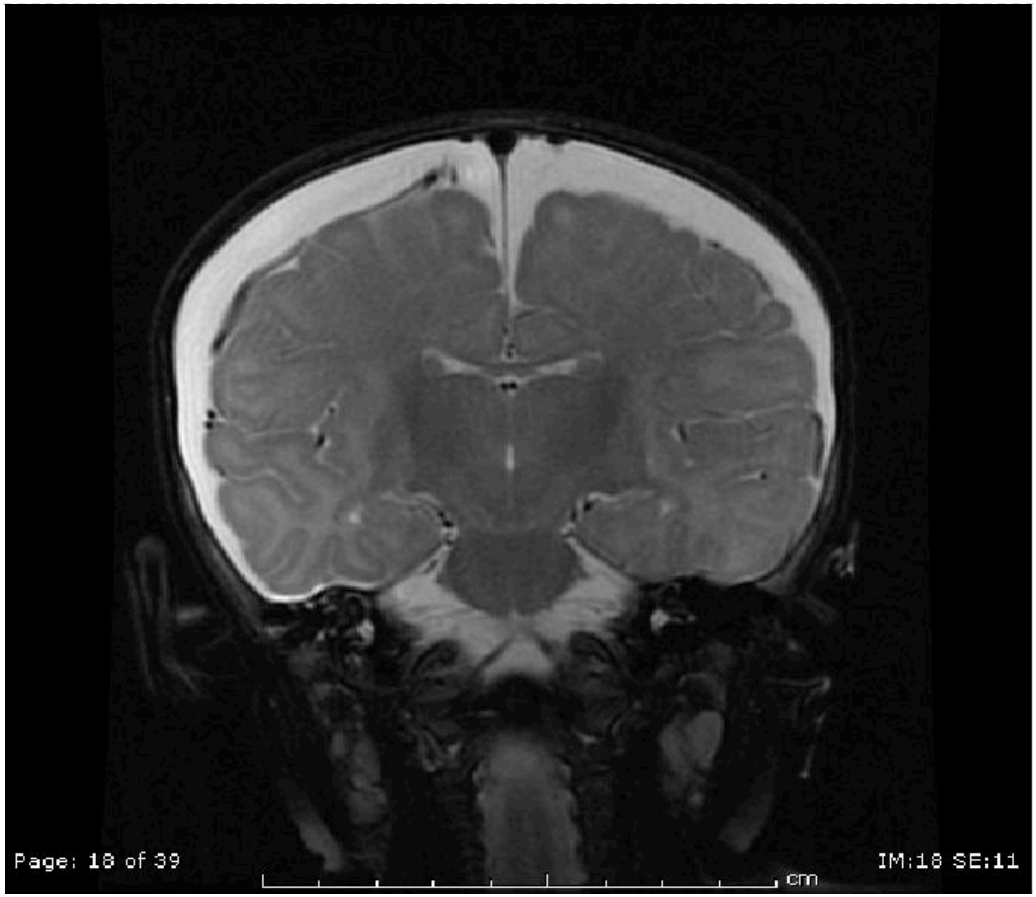
CT images of
subdural hemorrhages

# Intracranial Injury-Radiology

- MRI is superior to CT for differentiation of hypoattentuating SDH and cerebrospinal fluid (CSF), and for the detection of small, extraaxial fluid collections.

| | T1 | T2 |
|---|---|---|
| Acute SDH (1-3 d) | Iso- to hypo-intense | Hypo-intense |
| Subacute SDH (3-7d) | Hyper-intense | Hypo-intense |
| Late SDH (8-14d) | Hyper-intense | Hyper-intense |
| SDH > 14d old | Iso- to hypo-intense | Hypo-intense |

Lonergan et al *Radiographics* 2003.




# Late Subdural

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# Intracranial Injury-Radiology

- Ultrasound can be used on infants with open fontanels to differentiate benign enlarged subarachnoid space (BESS) from SDH in developmentally normal infants with macrocephaly.

- BESS is a self-limiting, transient condition in which there is symmetric, diffuse enlargement of the subarachnoid space likely from a communicating hydrocephalus

- On US:
  - BESS: multiple cortical veins in the subarachnoid space in anechoic fluid
  - SDH: few or no cortical veins in a variable echogenicity fluid; sometimes, a thickened inner membrane

# Intracranial Injury vs Birth Trauma

- Difficult to differentiate the first few months of life.

- Common characteristics of birth trauma include[1]:
  - lack of presenting symptoms or significant sequelae
  - resolution of subdural hematoma by 6 weeks of age
  - indistinct appearance of skull fracture by 2 months of age
  - resolution of skull fracture by 6 months of age

[1]Fernando et al. *Pedatr Radiol* 2008.

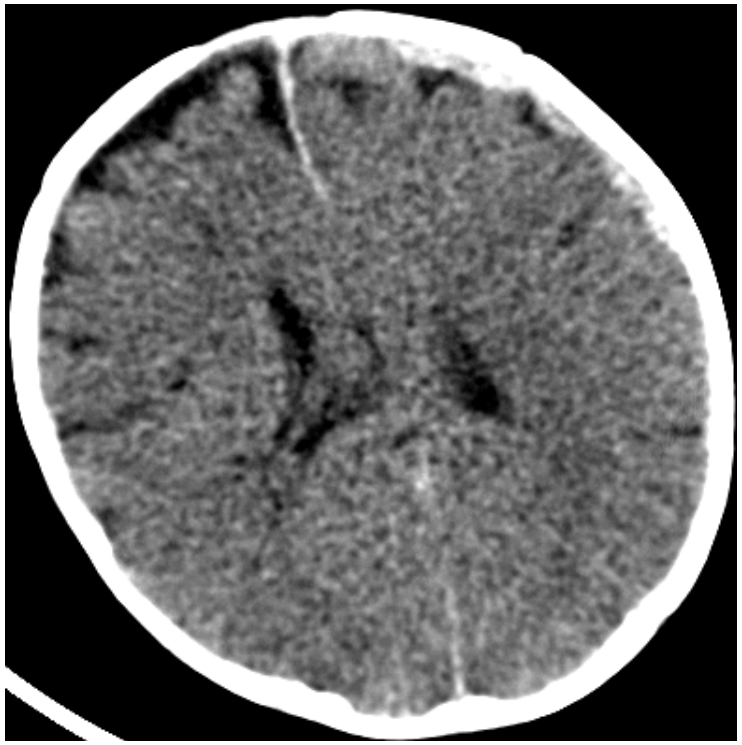
# Brain Parenchymal Injury

- Cerebral edema
  - Most common
  - Can be global, localized to a vascular territory, or focal.
  - May be a manifestation of primary , blunt impact or a hypoxic ischemic encephalopathy

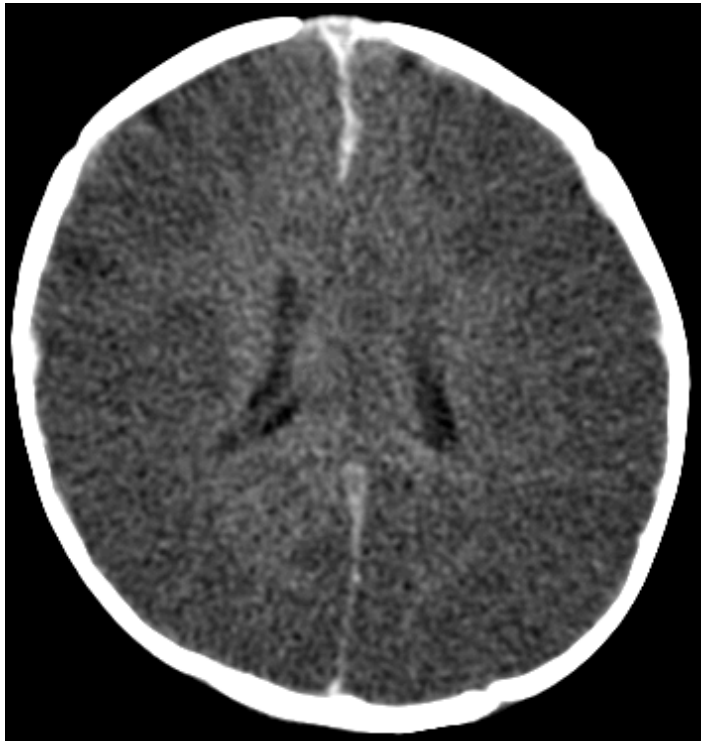
- Shear injury
  - Occurs at the gray-white junction
  - Also called *axonal injury* and can be focal or diffuse
    - Diffuse axonal injury is a devastating consequence of abusive head trauma

- Contusion
  - A focal hemorrhage within the brain parenchyma
  - Frontal and temporal lobe locations common

# Cerebral Edema



**CT Day 1** post-abuse. Early cerebral edema with decreased grey – white contrast. Also left anterior SDH.



**CT Day 2** post-abuse. Severe edema and swelling with "reversal sign" (white matter denser than grey matter). SDH in the anterior interhemispheric fissure.

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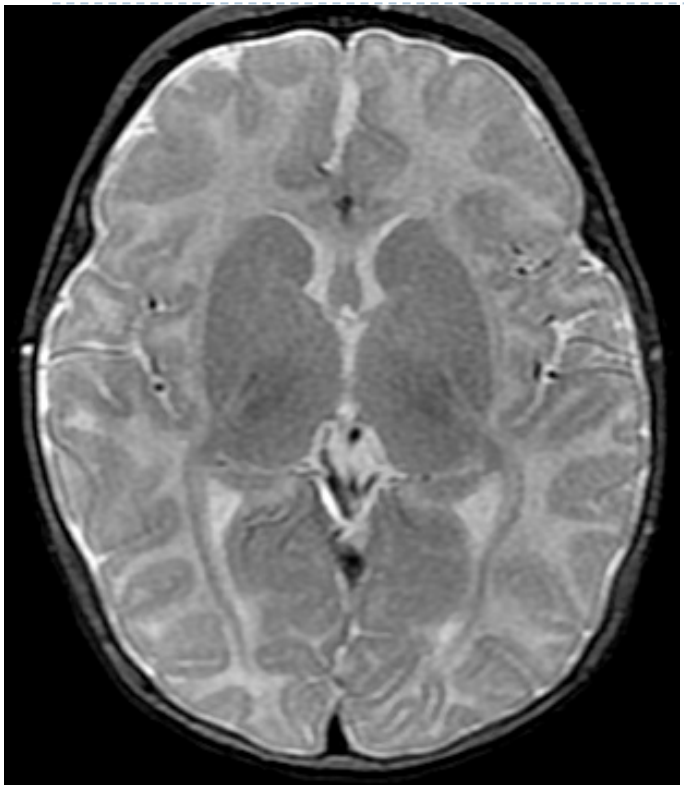
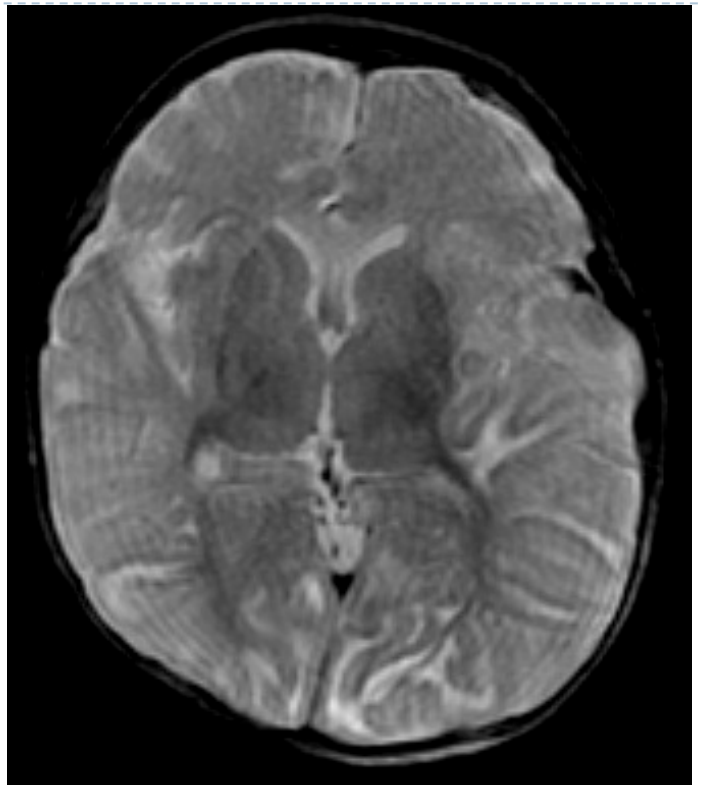
# Cerebral Edema



MRI-Axial T2-**Normal**



MRI-Axial T2-**5 days** post-abuse. Diffuse cortical cerebral edema seen by the loss of grey-white matter contrast.

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# Visceral Injuries associated with Abuse

Solid organ laceration, transection
Bowel hematoma, perforation
Thoracic injuries

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# Statistics

- Second most common cause of death from abuse
- Recent data shows mortality rates from visceral injury at 13-30%.[1]

[1]Hilmes et al *Pediatr Radiol* 2011.

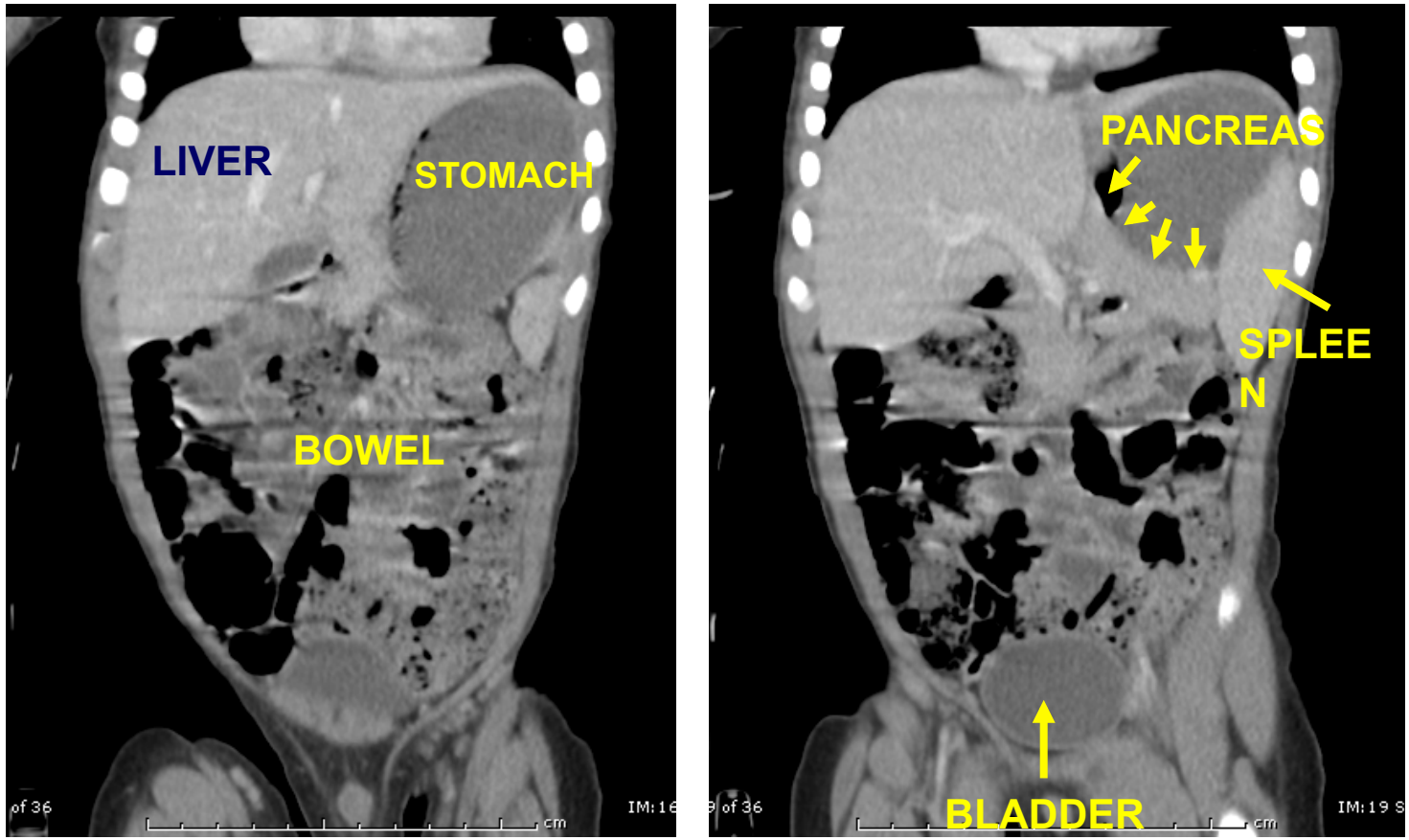
# Imaging Recommendations for Thoraco-abdominal Trauma

1. Helical CT of abdomen and/or thorax with IV contrast

2. US of abdomen, usually as a follow-up

3. Upper GI series as needed

Diagnostic Imaging of Child Abuse. Section on Radiology. *Pediatrics 2009.*




Normal CT Abdomen

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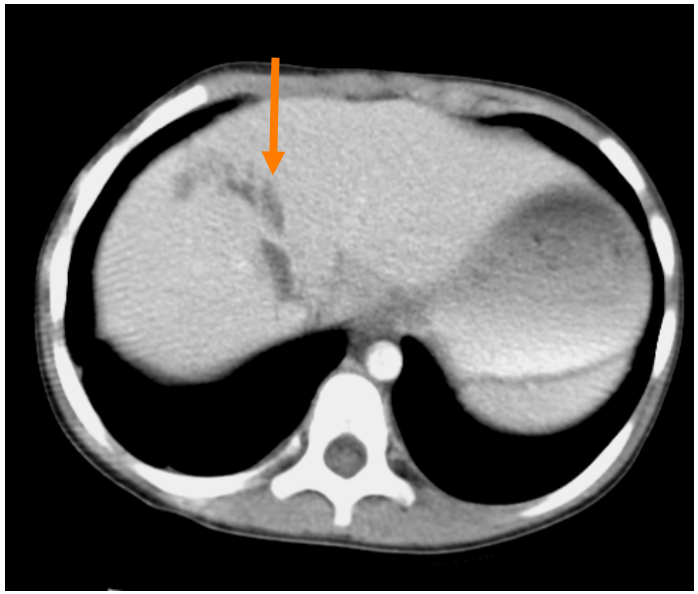
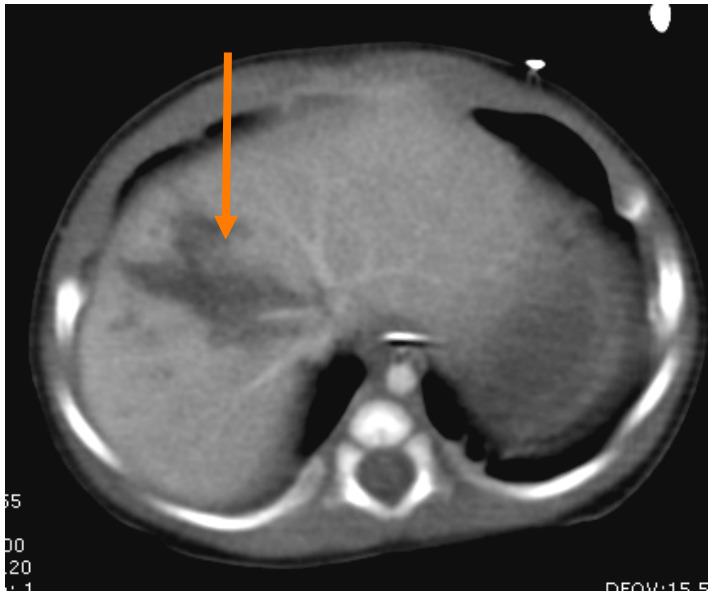
# Liver Injury

- One recent study found the liver to be the most commonly injured abdominal organ[1]



Liver Laceration



Liver Laceration

[1]Hilmes et al *Pediatr Radiol* 2011.

# Pancreatic Injury

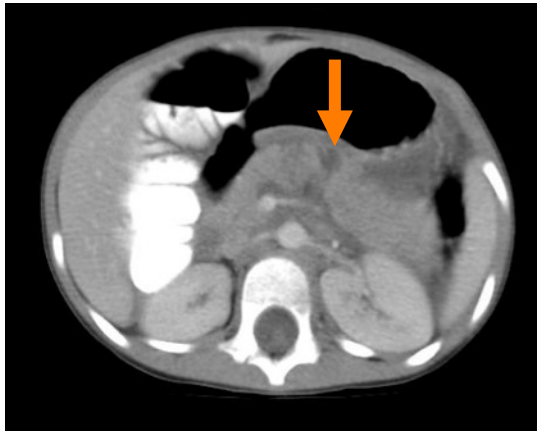
- In children, trauma is the leading cause of pancreatic injury.
  - About one-third of all posttraumatic pancreatitis in children is abuse-related.[1]

- Pancreatic injury includes: pancreatitis, hemorrhage, and contusion, which can all result in pseudocyst formation.
  - Among infants and preschool children, any pancreatic injury is more likely to be inflicted than accidental

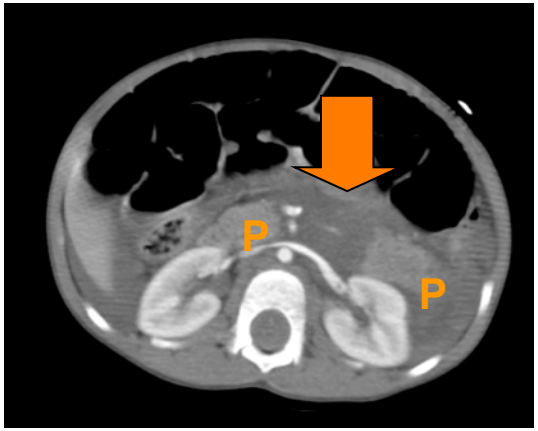
[1]Lonergan et al *Radiographics* 2003.

# Pancreatic Injury-Radiology

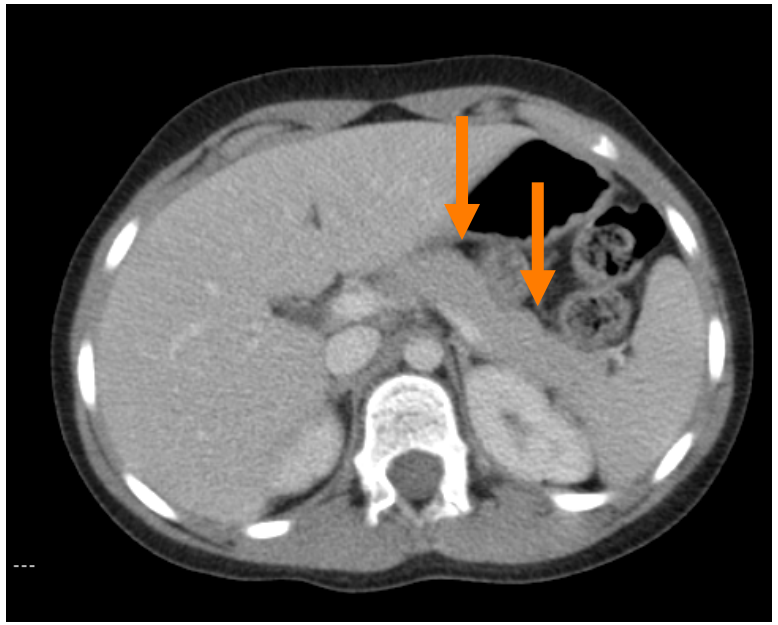
- Children present with abdominal pain, vomiting, fever, and elevated serum amylase.
- CT and US can show pancreatitis and pseudocyst, but CT is superior
  - US: Shows an enlarged, hypoechoic pancreas.
  - CT: Pancreas is hypo-attenuating. Extapancreatic fluid is the most common imaging finding.
- Interestingly, pancreatitis associated with child abuse may lead to widespread intramedullary necrosis of bone manifested by multifocal, lytic skeletal lesions.
- Pancreatic transection can also be observed on imaging of abusive injury.



Pancreatic Laceration




Pancreatic Transection



Normal

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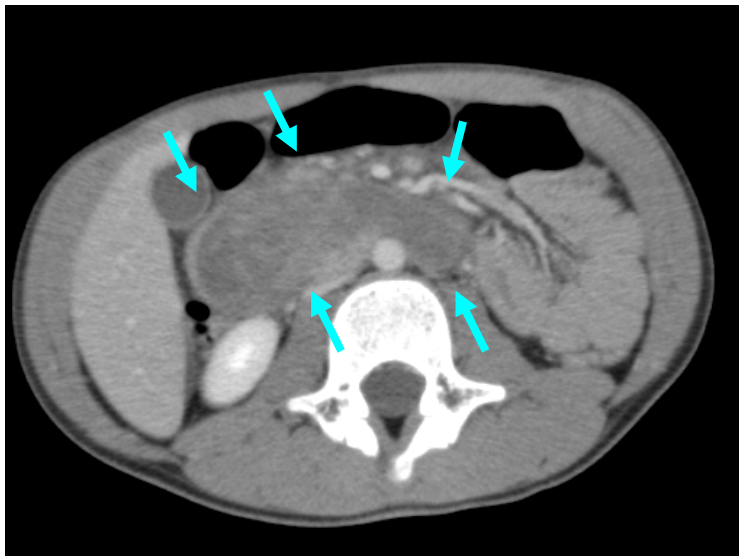
# Bowel Injury

- Most common hollow organ injury in the abdomen is the small bowel
  - Injury usually occurs in the duodenum and proximal jejunum.
    - Rich vascular supply of duodenum → hematomas
    - Fixed position of the jejunum → perforation
- Blunt impact and acute deceleration of the abdomen cause these injuries

# Bowel Injury-Radiology

- Hematoma:
  - Child presents with pain and vomiting
  - Upper GI series will show a submucosal mass, often at the descending duodenum
    - Also shows strictures in the small bowel due to injury
  - On CT, it is a high attenuation mural mass that diminishes over time
  - On US, mass starts as hyperechoic and become hypoechoic over days to weeks.

CT of duodenal hematoma

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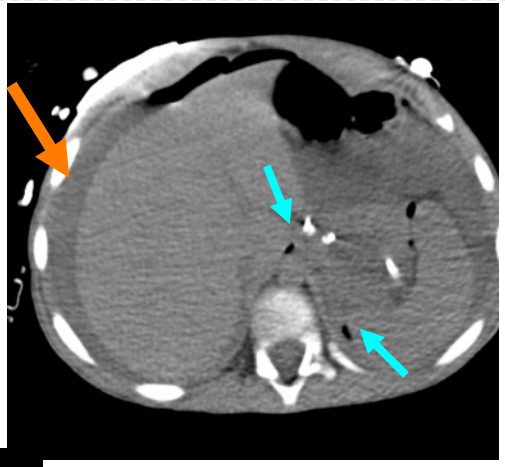
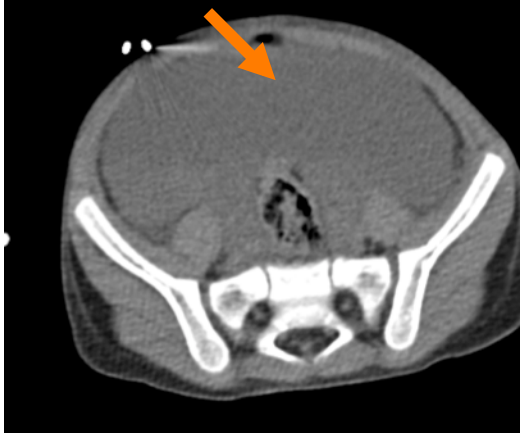
# Bowel Injury-Radiology

- Perforation
  - Child presents with pain and fever
  - Plain radiography and CT may show free intraperitoneal air, which is highly specific for bowel perforation. However, it is only seen about one-third of the time with perforations
  - Free fluid (ascites) is the most common finding on CT
    - It occurs due to bleeding or peritonitis.

Free intraperitoneal air



Free intraperitoneal fluid (ascites)



Free intraperitoneal fluid (ascites)

# Other Visceral Injuries

- Lacerations, contusion, and rupture can occur in the stomach, liver, spleen, adrenal gland, kidney, colon.
  - Children often present with nonspecific abdominal symptoms.
- Thorax: lung contusion, pneumothorax, pleural effusion, hemothorax, and cardiac laceration have been observed secondary to abuse.
- Traumatic perforation of the pharynx has been reported as well
  - Chest and neck radiographs, water-soluble contrast studies, and CT scans aid in its diagnosis.

WFPI

# Differential Diagnosis

# Osteogenesis Imperfecta (OI)

- Generalized disorder of connective tissue
- 4 types of which I and IV are mild enough to be confused with abuse
- Major clinical findings:
  - blue sclerae
  - abnormal skin texture
  - hearing loss
  - joint laxity
  - dentinogenesis imperfecta

# OI-Radiology

- Findings primarily via plain films
- Essential to the diagnosis is the finding of demineralization in the axial and appendicular skeleton
- Sometimes find bowing (long bone angulation), especially in weight-bearing areas
- Excessive wormian bones (> 10)

# OI-Radiology

- Unlike the corner and bucket-handle CML fractures seen in abuse, long bone fractures in OI are typically metadiaphyseal in nature
- Rib fractures are rare in OI
  - Rib fractures here are singular occurrences unlike the multiple, same location, and bilateral fractures seen in abuse
- Even mild cases of OI show excessive wormian bones and some demineralization

# OI Workup

1st: Skeletal survey in patient suspected of being physically abused

2nd: If demineralization found on radiographs, collect thorough family history and conduct physical exam to assess for clinical findings of OI

3rd: If physical exam is negative, obtain blood test specific for OI

4th: If test is negative, patient most likely does not have OI

# OI

- It is important to remember that the fractures associated with OI occur with minimal trauma
- It is important to always compare radiographic findings with the clinical history given to decide whether to pursue a workup for OI


# Osteogenesis Imperfecta

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OI--Wormian bones

OI—Bowing of long bones; also notice the osteopenia and thin bones

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# Rickets

- Similar to cases of abuse, one can see metaphyseal irregularity and subperiosteal new bone formation
- Unlike abuse, see decreased bone density, and poor definition and fraying of long bone metaphyses
- Acute and healing fractures may be present, but will have underlying features of rickets

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Rickets Normal CML

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# Other Diseases mimicking Skeletal Injuries of Abuse

- Spinal dysraphism
  - Acute fractures appear like CMLs, but often happen only in the lower extremities.
    - Closer inspection usually reveals the fractures are of Salter-Harris type II variety
- Osteomyelitis
  - Metaphyseal lesions seen, but the lucencies are less well-defined and corner fractures are not present
  - Over time, bone destruction can be seen in cases of osteomyelitis unlike in abuse

# Other Diseases mimicking Skeletal Injuries of Abuse

- Congenital syphilis
- Scurvy
- Caffey's Disease
- Leukemia
- Menkes' Syndrome
- Inherited bone dysplasias

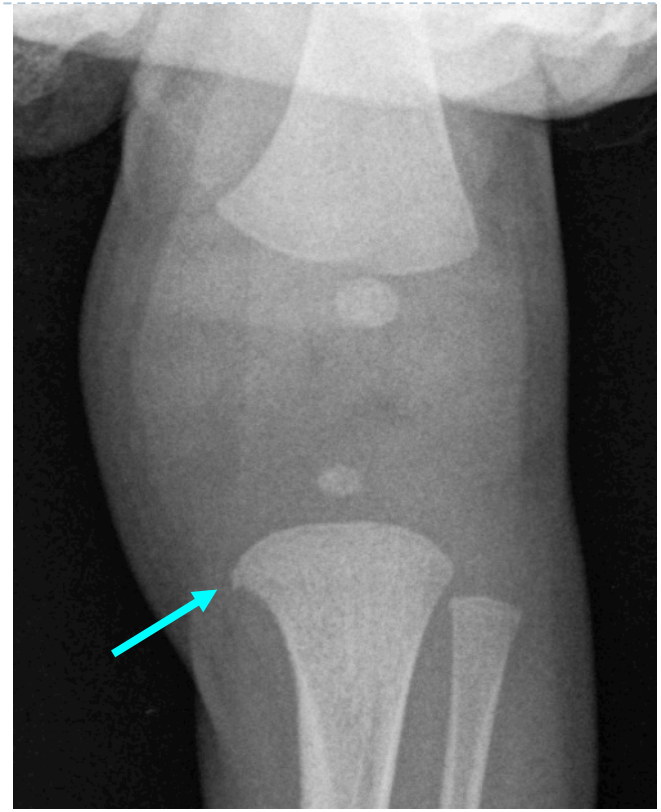
# Obstetric Trauma mimicking Skeletal Injuries of Abuse


- Clavicle is the most common site of obstetric fracture, especially in the middle third.
  - Callus formation is rapid in young infants; If no callus on radiographs by 11 days of age, birth injury is excluded
- Humerus is the most commonly fractured long bone
  - Long bone fractures usually only occur with breech and difficult vaginal deliveries
- Obstetric rib fractures have been reported in large babies undergoing difficult vaginal delivery
  - Unlike cases of abuse, will see signs of trauma, such as cephalohematoma, bruising, swelling, and crepitus

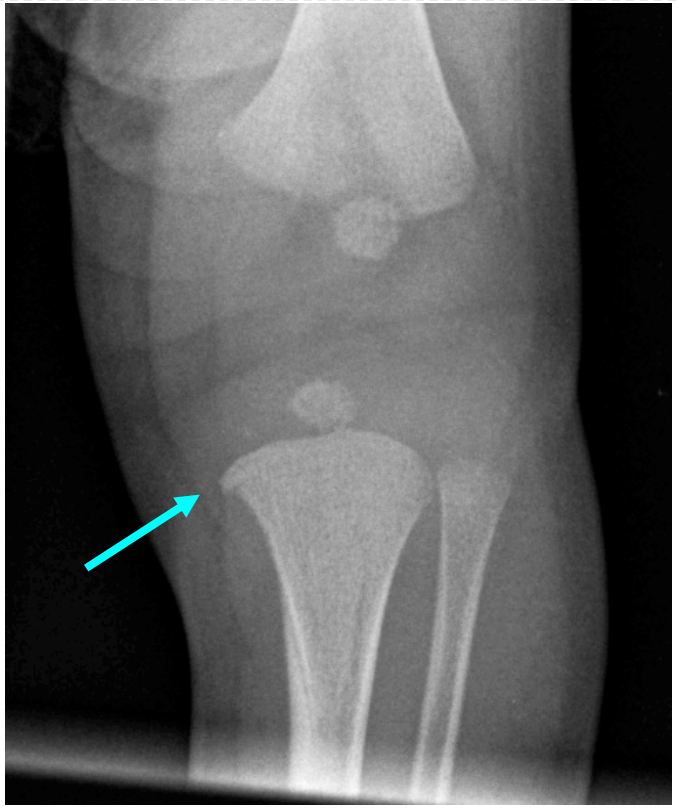
# Normal Variants mimicking Skeletal Injuries of Abuse


- Metaphyseal
  - Step-off
  - Spur
  - Beak
- Diaphyseal
  - Nutrient canals
  - Cortical irregularity
- Rib
  - Ossification defect
  - Posterior synostosis
  - Lateral Notch

# Metaphyseal Spur



Initial



2 week follow-up (No change unlike corner metaphyseal fracture)

# Mimics of CNS Injuries of Abuse

- Accidental trauma
- Coagulopathies
- Meningitis
- Glutaric aciduria type I
  - Can cause SDH, and retinal hemorrhages
  - Also see macrocephaly, seizures, motor delay, and mental retardation
- Hemophagocytic Lymphohistiocytosis
  - Retinal hemorrhage seen is not typical of that seen in nonaccidental trauma. Can also see SDH
  - Clinical manifestations differ greatly from abuse. Includes hepatomegaly, fever, and coagulopathy

Fernando et al *Pediatr Radiol* 2008.

# Mimics of Visceral Injuries of Abuse

- Accidental injury involves high energy impact
  - MVA
  - Lap belts
  - Handle bars
  - Long falls

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