

# Fractures and Child Abuse

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I do not have any relevant financial interests with any commercial entities.

**CME DISCLAIMER**

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## OBJECTIVES

- ▶ Describe types of fractures seen in child abuse
- ▶ Review basic mechanisms of injuries
- ▶ Describe management plans to evaluate for fractures

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## ABUSE AND FRACTURES

- ▶ Up to one third of abused children are diagnosed with fractures.
- ▶ Fractures are often occult or the diagnosis is missed, particularly in younger children that are not walking or talking.
- ▶ Fractures are a very common accidental injury.
- ▶ Some fractures and fracture features are more commonly observed in abusive situations.
- ▶ Some fractures rarely occur accidentally.
- ▶ Any type of fracture can occur due to child abuse.

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## CASE

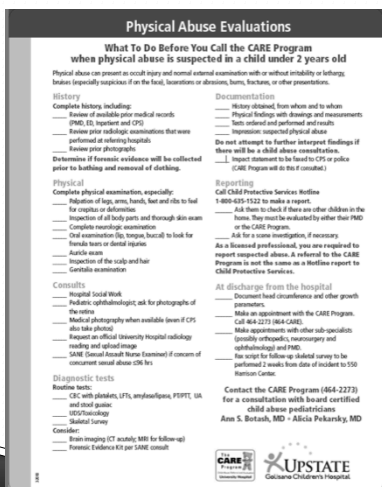
- ▶ A 7 week old presented to his primary care doctor with evidence of a bruise under his right eye.
- ▶ He had been seen (ED) 3 days prior to this visit for blood in his diaper and was found to have a normal examination. Parents were also concerned about the shape of his head, ultimately diagnosed as plagiocephaly.
- ▶ He had been left in the care of his father while the mother worked during the day.
- ▶ The father said that the fall was unwitnessed and occurred one week ago.
- ▶ The father had put the baby on the couch and momentarily went to another room, heard a thump and found him on the carpeted floor.



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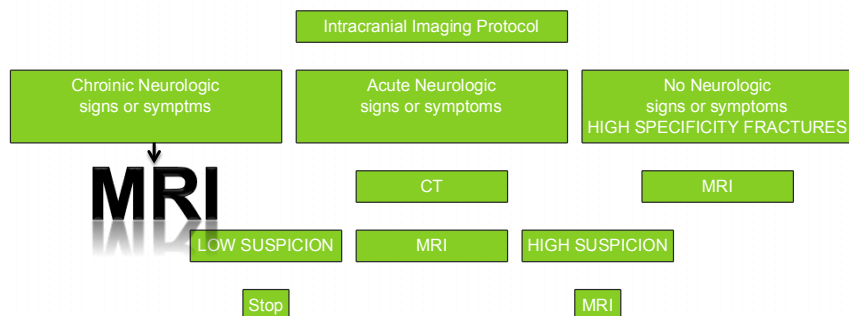
# THE “WHAT TO DO” SERIES



- A complete evaluation in suspected physical abuse includes obtaining a complete history, physical, lab work, reporting and child abuse pediatrician consultation when needed.

<http://champprogram.com/resources.shtml>

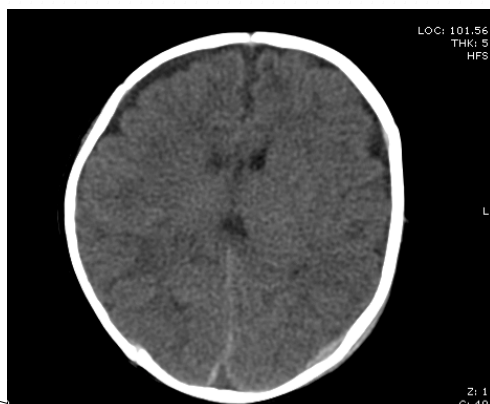
## IMAGING PROTOCOL



Adapted from: Kleinman PK, ed. *Diagnostic imaging of child abuse*. 2nd ed. St Louis, MO: Mosby, 1998.



## Subdural Hemorrhage



- The finding of apnea and/or retinal hemorrhage in a child with brain injury is more strongly associated with iTBI than with nTBI.

Maguire S, Pickerd N, Farewell D, Mann M, Tempest V, Kemp AM. Which clinical features distinguish inflicted from non-inflicted brain injury? A systematic review. Arch Dis Child. 2009 Nov;94(11):860-7. Epub 2009 Jun 15. Review.

## MECHANISMS OF ABUSIVE HEAD TRAUMA

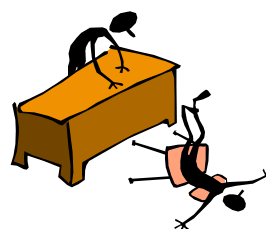
- Moving head strikes stationary object.
- Stationary head hit by a moving object.
- Both head and object colliding.
- Direct vs. Indirect Injury
  - Parenchymal brain injury
  - Secondary brain injury



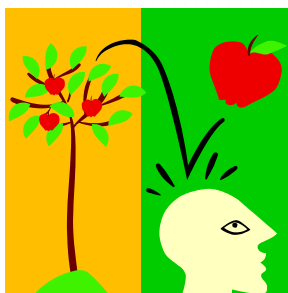
## SHORT FALLS

Serious injuries attributed to a fall from a low height are unlikely and in most instances due to child abuse.

- Helfer, 1977, 246 short falls, 85 in the hospital
- Nimityongskul, 1987, 76 hospital falls
- Williams, 1991, 44 falls
- Lyons, 1993, 124 cribs, 83 beds
- Chiavello, 1994, stairway falls
- Chadwick, 1991...

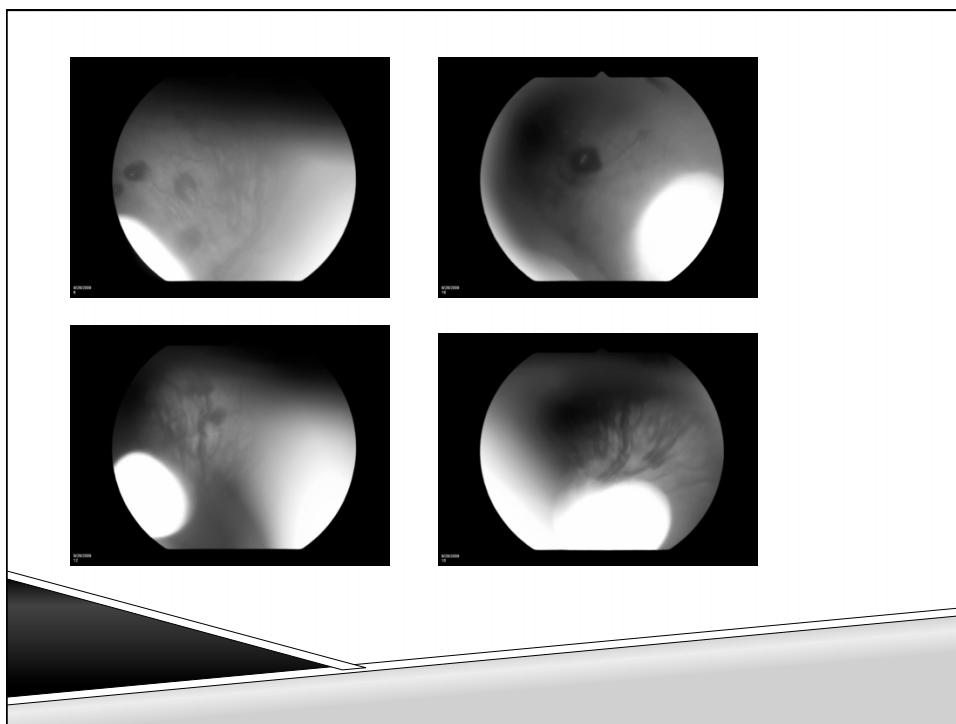


## THE “OTHER” POSSIBILITIES



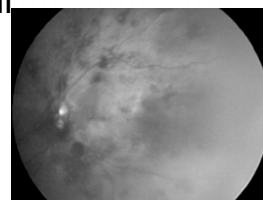
Bishop FS, Liu JK, McCall TD, Brockmeyer DL. Glutaric aciduria type 1 presenting as bilateral subdural hematomas mimicking nonaccidental trauma. Case report and review of the literature. J Neurosurg. 2007 Mar;106(3 Suppl):222-6. Review.

- ▶ Subdural collections occur without trauma.
- ▶ “Statistics don't matter - you're going to see the one in a million or billion or whatever at some time, and why can't this kid right here be the one.”
- ▶ Glutaric aciduria Type I
- ▶ Rebleeds (from birth trauma)
- ▶ Primary brainstem damage leading to an anoxic event (Geddes)



## RETINAL HEMORRHAGES

- ▶ Retinal hemorrhages are a cardinal manifestation of abusive head trauma.
- ▶ May be a few, exclusively intra-retinal, confined to the posterior pole, or microscopic (seen at autopsy only).
- ▶ Asymmetry and unilaterality are well recognized.
- ▶ Traumatic retinoschisis may occur.



Alex Levin. Ophthalmic manifestations of inflicted childhood neurotrauma.  
AAP Conference Proceedings, 2002.

## RETINAL HEMORRHAGES

- ▶ Accidental retinal hemorrhages
  - ▶ Studies estimate these can occur in less than 3% of accidental head traumas.
  - ▶ Almost always following significant trauma by history.
- ▶ Vaginal birth
  - ▶ Superficial (splinter) hemorrhages resolve within one week.
  - ▶ Deeper hemorrhages (dot blot) resolve within 6 weeks.

Huges et al. Incidence distribution and duration of birth related RH. J AAPOS. 2006  
Emerson MV, et al . Incidence and rate of disappearance of RH in newborns. Ophthalmology 2001; 108: 36-9

## RETINAL HEMORRHAGES

- CPR (6 studies, one prospective, 1 multicenter)-- RH rarely occur from CPR. When they do, they are few and confined to the posterior pole.
- Increased ICP: Seen with central retinal vein occlusion and papilledema. No evidence that increased ICP causes RH in SBS.

## WHEN TO SUSPECT ABUSIVE FRACTURES

- ▶ An inconsistent or inadequate history is provided, particularly if the mechanism of trauma is not consistent with the finding.
- ▶ Child is developmentally unable to cause the injury to self.
- ▶ Unexplained or poorly explained delay in seeking medical care.
- ▶ Associated injuries with poor explanation(s).
- ▶ Absence of radiologic (and serologic, if testing performed) evidence of bone disease.
- ▶ Confession of intentional trauma or witnessed event.
- ▶ Other signs or symptoms of abuse in a child less than 2 years.

## EVALUATION OF FRACTURES

- ▶ A detailed history (how, when, what, where and witnesses)
- ▶ A clear developmental history
- ▶ Past medical history (past injuries)/ family history
- ▶ Scene evaluation: pictures and measurements
- ▶ Skeletal survey (when indicated)
- ▶ CT and/or bone scan may complement evaluation
- ▶ Consider Vitamin D or other assessment for bone demineralization or pathology
- ▶ Family history of fractures, mother's dietary intake during pregnancy, family history of bad teeth

## SKELETAL SURVEY

- ▶ Recommended in situations of suspected child abuse in children under the age of 2 years.
- ▶ Most recommend oblique rib radiographs (not shown on this table).
- ▶ REPEAT SKELETAL SURVEY IN 2 WEEKS.

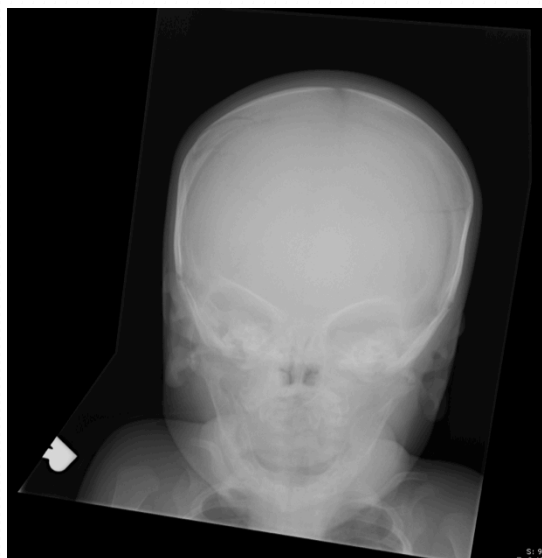
TABLE 1 Complete Skeletal Survey Table<sup>14</sup>

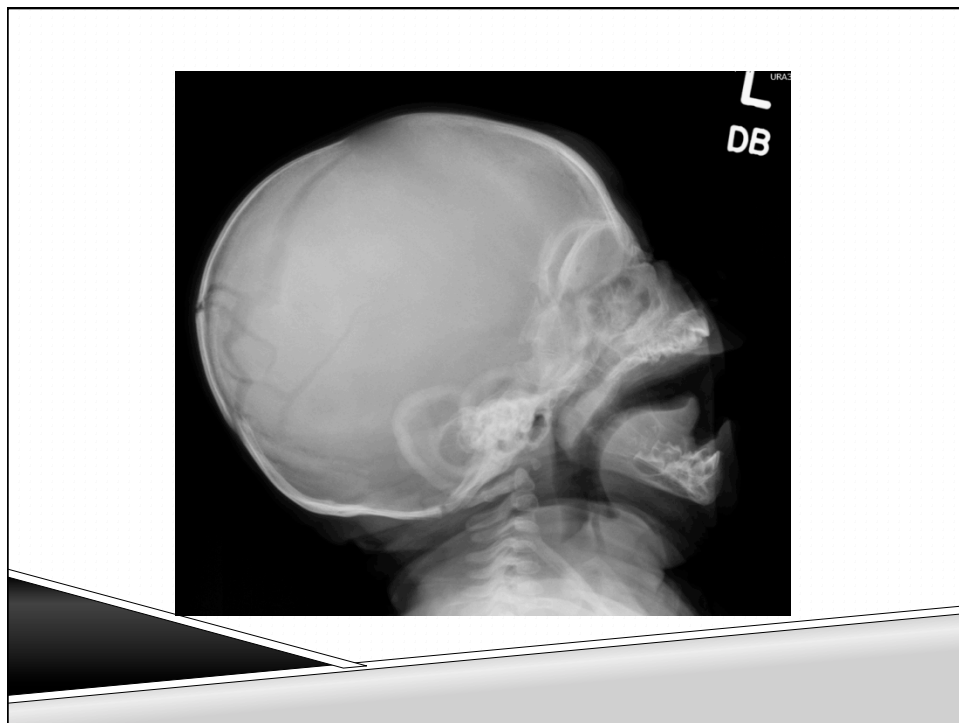
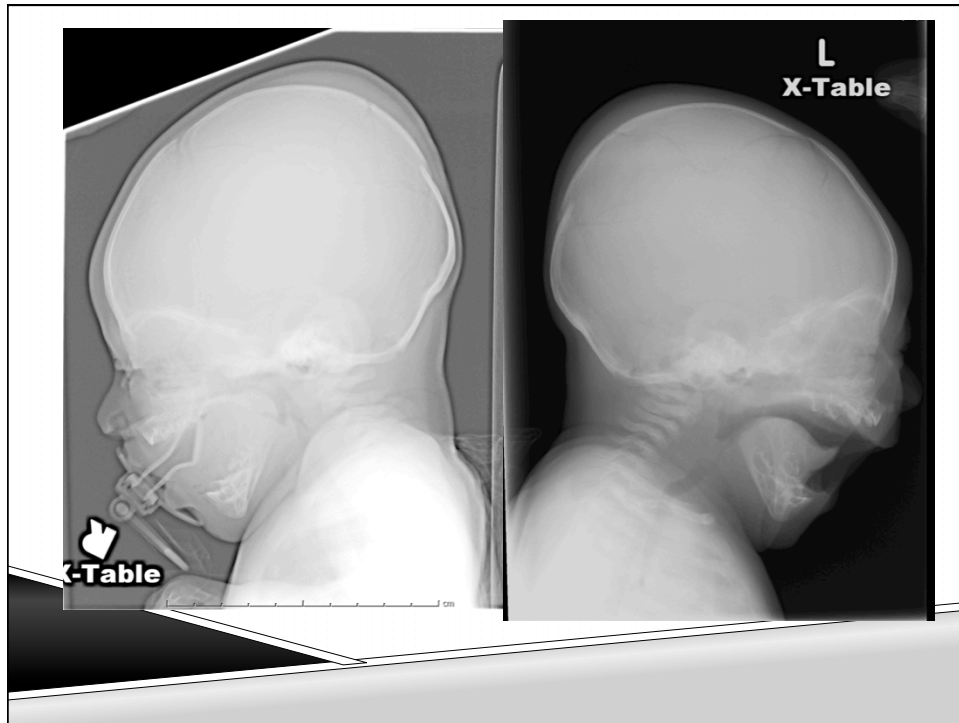
Appendicular skeleton
Arms (AP)
Forearms (AP)
Hands (PA)
Thighs (AP)
Legs (AP)
Feet (PA or AP)
Axial skeleton
Thorax (AP and lateral), to include thoracic spine and ribs
AP abdomen, lumbosacral spine, and bony pelvis
Lumbar spine (lateral)
Cervical spine (AP and lateral)
Skull (frontal and lateral)

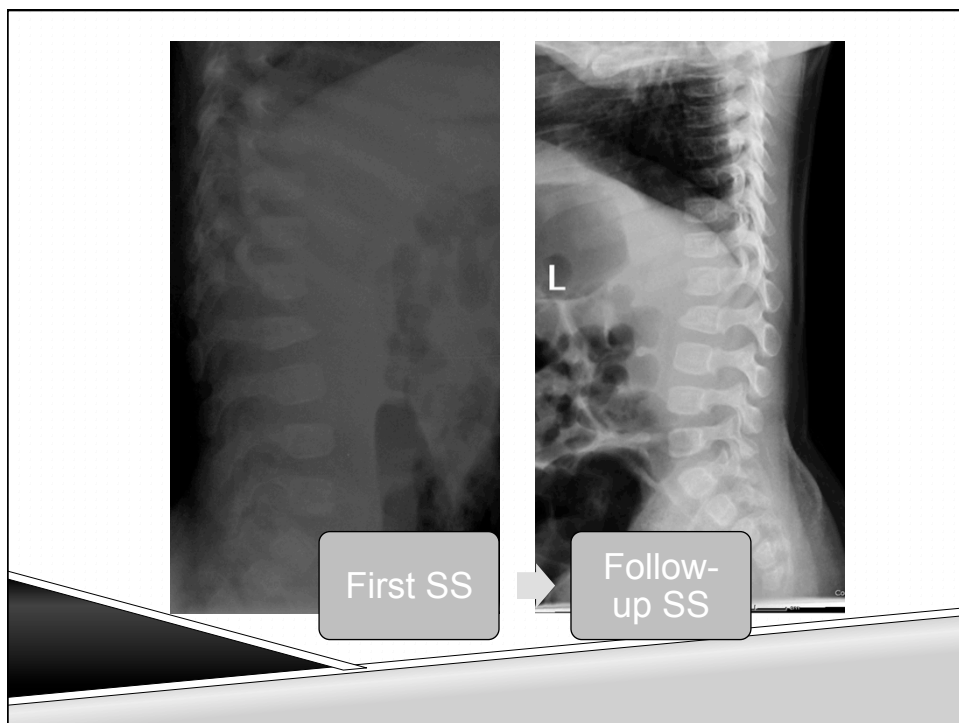
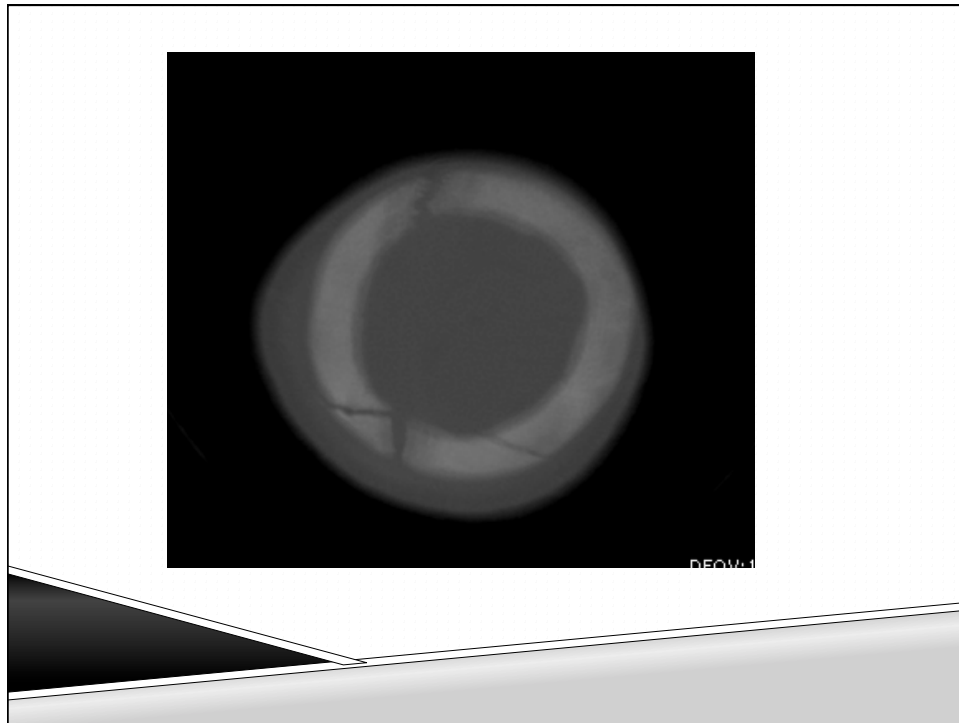
AP indicates anteroposterior; PA, posteroanterior.

American Academy of Pediatrics; Section on Radiology. Diagnostic imaging of child abuse. Pediatrics. 2009 May;123(5): 1430-5.

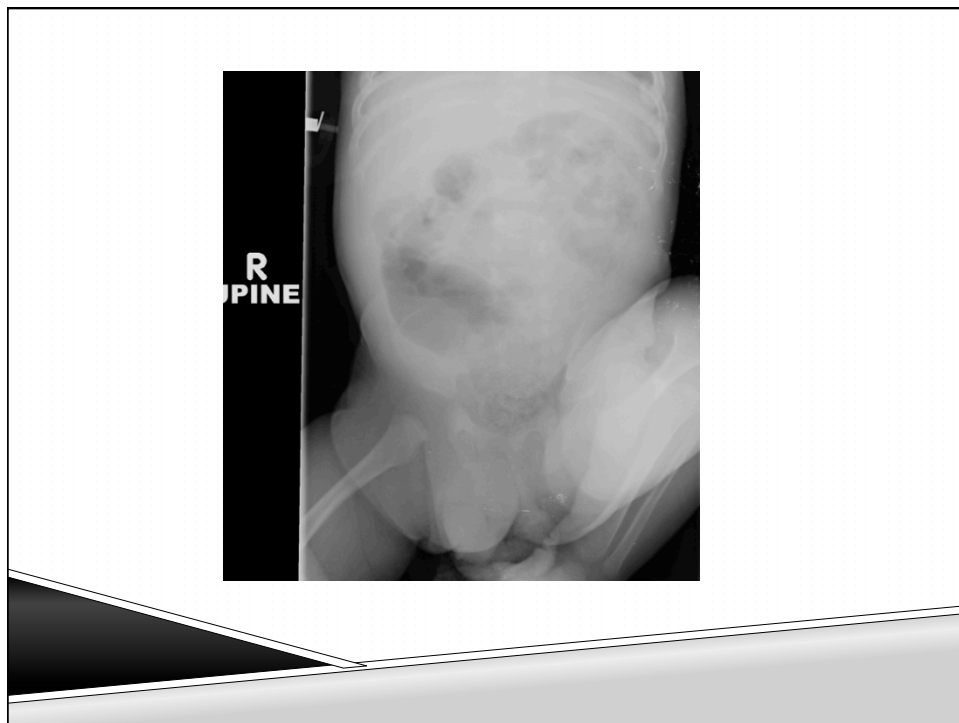
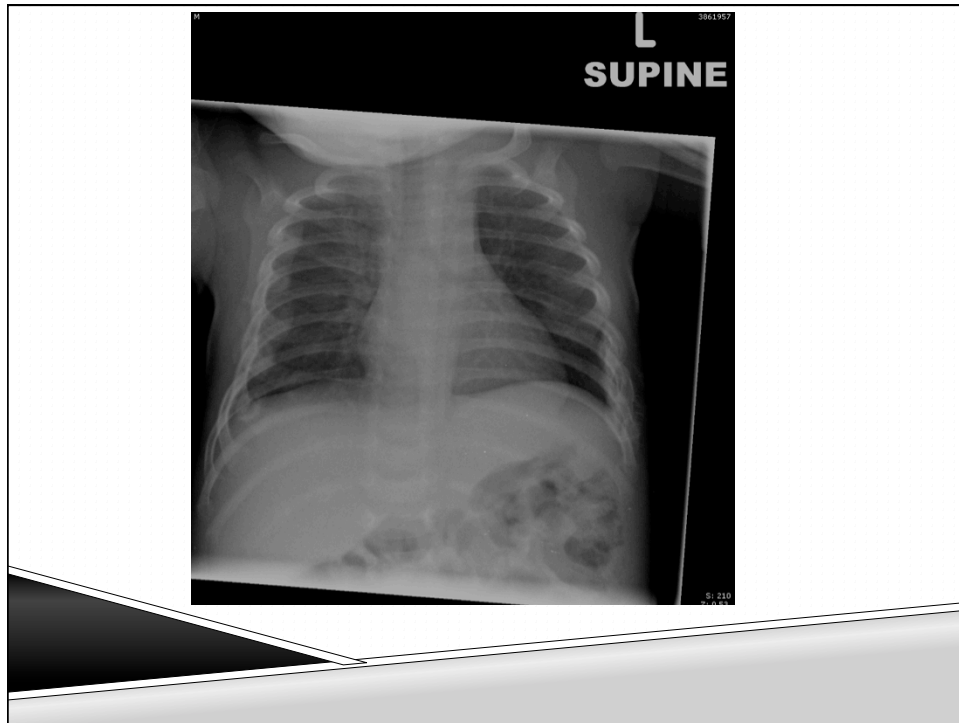
<http://www.champprogram.com/practice-recommendations.shtml>



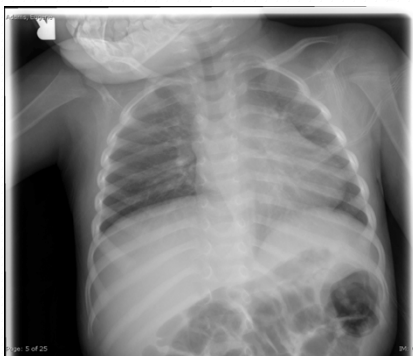








## IDENTIFYING RIB FRACTURES ON BONE SCAN



Rib fractures may not be apparent on plain films and bone scintigraphy (bone scan) is sometimes indicated. Follow-up skeletal survey is recommended in 2 weeks as an alternative to bone scan.

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## SKELETAL SURVEY VS. BONE SCAN

- ▶ The optimal yield of occult fractures is in children under 2 years of age... (& older kids with disabilities).
- ▶ Either SS or BS gives information on the age of injuries; SS or BS alone will miss occult fractures.
- ▶ BS may miss skull fractures, metaphyseal and epiphyseal fractures.
- ▶ Oblique views of the ribs increase the diagnostic yield of rib fractures in a SS.
- ▶ Repeat SS (1-2 weeks later) increases the identification rate of fracture.



*Kemp, Butler. Clinical Radiology (2006) 61, 723-736*

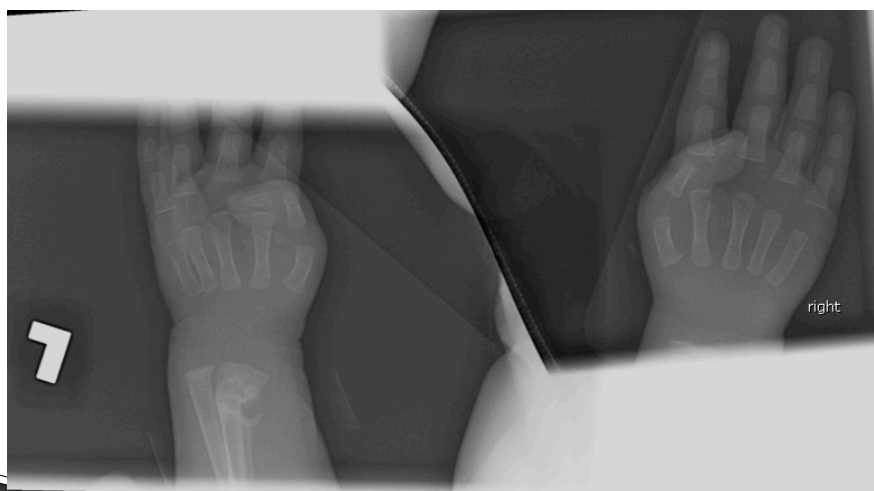
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## COMMONLY MISSED FRACTURES

- ▶ Acute rib fractures
- ▶ Pelvic fractures (pubic rami)
- ▶ Vertebral fractures, spinal fractures and dislocations
- ▶ Metaphyseal fractures
- ▶ Skull fractures, especially if only CT is performed
- ▶ Fractures of the hands and feet

Kemp AM, Butler A, Morris S, Mann M, Kemp KVV, Rolfe K, Sibert JR, Maguire S.  
Which radiological investigations should be performed to identify fractures in  
suspected child abuse? Clin Radiol. 2006 Sep; 61(9): 723-36.

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## MULTIPLE UNEXPLAINED FRACTURES

- ▶ Head injury, including fracture
- ▶ Rib fractures
- ▶ Radius fracture
- ▶ Vertebral fracture
- ▶ Other:
  - Retinal hemorrhages
  - History of rectal bleeding

## MOST COMMON ABUSIVE FRACTURES

### Specificity of Radiologic Findings

#### 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

#### Common but low specificity

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

Highest specificity applies in infants.

- The most common fractures in abused children involve the skull, long bones and ribs. The numbers vary (relatively) depending on the series studied (detail of radiologic imaging), age of the children and whether the studied populations included fatalities.

Kleinman PK. Diagnostic imaging in infant abuse. AJR Am J Roentgenol. 1990 Oct;155(4):703-12. Review.

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## CASE Fractures

- Skull Fracture
- Radial Fracture
- Rib Fractures
- Vertebral Body Fracture

### Specificity of Radiologic Findings

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Linear skull fractures ☆

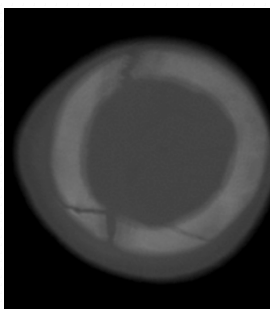
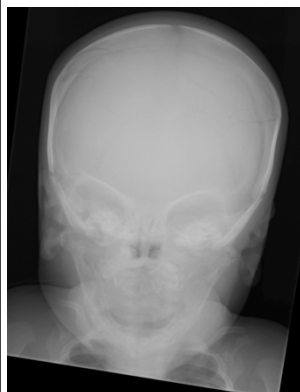
Highest specificity applies in infants.

## POTENTIAL DIFFERENTIAL DIAGNOSIS OF MULTIPLE FRACTURES: HIGHLIGHTS FROM THE AAP CLINICAL REPORT

- ▶ Child abuse
- ▶ Osteogenesis Imperfecta: Not all OI have classic findings
- ▶ Preterm birth--osteopenia
- ▶ Rickets---Vitamin D deficiency
- ▶ Osteomyelitis
- ▶ Copper deficiency
- ▶ Paralysis (demineralization)
- ▶ Rare conditions

Jenny C; Committee on Child Abuse and Neglect. Evaluating infants and young children with multiple fractures. Pediatrics. 2006 Sep;118(3):1299-303.

## COMPLEX OR SIMPLE?



### Specificity of Radiologic Findings

#### High specificity

Classic metaphyseal lesions  
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Sternal fractures

#### Moderate specificity

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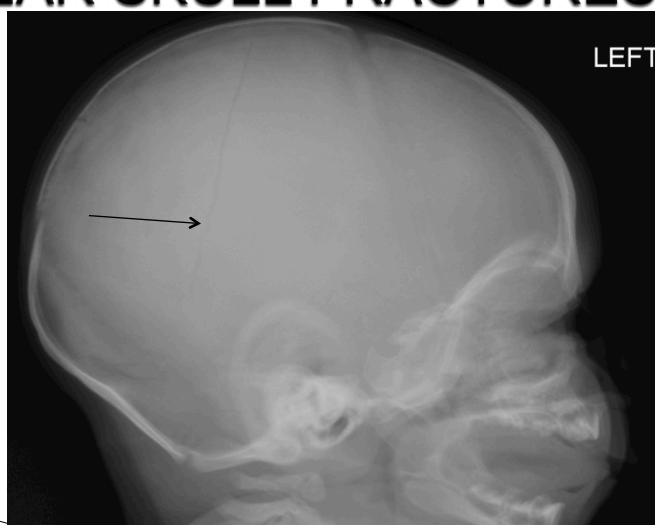
Highest specificity applies in infants.

## Moderate Specificity: Complex Skull Fractures

- ▶ Simple: A single fracture that extends in a straight, curved or linear fashion. The fracture margins are separated by less than 3mm. They are restricted to a single bone.
- ▶ Complex: Consist of more than one fracture line. May have a stellate or branching pattern. May cross suture lines.
- ▶ Compound: There is a skull fracture with an overlying laceration of the scalp.

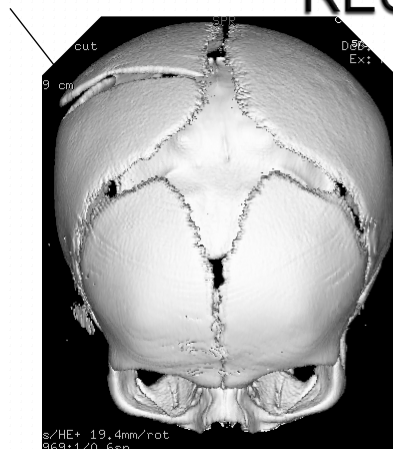
Kleinman PK, ed. *Diagnostic imaging of child abuse*.  
2nd ed. St Louis, MO: Mosby, 1998

## LINEAR SKULL FRACTURES



Most common fracture in both abused and non-abused children.

## LINEAR SKULL FRACTURES: CT RECONSTRUCTION



CT reconstruction may assist with determination of fractures. In this case there is a finding of a depressed fracture that was not as evident on the skull films.

FIG. 4.

### Fracture Patterns in Children and Young Adults Who Fall from Significant Heights.

Sawyer, Jeffrey; Flynn, John; Dormans, John; Catalano, John; Drummond, Denis.  
Journal of Pediatric Orthopaedics. 20(2): 197-202, March/April 2000.

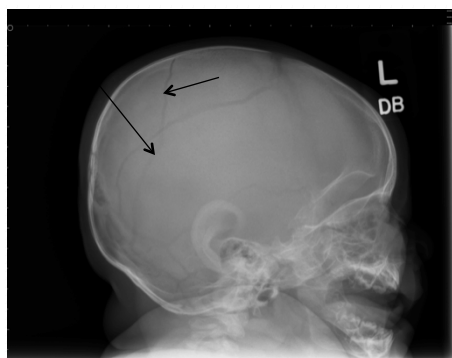
FIG. 4. Typical suspected body position as infants, children, and adolescents/adults approach the landing surface.

Mechanism of trauma

Scene investigation



## MODERATE SPECIFICITY: COMPLEX SKULL FRACTURES



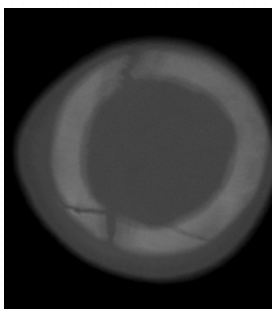
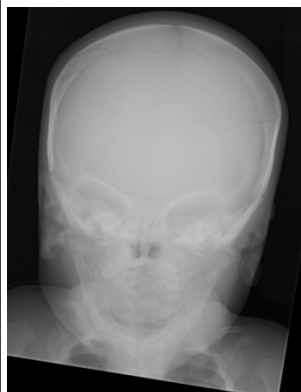
Multiple fractures, bilateral fractures, and fractures crossing sutures occur more often in abuse cases than in accidental injury.



Chiaviello CT, Christoph RA, Bond GR. Stairway-Related Injuries in Children. *Pediatrics* 1994;94:679-681

Kemp AM, Dunstan F, Harrison S, Morris S, Mann M, Rolfe K, Datta S, Thomas DP, Sibert JR, Maguire S. Patterns of skeletal fractures in child abuse: systematic review. *BMJ*. 2008 Oct 2; 337:a1518 doi: 10.1136/bmj.a1518

## COMPLEX



### Specificity of Radiologic Findings

#### 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

#### Common but low specificity

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

Highest specificity applies in infants.

## HIGH SPECIFICITY FOR ABUSE: RIB FRACTURES

- ▶ Relatively commonly caused by abuse.
  - ▶ Can be occult.
- ▶ 90% seen < 2 years of age.
- ▶ Rib fractures from abuse can be seen in any location along the rib and may be unilateral or bilateral.
- ▶ Posterior rib fractures are most commonly due to levering action and involve either:
  - ▶ Rib head: costo-vertebral articulation
  - ▶ Rib neck: costo-transverse process articulation



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## RIB FRACTURES: MECHANISM OF TRAUMA

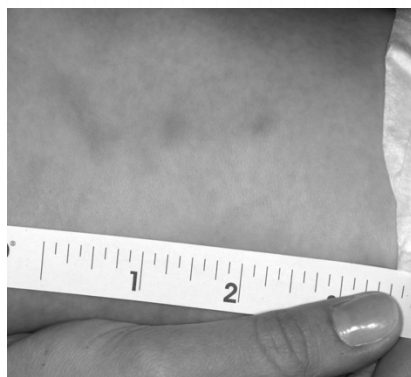
- ▶ Squeezing
- ▶ Rotation of the ribs posteriorly with squeezing action
- ▶ Crush injury
- ▶ Direct trauma to thoracic area
- ▶ Bone disease and trauma to the chest

## RIB FRACTURES: CAUSES

- ▶ Uncommon with birth trauma.
- ▶ Not likely from cardiopulmonary resuscitation, especially posterior rib fractures (has been reported with 2-handed CPR).
- ▶ Generally compressive forces, not direct blows (has been reported after Chest Physiotherapy).
- ▶ Seldom see overlying bruises.
- ▶ After fractures, infant may be asymptomatic.

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## RIB FRACTURES AND OVERLYING BRUISES: AN UNCOMMON FINDING



- ▶ In a case control study of 71 bruised patients admitted to a PICU with either accidental or non-accidental trauma, 33 were abused and 38 admitted due to accidental trauma.
- ▶ Characteristics predictive of abuse were bruising to the chest, torso, ear or neck for a child less than 4 or bruising anywhere on a child less than 1 year.

Pierce MC, Kaczor, K, Aldridge, S, O' Flynn J, Lorenz DJ. Bruising characteristics discriminating physical child abuse from accidental trauma. Pediatrics. 2010. 125(1): 64-71.

## THE ABSENCE OF BRUISING

- ▶ In the Peters study of 192 children (6 weeks to 120 months) with inflicted fractures (626 fractures) no bruising was found in 57.8% of the study participants.
- ▶ 20.8% had bruising near the site of at least one fracture.
- ▶ Of these, 43. 3% were skull fractures with bruising or associated subgaleal hematomas.
- ▶ The presence of bruising near the site of an extremity or rib fracture was an uncommon finding.

Peters ML, Starling SP, Barnes-Eley ML, Heisler KW. Arch The presence of bruising associated with fractures. *Pediatr Adolesc Med.* 2008 Sep;162(9):877-81.

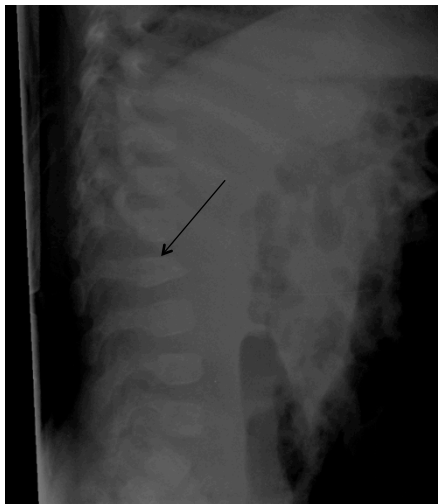
## NOT EVERYONE AGREES...

- ▶ <http://www.bailii.org/ew/cases/EWHC/Fam/1994/5.html>
- ▶ Garcia VF, Gotschall CS, Eichelberger MR, Bowman LM. Rib fractures in children: a marker of severe trauma. *J Trauma.* 1990 Jun;30(6):695-700.

## CASE: VERTEBRAL FRACTURES



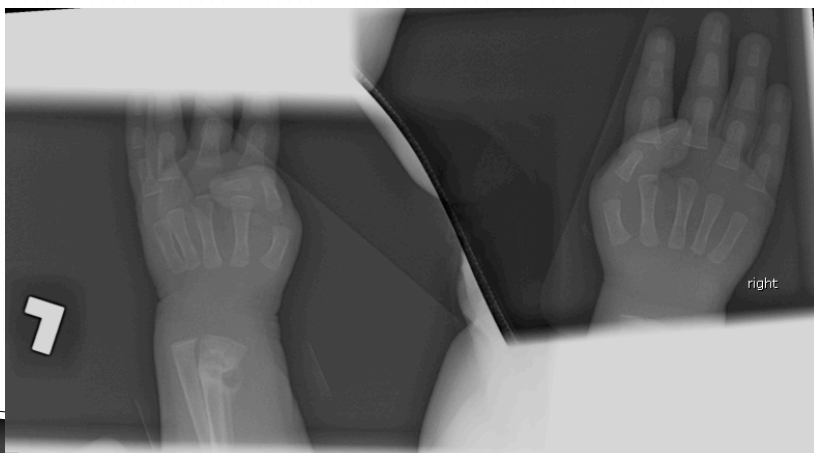
## MODERATE SPECIFICITY: VERTEBRAL FRACTURES



- ▶ Mechanism is usually compression of the spine.
- ▶ Often missed on infant's or children's X-rays.
- ▶ Can result in spine deformities.
- ▶ Does not show up well on bone scan.

[http://  
www.champprogram.com/  
question/5.shtml](http://www.champprogram.com/question/5.shtml)

## CASE: LONG BONE FRACTURE



Specificity of Radiologic Findings
<b>High specificity</b>
Classic metaphyseal lesions
Rib fractures, especially posterior
Scapular fractures
Solitary process fractures
Sternal fractures
<b>Moderate specificity</b>
Multiple fractures, especially bilateral
Fractures of different ages
Epiphyseal separations
Vertebral body fractures and subluxations
Digital fractures
Complex skull fractures
<b>Common but low specificity</b>
Subperiosteal new bone formation
Cloacal fractures
Long bone shaft fractures
Linear skull fractures
<small>Highest specificity applies to infants.</small>

## TYPES OF LONG BONE FRACTURES

For more information and diagrams depicting long bone fractures see:  
<http://childabusemd.com/appendices/appendix-F.shtml>

## LONG BONE FRACTURES

- “Is the fracture morphology consistent with the direction, magnitude and rate of loading described by the mechanism?”
- What is the child’s developmental capability and could the child have generated the necessary energy, independent of the “outside” forces, to cause the observed injury?
- Did the event generate enough energy to cause this fracture?
- Were there structural factors of the bone itself that contributed to the likelihood of fracture?”

Pierce, et al. Evaluating long bone fractures in children: A biomechanical approach with illustrative cases. *Child Abuse and Neglect* 28 (2004): 504-524.

## HIGH SPECIFICITY FRACTURES: CLASSIC METAPHYSEAL LESIONS

- ▶ There is minimal or no periosteal disruption or reaction.
- ▶ Shearing forces disrupt the immature mineralized bone and not the adjacent cartilaginous physis.
- ▶ Bone scan should not be used to diagnose CMLs.



## MECHANISM OF TRAUMA FOR CMLS

- ▶ Requires shearing forces not generally produced in accidental trauma.
- ▶ Possibly produced during shaking when limbs flail.
- ▶ Also consider twisting, jerking or pulling mechanisms.

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## OUR CASE

- ▶ 7 week old
- ▶ Multiple fractures
- ▶ Head trauma with SDH and RH
- ▶ No CMLs
- ▶ Minimal bruising
- ▶ History not consistent with findings





## POTENTIAL DIFFERENTIAL DIAGNOSIS OF MULTIPLE FRACTURES: THE DEFENSE ATTORNEY'S DREAM

- ▶ Infant has Osteogenesis Imperfecta.
- ▶ Infant was breast fed and his skin is pigmented, so he likely is Vitamin D deficient, therefore, more likely to fracture.
- ▶ Infant probably has temporary brittle bone disease.

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## HIGHLIGHTS FROM THE AAP CLINICAL REPORT

**TABLE 1** Signs and Symptoms of Osteogenesis Imperfecta

Fragile bones, with few, some, or many of the following findings:
Poor linear growth
Hypoplastic, translucent, carious, late-erupting, or discolored teeth
Blue sclera
Easy bruisability
Limb deformities
Scoliosis and/or kyphosis
Hyperextensible joints
Wormian bones
Hearing impairment as a result of otosclerosis
Inguinal and/or umbilical hernias
Triangular-shaped face
Macrocephaly
Deminerlized bones

- ▶ Not all OI have classic findings.

Jenny C; Committee on Child Abuse and Neglect. Evaluating infants and young children with multiple fractures. Pediatrics. 2006 Sep;118(3):1299-303.

## OSTEOGENESIS IMPERFECTA

- ▶ There are now at least 8 identified types of OI.
- ▶ Clinical features overlap of some.
- ▶ Not all have blue sclera.
- ▶ Type II (perinatal) is lethal.
- ▶ Type III, VII, VIII are severe phenotypes. DI may be present.
- ▶ Hearing loss is later onset.
- ▶ Type I may have normal stature, normal appearing bones, and fractures. Hearing loss is a feature.

Basel D, Steiner RD. Osteogenesis imperfect: Recent findings shed new light on this once well-understood condition. *Genetics in Medicine*. 2009; 11(6): 375-385.

## HISTORY FOR OI

- ▶ Short stature or stature shorter than predicted based on stature of unaffected family members, often with bone deformity
- ▶ Blue sclera
- ▶ Dentinogenesis Imperfecta (smile, mom!)
- ▶ Progressive, postpubertal hearing loss (family members or patient)
- ▶ Ligamentous laxity and other signs of connective tissue abnormality (in family members or patient)
- ▶ Family history of OI, usually consistent with autosomal dominant inheritance

Basel D, Steiner RD. Osteogenesis imperfect: Recent findings shed new light on this once well-understood condition. *Genetics in Medicine*. 2009; 11(6): 375-385.

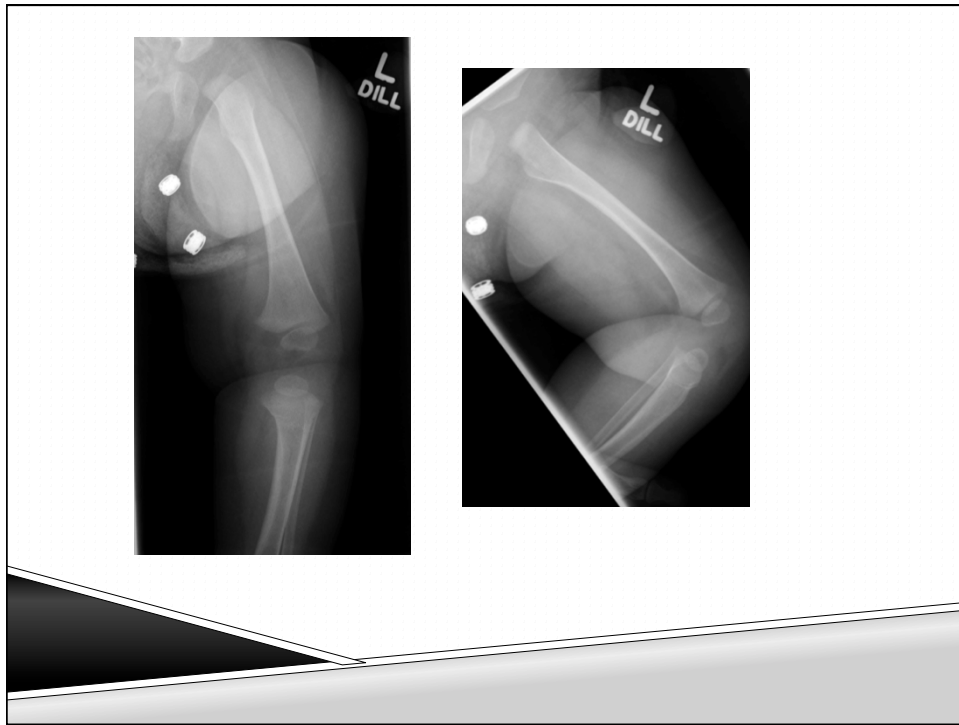
## AREAS OF OVERLAP OF OI AND ABUSE

- ▶ Fractures of varying ages and stages of healing, often of the long bones but may also involve ribs and skull.
- ▶ The metaphyseal chip fractures characteristic of child physical abuse can be seen in a small number of children with OI.
- ▶ “Codfish” vertebrae, which are the consequence of spinal compression fractures, seen primarily in the adult.
- ▶ Wormian bones, defined as “sutural bones that are 6 mm by 4 mm (in diameter) or larger, in excess of 10 in number, with a tendency to arrangement in a mosaic pattern.”
- ▶ Wormian bones are suggestive of, but not pathognomic, for OI. They are present in up to 60% of affected children.

Basel D, Steiner RD. Osteogenesis imperfect: Recent findings shed new light on this once well-understood condition. *Genetics in Medicine*. 2009; 11(6): 375-385.

## OSTEOGENESIS IMPERFECTA





## OUR CASE

- ▶ No FH of OI
- ▶ No FH of short stature, easy bruising or fractures or bad teeth
- ▶ No other siblings
- ▶ No triangular face, no blue sclera
- ▶ Birth history was negative for trauma...
- ▶ FT baby (not premature birth)
- ▶ No wormian bones

REASONABLE DOUBT?

## WHAT ABOUT VITAMIN D DEFICIENCY?

- The major function of cholecalciferol is to increase the efficiency of calcium absorption from the small intestine.
- Adequate calcium and phosphorus absorption is important for proper mineralization of bone.
- The second major function of cholecalciferol is for the maturation of osteoclasts to resorb calcium from the bones.

## Chapman, et al.: Rickets

- ▶ 45 children (2-24 months), with only 4 younger than 7 months.
- ▶ The majority (32 had nutritional rickets), the rest were metabolic causes or secondary to other diseases.
- ▶ 40 children were included in the data (2 had elevated alk phos only, 3 with unknown causes of rickets were excluded, none of these had fractures).
- ▶ 7 children had fractures and all 7 had nutritional rickets.
- ▶ All 7 were mobile.
- ▶ All 7 had widespread rachitic changes.
- ▶ Fractures were all considered structural insufficiency fractures and did not resemble those seen in NAT.

Chapman T, Sugar N, Done S, Marasigan J, Wambold N, Feldman K. Fractures in infants and toddlers with rickets. *Pediatr Radiol.* 2010 Jul;40(7):1184-9. Epub 2009 Dec 9. Erratum in: *Pediatr Radiol.* 2010 Jul;40(7):1308.

## Paterson: Rickets

- ▶ 4 cases; 3 infants, 1 almost 3 year old.
- ▶ Rickets is presumably clinically apparent on radiographs of all 4 per table.
- ▶ No information regarding abuse.
- ▶ Not enough data.

Patterson CR. Vitamin D deficiency rickets and allegations of non-accidental injury. *Acta Paediatr.* 2009; 98: 2008G2.

## Feldman & Done: Rickets

- ▶ Cases spanned 1980-2000.
- ▶ Case 1 and 2 did not have Vit D levels reported.
- ▶ Case 3 presented with hypocalcemic seizures.
- ▶ Rib ends are cropped in case 1.
- ▶ Case 2 had dense metaphyses not c/w rickets.
- ▶ Case 3—figure shows CML.
- ▶ Case 4—had a skull fx, unusual for rickets (in a 9 week old).
- ▶ Some had Vit D deficiency, questionable metabolic bone dz, some were probably also abused...

Feldman KW, Done S. Vitamin D deficiency rickets and allegations of non-accidental injury. *Acta Paediatr.* 2010 Apr; 99(4):486-7.

## Keller & Barnes: Rickets

- ▶ Congenital rickets is “inevitable” due to maternal deficiencies.
- ▶ 4 cases/ “reports.”
- ▶ All were cases they reviewed as defense witnesses.
- ▶ Personal profit gained by promoting the existence of congenital rickets.
- ▶ ¾ of the court findings disagreed with these authors regarding the cause of the fractures.

[Keller KA, Barnes PD. Rickets vs. abuse: a national and international epidemic. \*Pediatr Radiol\*. 2008 Nov;38\(11\):1210-6. Epub 2008 Sep 23.](#)

<http://medicalmisdiagnosisresearch.wordpress.com/2010/12/22/father-found-not-guilty-of-sbs-returns-to-his-family/>

## REASONABLE DOUBT?



## CALLING DR. PATERSON TO THE STAND...

- ▶ Paterson CR, McAllion SJ. Classical osteogenesis imperfecta and allegations of nonaccidental injury. Clin Orthop Relat Res. 2006 Nov;452:260-4.
- ▶ Paterson CR. Vitamin D deficiency rickets and allegations of non-accidental injury. Acta Paediatr 2009; 98:2008–12.
- ▶ Paterson CR. Temporary brittle bone disease: fractures in medical care. Acta Paediatr. 2009 Dec;98(12):1935-8. Epub 2009 Jun 25.
- ▶ Paterson CR. Bone disorders that cause fractures and mimic non-accidental injury. Acta Paediatr. 2010 Sep;99(9):1281-2.

## MULTIPLE FRACTURES: TBBD

- Temporary Brittle Bone Disease (TBBD) is not a diagnosis.
- There is no scientific evidence that it exists.

Jenny C. Multiple unexplained fractures in infants--the need for clear thinking. Acta Paediatr. 2010 Apr;99(4):491-3.



SYMPOSIUM: NONACCIDENTAL TRAUMA IN  
CHILDREN

Unexplained Fractures: Child Abuse or Bone  
Disease A Systematic Review

Nirav K. Pandya MD, Keith Baldwin MD, MPH,  
MSPT, Atul F. Kamath MD, Dennis R. Wenger  
MD, Harish S. Hosalkar MD, MBMS (Ortho),  
FCPS (Ortho), DNB (Ortho)

Clin Orthop Relat Res (2011) 469:805–812

Pediatrics. 2011 Apr 11. [Epub ahead of print]  
**Vitamin D Status in Abused and Nonabused  
Children Younger Than 2 Years Old With  
Fractures.**

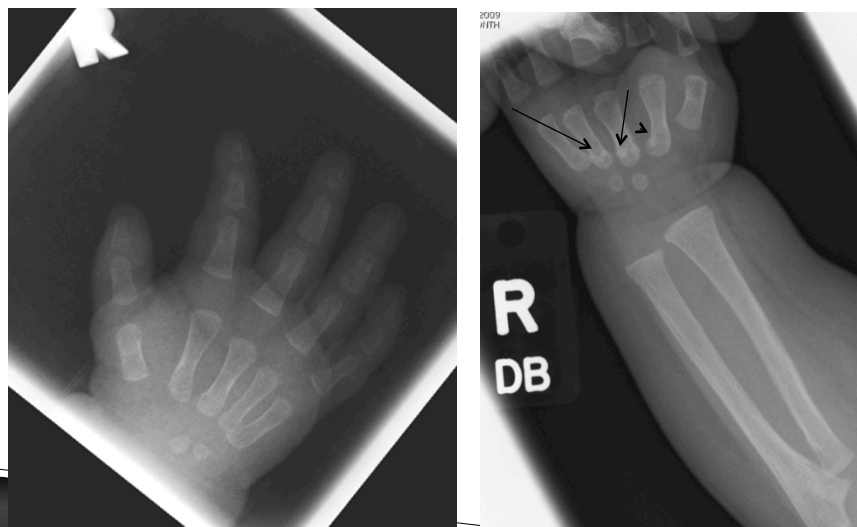
Schilling S, Wood JN, Levine MA, Langdon D,  
Christian CW.

“There was no association between vitamin  
D levels and any of the following outcomes:  
child abuse diagnosis ( $P$ .32), multiple  
fractures ( $P$  .24), rib fractures ( $P$  .16), or  
metaphyseal fractures ( $P$  .49).”

## DELAYED IDENTIFICATION OF FRACTURES

- Approximately 20% of abusive fractures were missed at initial physician visits.
- In all of these cases, the signs/symptoms of the fracture were observed, but the possibility of abuse was not raised.
- Boys, children who present to a non-pediatric ED or a primary care setting, and/or those with an extremity fracture appeared to be at the greatest risk of missed abuse diagnosis.
- A detailed review of the mechanism of trauma and screening for risk factors for abuse should occur with the evaluation of any young child with a fracture.

Ravichandiran N, Schuh S, Bejuk M, Al-Harthy N, Shouldice M, Au H, Boutis K. Delayed identification of pediatric abuse-related fractures. *Pediatrics*. 2010 Jan; 125(1): 60-6. Epub 2009 Nov 30.



Left radiograph shows the hand in a skeletal survey shortly after an incident. Right shows the same hand two weeks later with healing 3rd and 4th proximal metacarpal fractures.

# THE BIGGER PICTURE

**Physical Abuse Evaluations**

**What To Do Before You Call the CARE Program**  
when physical abuse is suspected in a child under 2 years old

Physical abuse can present as a cut, bruise, burn, or other external examination with or without instability or bruising. Bruises (especially suspicious if on the face, torso, or extremities, burns, fractures, or other presentations).

**History**  
Complete history including:  
— Review of available prior medical records (PMD, IS, Incident and CPS)  
— Review prior radiologic examinations that were performed at referring hospital  
— Review prior photographs  
— Determine if forensic evidence will be collected prior to bathing and removal of clothing.

**Physical**  
Complete physical examination, especially:  
— Evaluation of legs, arms, hands, feet and ribs to feel for swelling or deformities  
— Inspection of all body parts and thorough skin exam  
— Complete head/neck examination  
— Oral examination (lip, tongue, buccal) to look for trauma, tears or dental injuries  
— Auricle exam  
— Inspection of the scalp and hair  
— Genital examination

**Consults**  
— Hospital social work  
— Pediatric ophthalmologist; ask for photographs of the retina  
— Medical photography when available (even if CPS also take photos)  
— Request an official (University Hospital) radiology reading and upload image  
— SANE (Sexual Assault Nurse Examiner) if concern of concurrent sexual abuse (SANE has)

**Diagnostic tests**  
Baseline tests:  
— CBC with platelets, LFTs, amylase/lipase, PPTT, UA and stool guaiac  
— Urinalysis  
— Skeletal survey  
Consider:  
— Brain imaging (CT scan; MRI for follow-up)  
— Forensic evidence kit per SANE consult

**Documentation**  
— History obtained, from whom and to whom  
— Physical findings with drawing and measurements  
— Tests ordered and performed and results  
— Narrative, suspected physical abuse  
Do not attempt to further interpret findings if there will be a child abuse consultation.  
— Report statement to be furnished to CPS or police (CARE Program will do this if consult.)

**Reporting**  
Call CARE Protective Services Hotline  
1-800-435-1522 to make a report  
— Ask them to check if there are other children in the home. They must be evaluated by either the PMD or the CARE Program.  
— Ask for a scene investigation, if necessary  
As a licensed professional, you are required to report suspected abuse. As referred to the CARE Program to act the same as a Hotline report to Child Protective Services.

**At discharge from the hospital**  
— Document head circumference and other growth parameters  
— Make an appointment with the CARE Program. Call 404-527-3848 (CARE).  
— Make appointments with other sub-specialists (pediatric ophthalmologist, neurosurgeon and ophthalmologist and PMD).  
— See report for follow-up dated same to be performed 2 weeks from date of incident to SSO Harrison Center.

Contact the CARE Program (864-2277) for a consultation with a trained and certified child abuse pediatrician.  
Ann S. Betts, MD - Abilene Pediatrics, MD

**CARE**  
Child Abuse Reporting  
**UPSTATE**  
Greenville Children's Hospital

- Fractures are only one type of injury seen in physical abuse.
- A complete evaluation in suspected physical abuse includes obtaining a complete history, physical, lab work, reporting and child abuse pediatrician consultation when needed.



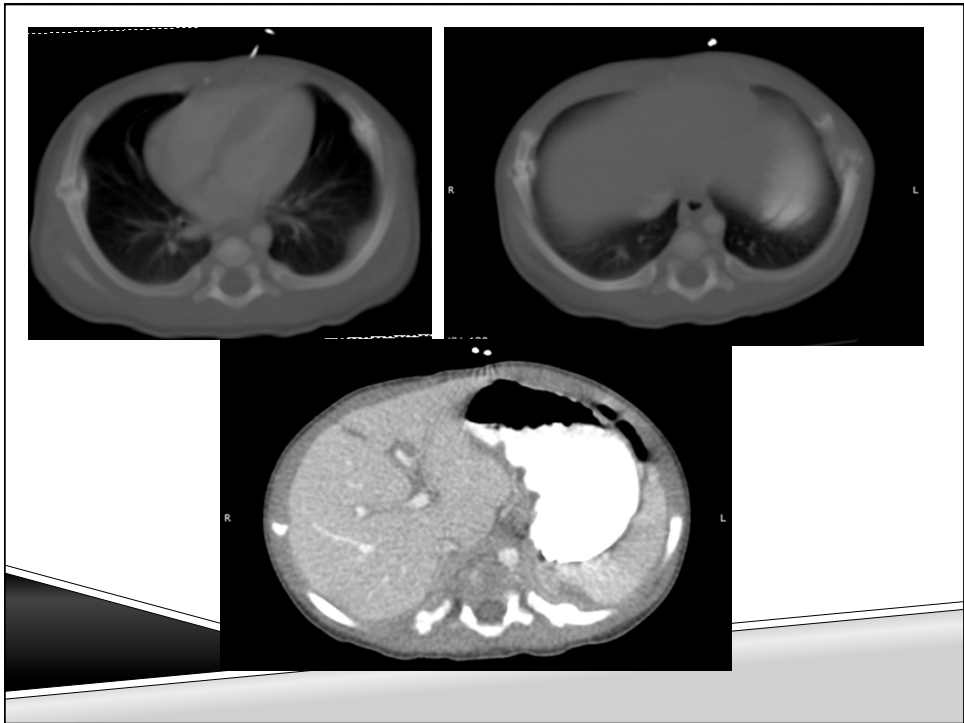
<http://champprogram.com/resources.shtml>

DATE/TIME	HEMO GLOBIN (10-18) g/dl	MEAN CELL VOLUME (85-123) fl	PLATELET COUNT (150-400) K/uI	PTT Patient (24.4-34.8) sec	PT PATIENT (12.5-14.9) sec
30 Sep 2009 03:50	7.9 L	97.6	693 H		
28 Sep 2009 22:35	7.5 L	96.9	603 H	39.7 H	14.2
27 Sep 2009 04:30	8.1 L	95.5	295		
25 Sep 2009 18:30	7.0 L	94.2	Confir med H	34.5	13.9

6/7/09/11

	ALK PHOS (<449) U/L	TOTAL PROTEI N (4.4-7.6) g/dL	AST/ SGO (<38) U/L	ALT/ SGP (<41) U/L
29 Sep 2009 05:50	426		24	36
26 Sep 2009 00:10	475 H	5.5	45 H	77 H

Lindberg D, Makoroff K, Harper N, Laskey A, Bechtel K, Deye K, Shapiro R; ULTRA Investigators. **Utility of hepatic transaminases to recognize abuse in children.** Pediatrics. 2009; 124(2): 509-16



## FOLLOW-UP HISTORY

- ▶ Mother had suffered a broken nose due to DV.
- ▶ Baby's father told the grandparents that the baby fell off the couch on the day seen in the ED and the grandparents note that the discharge papers were wrong about the chief complaint.
- ▶ Father incarcerated (felony, reckless assault of a child) after confession to the police.

## SUMMARY

- ▶ This child suffered from physical abuse.
- ▶ Facial trauma, head trauma and multiple fractures (independently) should trigger a medical and social evaluation and investigation for child abuse.
- ▶ Vitamin D deficiency without clinical rickets has not been shown to be a cause of multiple fractures and is unlikely to be related to findings that are more characteristic of child abuse injuries.