

Non-Accidental Trauma (NAT) in Pediatric Patients

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2nd Revision: Joshua Klatt, MD; Revised September 2009

Overview

- Definitions
- History
- Epidemiology
- Evaluation
- Imaging
- Differential Diagnosis
- Clinical Features
 - Nonorthopaedic Features
 - Orthopaedic Features
- Management
- Summary

Definitions

- Federal law identifies minimum set of acts that characterize maltreatment
- Defines child abuse and neglect as:
 - ‘at a minimum, any act or failure to act resulting in imminent risk of serious harm, death, serious physical or emotional harm, sexual abuse, or exploitation of a child by a parent or caretaker who is responsible for the child’s welfare’

Definitions

- 4 Types
 - Physical abuse
 - Infliction of physical injury as a result of punching, beating, kicking, biting, burning, shaking, throwing, or otherwise harming a child with or without intention
 - Neglect
 - Sexual abuse
 - Emotional abuse

History

- Writings from 1st and 2nd century A.D. describe afflictions of children who may have been stricken intentionally
- Tardieu, 1860 (Paris)
 - Published 1st article on mal-treatment of children
 - Detailed clinical findings, including description of fractures
- Ingraham & Matson, 1944
 - Suggested traumatic origin for subdural hematomas in infants, rather than infectious etiology

History

- Caffey, 1946 (NY)
 - Radiologist who published 1st systematic review of now well-recognized syndrome (AJR)
 - 6 children with chronic subdurals and 23 long bone fractures
 - Subsequently more systematic evaluation and study
- Kempe, 1962
 - Coined term ‘Battered Child Syndrome’
 - Described constellation of physical findings of children who have been abused with discrepancy in reported history
 - Failure to thrive
 - Subdural hematomas
 - Multiple soft-tissue and bony injuries
 - Poor hygiene
 - Greatly increased public awareness, leading to improved legislation

Epidemiology

Inconsistencies in reporting and variation in definitions make it difficult to precisely determine prevalence and track trends

Epidemiology:

How widespread a problem?

- 1 - 1.5% of children are abused per year
- In 2005, 3.6 million investigations
 - 899,000 known cases
 - 1460 deaths
- Estimates suggest that only 50-60% of cases of death due to neglect or abuse are actually recorded as such

Epidemiology

National Child Abuse and Neglect Data System (NCANDS) 2007

- Neglect 59%
- Multiple types 13%
- Physical abuse 11%
- Sexual abuse 8%
- Emotional maltreatment 4%
- Medical neglect < 1%

Epidemiology

National Child Abuse and Neglect Data System (NCANDS) 2007

- Perpetrators (non-fatal cases)
 - Parents 80%
 - Mother only 39%
 - Father only 18%
 - Both 17%
 - Unknown 10%
 - Male relative 3%
 - Female relative 2%
 - Partner of parent 3%

Epidemiology

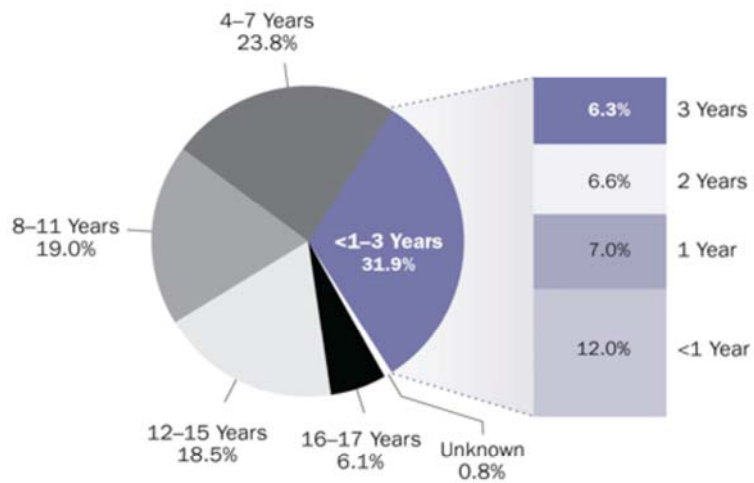
National Child Abuse and Neglect Data System (NCANDS) 2007

- Perpetrators (fatalities)
 - Parents 69%
 - Mother only 27%
 - Father only 16%
 - Both 18%
 - Unknown 16%
 - Male relative 2%
 - Female relative 2%
 - Partner of parent 3% (male 2.7%, female 0.3%)
 - Daycare staff 2%

Epidemiology

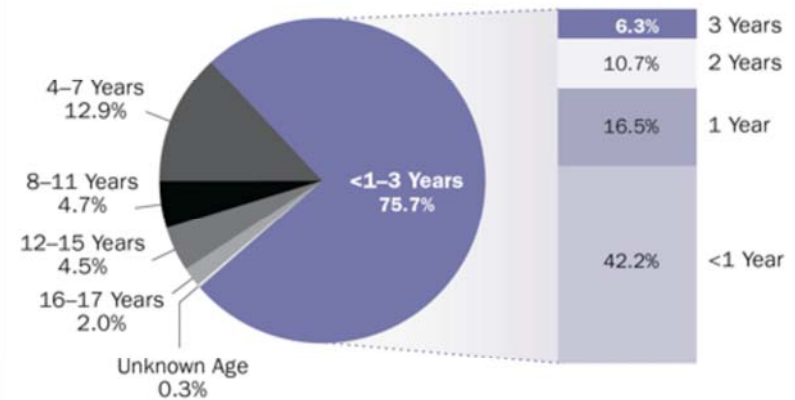
National Child Abuse and Neglect Data System (NCANDS) 2007

Figure 3-2 Age by Percentage of Victims, 2007



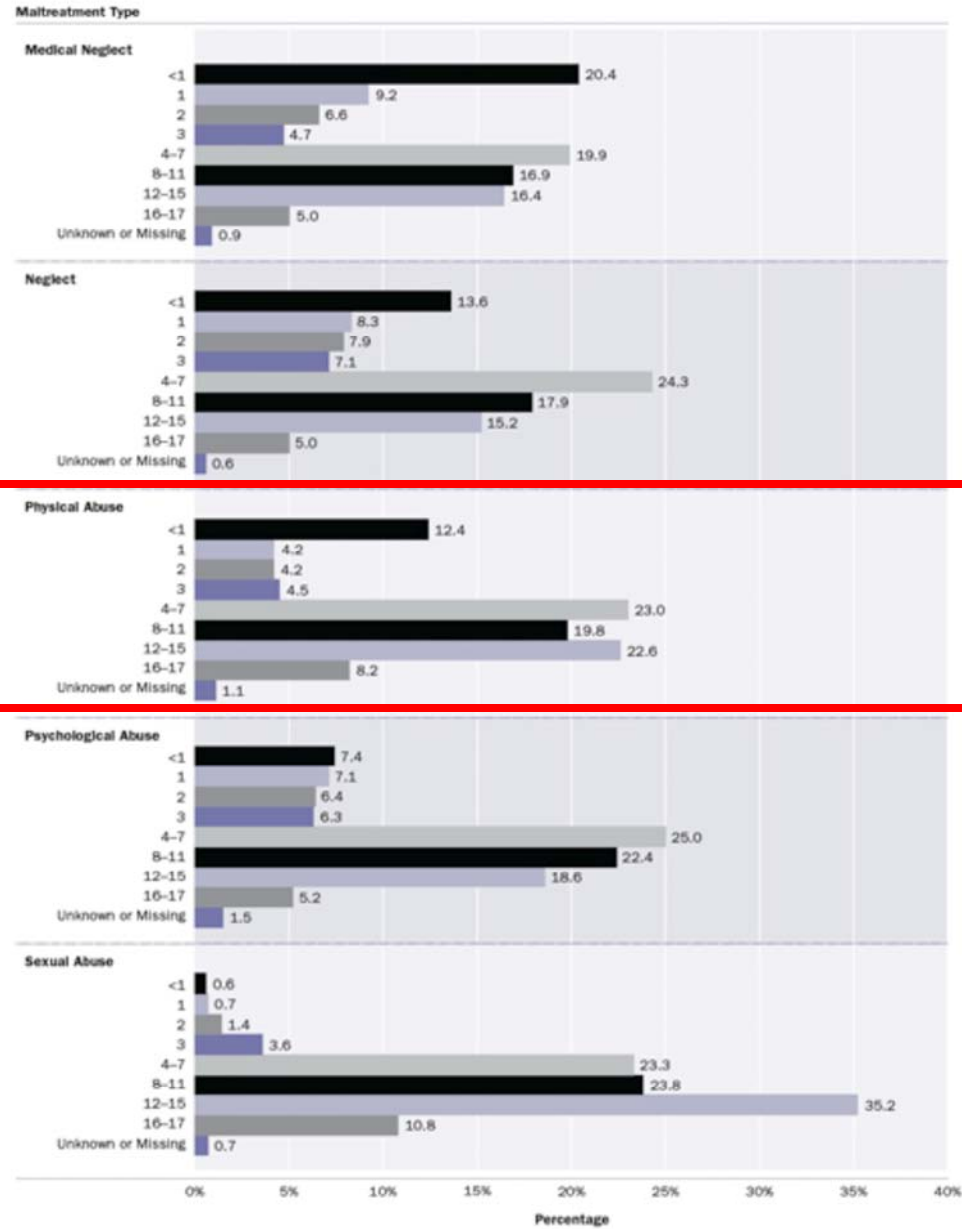
Based on data from table 3-6.

Figure 4-1 Age of Fatalities by Age Group Percentage, 2007



Based on data from table 4-3.

Figure 3-5 Victims by Maltreatment Type and Age, 2007



Based on data from table 3-11.

Epidemiology

- Unrecognized and returned to home
 - 25% risk of serious injury, 5% risk of death
- Abuse is second leading cause of mortality in infants and children
- Recognize and get child into safe environment!

Recognition of NAT is important!!

Epidemiology

Physical

- 80% of deaths from head trauma in children < 2 yr are NAT
- Fractures are 2nd most common presentation of physical abuse (25-50%)
- Estimated 10% of trauma cases seen in ED in children under 3 yr are nonaccidental
- 20% involve burns
- One third will be seen by an orthopaedist!

Risk Factors for NAT

Children of all ages, socioeconomic backgrounds & family types are victims

Risk Factors for NAT

- Young (age < 3 yr)
- First born children
- Unplanned children
- Premature infants
- Disabled children
- Stepchildren
- Single-parent homes
- Unemployed parents
- Substance abuse
 - 50-80% involve some degree of substance abuse
- Families with low income
 - < \$15k were 25x more likely than > \$30k
- Children of parents who were abused

High Stress Environments!

Evaluation

- A thorough history and complete general and orthopaedic exam are essential
- Diagnosis of abuse is frequently difficult and must include sociobehavioral factors and clinical findings

Evaluation

- Team approach helpful - pediatrician, medical social worker, subspecialties, law enforcement, government child protection agencies
- But...orthopaedic surgeon may be alone in recognition and documentation!

Myth

- Easy to recognize child with NAT



Evaluation

- Age of Patient
- History
- Social Situation
- Other injuries (current and past)
- Specific injuries/ fractures

History

- Has there been a delay in seeking medical treatment?
- Is the parent reluctant to give an explanation?
- Is the injury consistent with the explanation given?
- Does the story change between caregivers?
- Between child and caregiver?

History

- The abused child may be overly compliant and passive or extremely aggressive
- Is the affect inappropriate between the child and the parents? (lack of concern, overly concerned)

Social Situation

- Families under stress (loss of job, etc..)
- Drug or alcohol abuse?
- Parents in abusive relationships?

Social Situation

- Poor compliance with past medical treatment
- Children born to adolescent parents
- Children who suffer from colic
- Other risk factors...?

Other Injuries

- Soft tissue injuries - bruising, burns
- Intraabdominal injuries
- Intracranial injuries
- Multiple fractures in different stages of healing

Specific Patterns

- Most are similar to accidental trauma fracture patterns
- Must rely on other factors, history, physical examination, etc. to corroborate
- *Age of child with specific fx's*

Physical Examination

Undress the child!

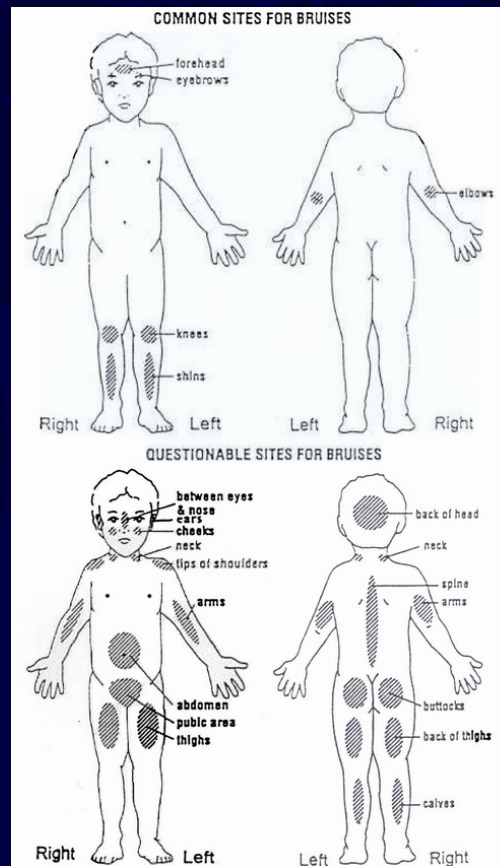


www.dcmsonline.org

Physical Examination

- Careful search for signs of acute or chronic trauma
- Skin - bruises, abrasions, burns
- Head - examine for skull trauma, palpate fontanelles if open, consider funduscopic exam for retinal hemorrhage
- Trunk - palpate rib cage, abdomen
- Extremities - careful palpation
- Genitalia – consider exam for sexual abuse

Physical Examination



www.boostforkids.org/images/bodyDiagram500.jpg

Radiographic Work-Up

- Skeletal survey for children with suspicion of NAT
- “Babygram” not sufficient as does not provide necessary detail to identify fractures
- AAP Section on Radiology recommends mandatory survey in all cases of suspected abuse in children less than 2
 - Individualized use of survey in children 2-5 yr
 - Not useful in children over 5 yr (exam more specific)
- Yield of surveys in neglect & sexual abuse is low

Radiographic Work-Up

Skeletal Survey

- AP/LAT skull
- AP/LAT axial skeleton and trunk
- AP bilateral arms, forearms, hands, thighs, legs, feet
- Repeat skeletal survey at 1-2 weeks can be helpful

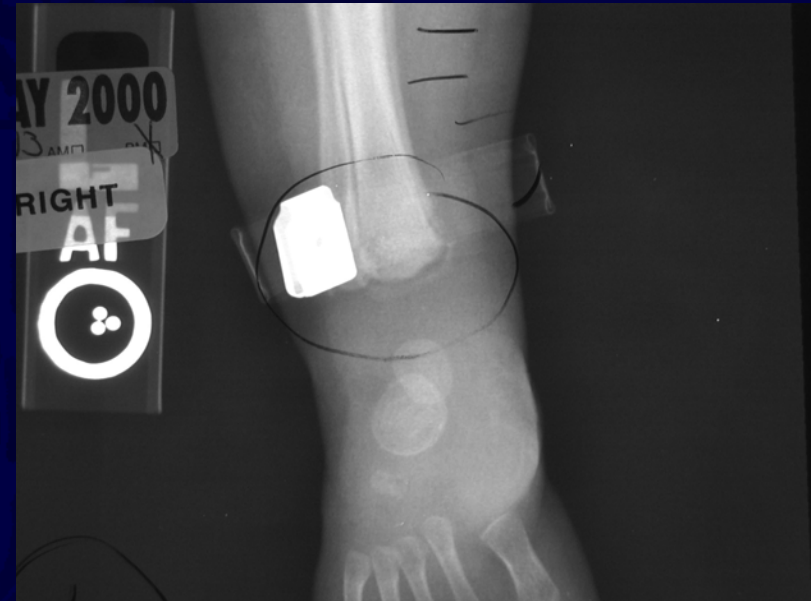


Bone Scan

- Usually reserved for highly suspicious cases with negative skeletal survey
- Good at picking up rib and vertebral fx's
- Repeat bone scan at 2 weeks can identify occult injuries

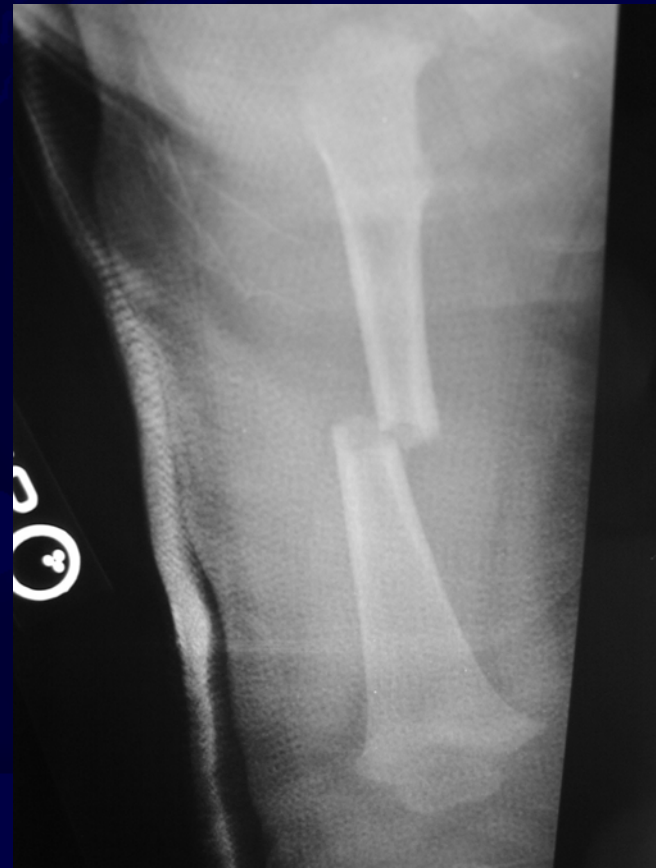
Orthopaedic Features

- 2nd most common presentation (9-55%) after bruising
- More common in younger children (demanding, nonverbal, defenseless)
 - Children < 1 yr, 45-55% of fx's associated with NAT
 - Children < 3 yr, 40% associated with NAT



Orthopaedic Features

- Long bone fractures in pre-ambulatory infants in absence of metabolic bone disease are more often NAT than accidental



Orthopaedic Features

- Fracture pattern not specific (spiral, transverse, etc.)
- Multiple fractures at different stages of healing highly specific

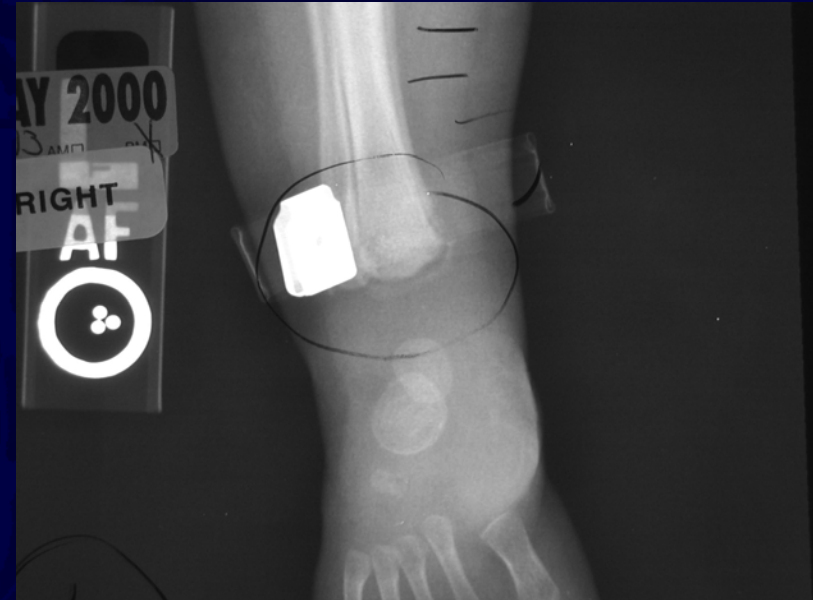


Table 3
Specificity of Musculoskeletal Radiologic Findings in Child Abuse*

High specificity

- Metaphyseal corner lesions
- Posterior rib fractures
- Scapular fractures
- Spinous process fractures
- Sternal fractures

Moderate specificity

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

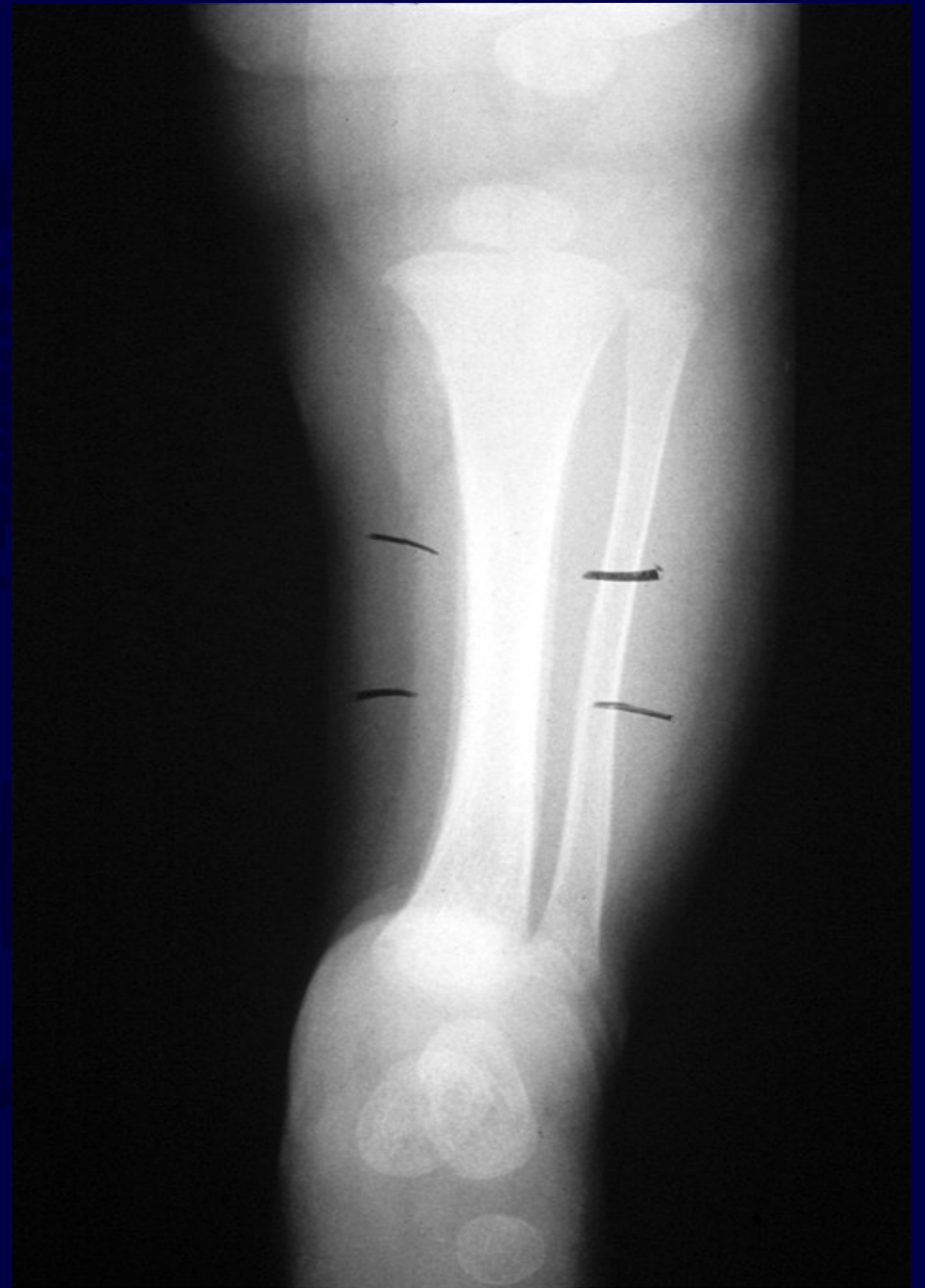
Common in child abuse, but low specificity

- Clavicular fractures
- Long-bone shaft fractures
(femur, tibia, humerus)
- Linear skull fractures

* Adapted with permission from O'Connor JF, Cohen J: Dating fractures, in Kleinman PK (ed): *Diagnostic Imaging of Child Abuse*. Baltimore: Williams & Wilkins, 1987, p 6.

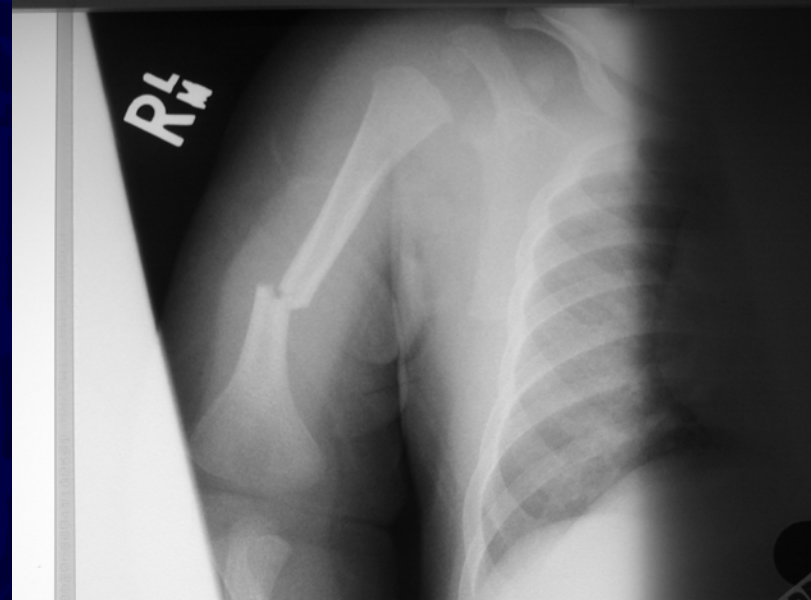
Fractures in Different Stages of Healing

- Present in 70% of physically abused children < 1 yr
- Present in 50% of all abused children



Fractures Commonly seen in NAT - High Specificity

- Femur fracture in child < 1 year old (any pattern)
- Humeral shaft fracture in < 3 year old
- Sternal fractures
- Metaphyseal corner (bucket-handle) fractures
- Posterior rib fx's
- Digit fractures in nonambulatory children



Myths

- Myth: Spiral Fractures have a high association with NAT
 - Actually commonly seen accidental fx pattern
 - Bone is weakest in tension/torsion failure mechanism



FIG. 4. Fourth most common type: femur, spiral, middle third. Considered by many authors to be the classic type.

Facts

- Spiral can occur accidentally
- Spiral only 8-36% of fx's in NAT series
- Toddlers fx of tibia common accidental injury



Femur Fractures

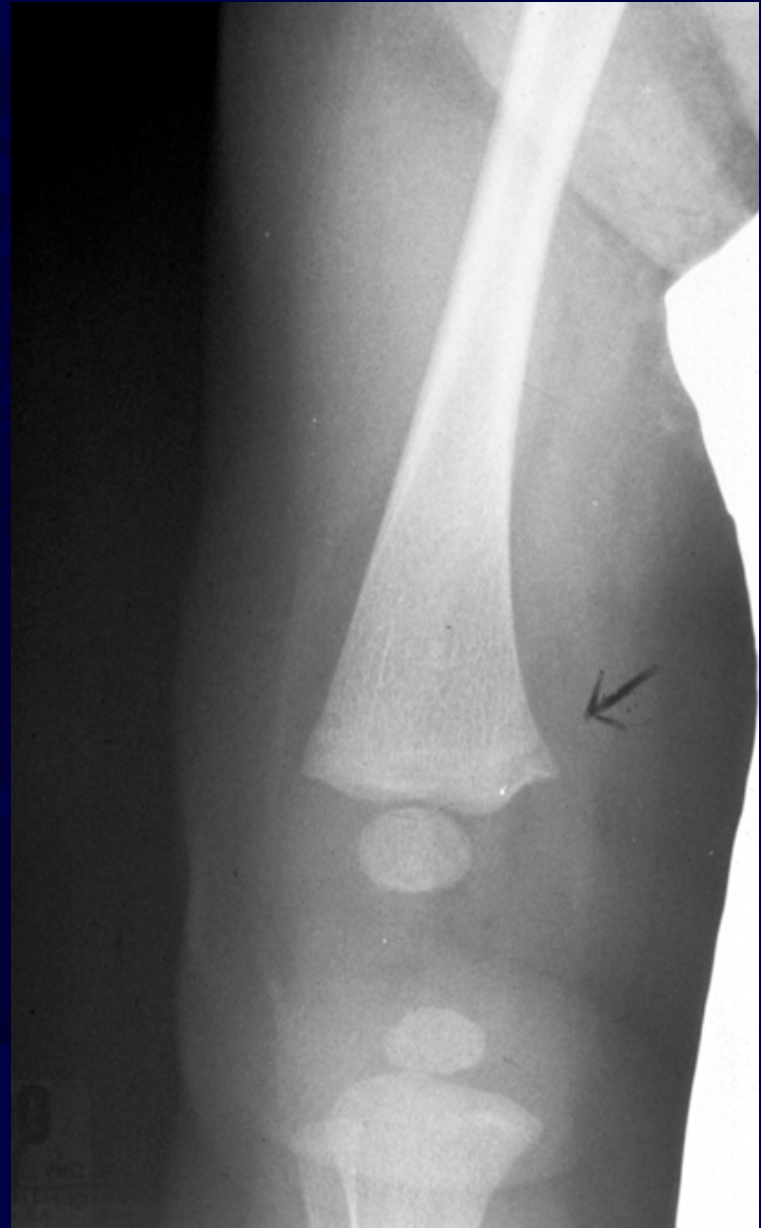
- Most femur fx's in children < 1 yr are from NAT (60-70%)
- Most femur fx's in children > 1 yr accidental (60-70%)



Femur Fractures

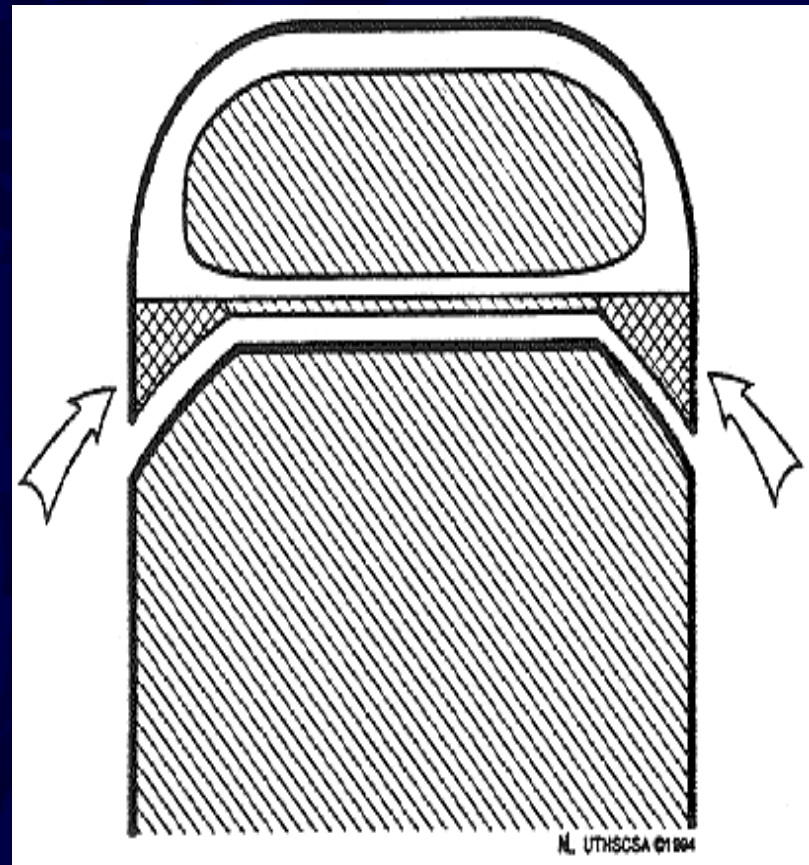
- Recommendations of 2009 AAOS Clinical Practice Guidelines for pediatric femur #s
 - Children younger than 36 months with diaphyseal femur fracture should be evaluated for NAT
 - Level of Evidence II, Grade A recommendation
 - Based on 3 population-based studies
 - 2 reported 14% & 12% of #s were result of abuse in children zero to 12 months, and zero to 3 years, respectively
 - 3rd study reported only 2% of #s result of abuse among children zero to 15 years
 - Emphasis on history and physical in evaluation
 - Selective use of a skeletal survey when considered appropriate by treating physician

**Metaphyseal
Bucket Handle
Fracture
(Corner Fracture)**



Corner Fractures

- Traction/rotation mechanism of injury
- Planar fracture through primary spongiosa, creates disk-like fragment of bone/cartilage, thicker at periphery



Bucket Handle Fractures

- Pathognomonic of NAT
- Less common than diaphyseal fractures, but more specific for NAT



FIG. 5. Characteristic corner metaphyseal fractures occurring in child abuse. Bilaterality is another clue to the battered child syndrome.

Humerus Fractures

- True purely physeal fractures uncommon except at distal humerus (traction injury)
- Transphyseal fx's - high association with NAT
- Supracondylar fx's common in accidental trauma

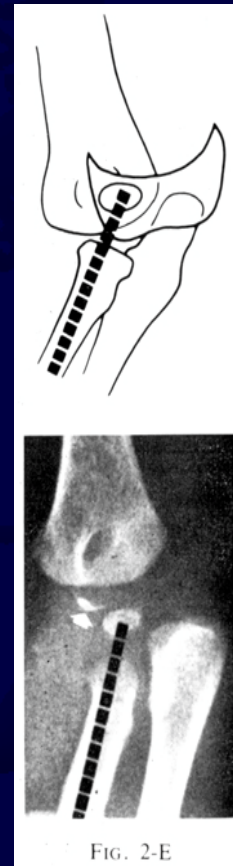
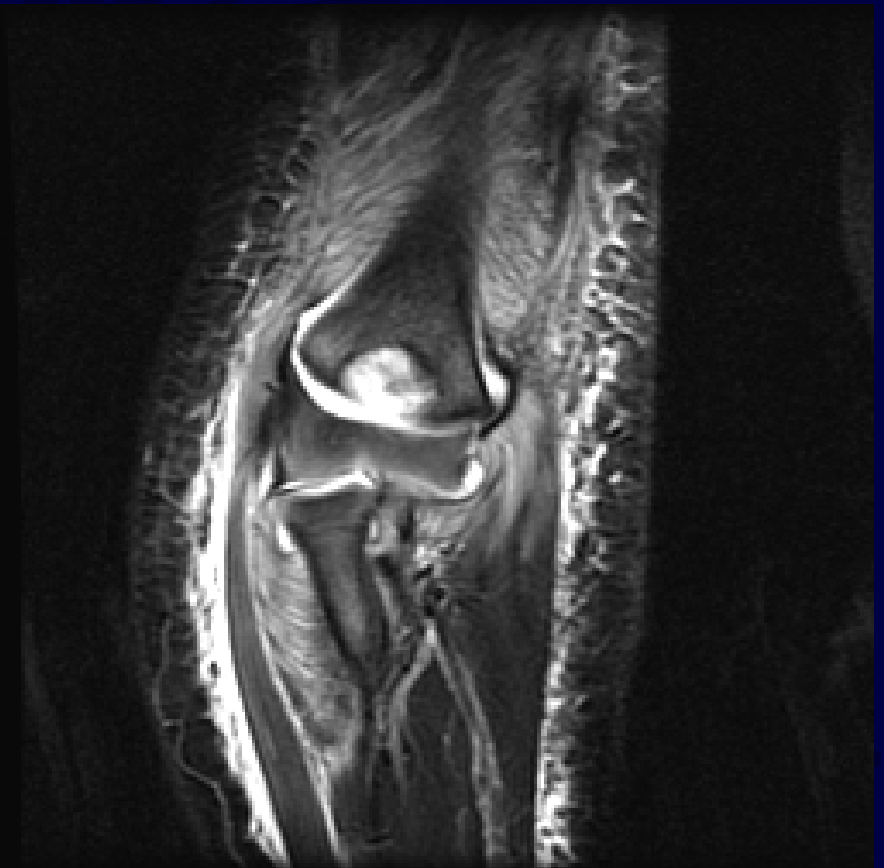


FIG. 2-E

Transphyseal Distal Humerus Fracture



Humerus Fractures

- Diaphyseal fractures in children < 3 yr are very suggestive of NAT



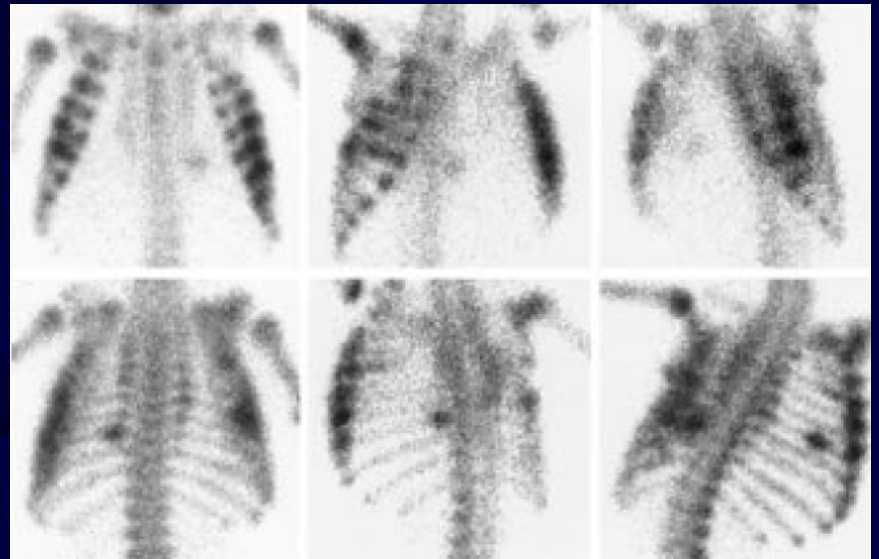
Rib Fractures

- Secondary to AP or lateral compressive forces
 - Squeezing, direct impact, shaking
- Present in 5-25% of abused children
- Posterior & posterolateral fractures most common and highly specific
 - Although may occur anywhere



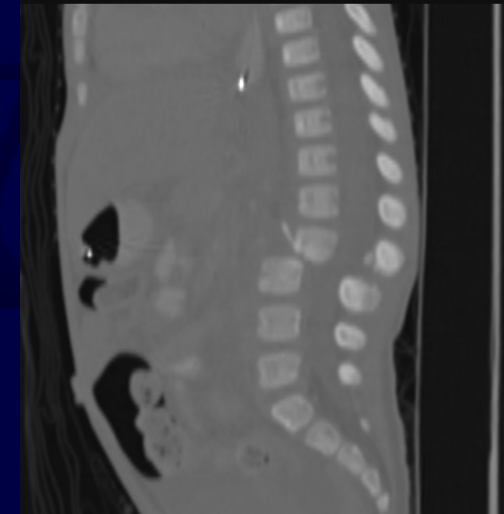
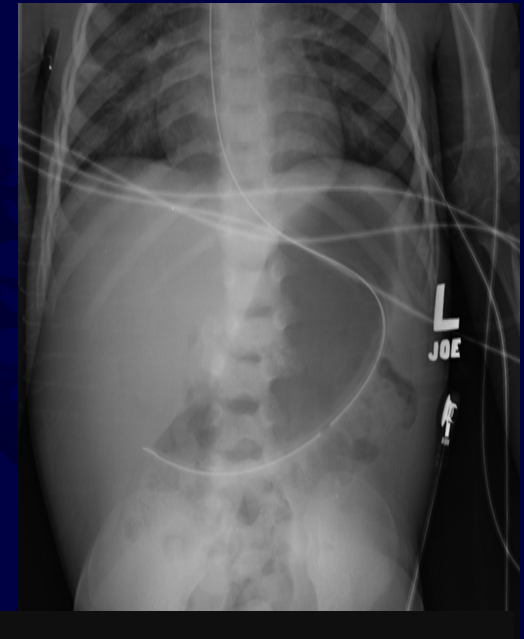
Rib Fractures

- Indicator of severe trauma due to relative compliance of rib cage
 - Associated with high risk of mortality
 - Even after vigorous CPR, rib fracture is uncommon in children
- Up to 50% of all postmortem fractures are rib fractures
- Only 35% of rib fractures are visible on skeletal survey



Spine Fractures

- Only 0-3% of fractures
- Most asymptomatic compression fractures detected on skeletal survey, not often catastrophic
- Fracture or avulsion of spinous processes if fairly specific to abuse
 - Most in lower thoracic and upper lumbar spine
 - May be many levels
 - Secondary to hyperflexion and hyperextension with shaking



Uncommon in NAT

- Mid clavicular fractures
- Simple linear skull fractures
- Single diaphyseal fractures
 - Especially in children over 18 months



Management - NAT Suspected

- Professional, tactful, nonjudgmental approach in initial encounter and workup
- Explain workup to parents as standard approach to specific ages/injury patterns
- Early involvement of child protection team if available
- Early contact/involvement of child's primary care physician

Management - Documentation

- Many cases result in medical records becoming part of legal record
- Carefully document history, physical exam and radiographic findings
- Document evidence supporting physical abuse
- Document statement regarding level of certainty of abuse

Legal Aspects of NAT

- All states require reporting of suspected cases of abuse by medical professionals
- Need only reasonable suspicion to report suspected maltreatment
- Law affords immunity from civil or criminal liability for reporting in good faith

Differential Diagnosis - NAT Fractures

- Accidental trauma
- Osteogenesis Imperfecta
- Metabolic Bone Disease (rickets, etc.)
- Birth trauma
- Physiologic periostitis



Osteogenesis Imperfecta

- Type II and III obvious bony disease
- Type I family history and blue sclera
 - Frequent dental involvement
 - Osteopenia
 - Wormian bones in skull
- Remember blue sclera may be normal until 4 yrs of age



<http://xakimich.hp.infoseek.co.jp/Image/blue-sclera-1.jpeg>

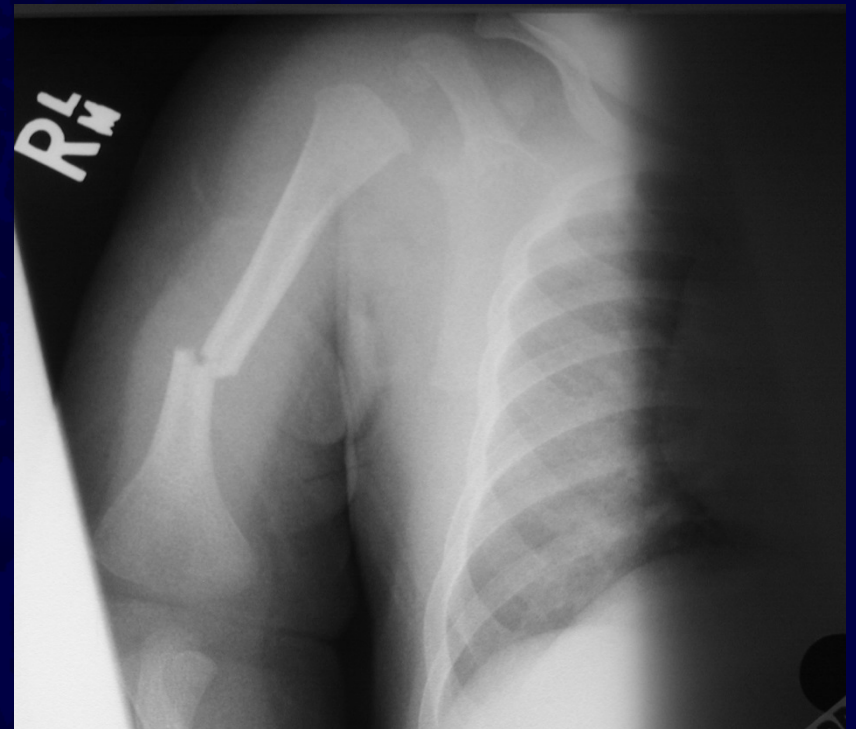
http://www.mypacs.net/repos/mpv3_repo/viz/full/17063/853184.jpg

Osteogenesis Imperfecta

- Type IV heterogeneous with mild to moderate disease, normal sclera, no dental involvement minimal osteopenia
- With no family hx, blue sclera, or wormian bones the chance of a new mutation is 1 in 3 million

Summary

- Child abuse is pervasive
- Major cause of disability and death among children
- Diagnosis involves careful consideration of
 - Sociobehavioral factors
 - Clinical findings



Summary

- Fractures are second most common presentation of physical abuse, after skin lesions
- No pathognomonic fracture pattern of abuse
- Suggestive findings include
 - Certain metaphyseal lesions
 - Multiple fractures in various stages of healing
 - Posterior rib fractures
 - Long-bone fractures in children less than 3 years old

Summary

- Management should be multidisciplinary
- Risk of repeated abuse and death are substantial

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