Non-Accidental Trauma (NAT) in Pediatric Patients

Ryan E. Fitzgerald, MD
Riley Children's Hospital
Indiana University

Disclaimer

- **All clinical and radiographic images provided are used with permission of Ryan Fitzgerald, MD and Chris Souder, MD, unless otherwise specified**

Overview

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

Definitions

- Federal law identifies a minimum set of acts that characterize maltreatment
- Defines child abuse and neglect as:
  - Imminent risk of serious harm
  - Death
  - Serious physical or emotional harm
  - Sexual abuse
  - Exploitation

Definitions

- 4 Types of abuse
  - Physical abuse
    - Harming a child with or without intention of injury
  - Neglect
    - Failing to provide a child's basic needs
      - Physical, medical, educational and emotional
  - Sexual abuse
  - Emotional abuse

History

- Writings from 1st and 2nd century A.D. describe afflictions of children who may have been stricken intentionally

- Ambrois Tardieu, 1860 (Paris) – Professor of Legal Medicine
  - Published 1st article on maltreatment of children
  - Detailed clinical findings, including description of fractures
  - Described parental collusion and response to removal of children

- Ingraham & Matson, 1944
  - Suggested traumatic origin for subdural hematomas in infants, rather than infectious etiology

History

- Caffey, 1946 (NY)
  - 6 children with chronic subdurals and 23 long bone fractures
  - Described metaphyseal fragmentation, cortical thickening, fractures in many stages of healing

- Kempe, 1962
  - Coined term ‘Battered Child Syndrome’
  - 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
  - The Child Abuse Prevention and Treatment Act - 1974

Epidemiology

- Difficult to determine prevalence and track trends
  - Inconsistencies in reporting
  - Variation in definitions

- The number of children who received child protective services (CPS) investigation increased 8.4% from 2014 to 2018.

- In 2018, 4.3 million referrals to CPS
  - 7.8 million children
  - 678,000 known cases
  - 1,770 deaths

Epidemiology

- In 2018:
  - 84.5% of abused children suffered a single type of abuse
    - 15.5% suffered from 2 or my types
  - Neglect is most common
    - 10.3% physically abused

- Rate of death from abuse is 2.39 per 100,000 children in the US

- *Estimated only 50-60% of cases of death due to neglect or abuse are recorded*

Epidemiology

National Child Abuse and Neglect Data System (NCANDS) 2018

Exhibit 4–E Maltreatment Types of Child Fatalities, 2018

Maltreatment Type	Child Fatalities	Maltreatment Types	Maltreatment Types Percent
Medical Neglect	-	120	8.1
Neglect	-	1,081	72.8
Other	-	116	7.8
Physical Abuse	-	684	46.1
Psychological Abuse	-	17	1.1
Sexual Abuse	-	9	0.6
Sex Trafficking	-	-	-
Unknown	-	-	-
National	**1,485**	**2,027**	**-**

Based on data from 44 states. Data are from the Child File. A child may have suffered from more than one type of maltreatment and therefore, the total number of reported maltreatments exceeds the number of fatalities, and the total percentage of reported maltreatments exceeds 100.0 percent. The percentages are calculated against the number of child fatalities in the reporting states. Dashes are inserted into cells without any data.

Epidemiology

National Child Abuse and Neglect Data System (NCANDS) 2018

- 546,365 perpetrators in 2018

- Demographics
  - Age: 83.3% of perpetrators – 18-44 y/o
  - Sex: 53.8% - Female
  - Relationship: 77.5% were parents of the victim

NAT in a Pandemic

- During a pandemic mass closures are necessary to mitigate transmission of disease
- Secondary effects of social distancing are present
- In a level 1 pediatric trauma center the total number of trauma patients due to physical child abuse (PCA) were analyzed
  - 13% during the pandemic
  - 4% the year prior to the pandemic ($P<0.05$)
- Most patients had public health insurance (75%)
- Awareness of this and strategies to mitigate this secondary effect should be implemented

Kovler ML, et al. Child Abuse & Neglect, 2020.

Physical Abuse

- Among infants and young children represent 12-20% of fractures

- **Fractures** are **2nd most common** presentation of physical abuse
  - Found in 25-50% of cases
  - ~20% involve burns

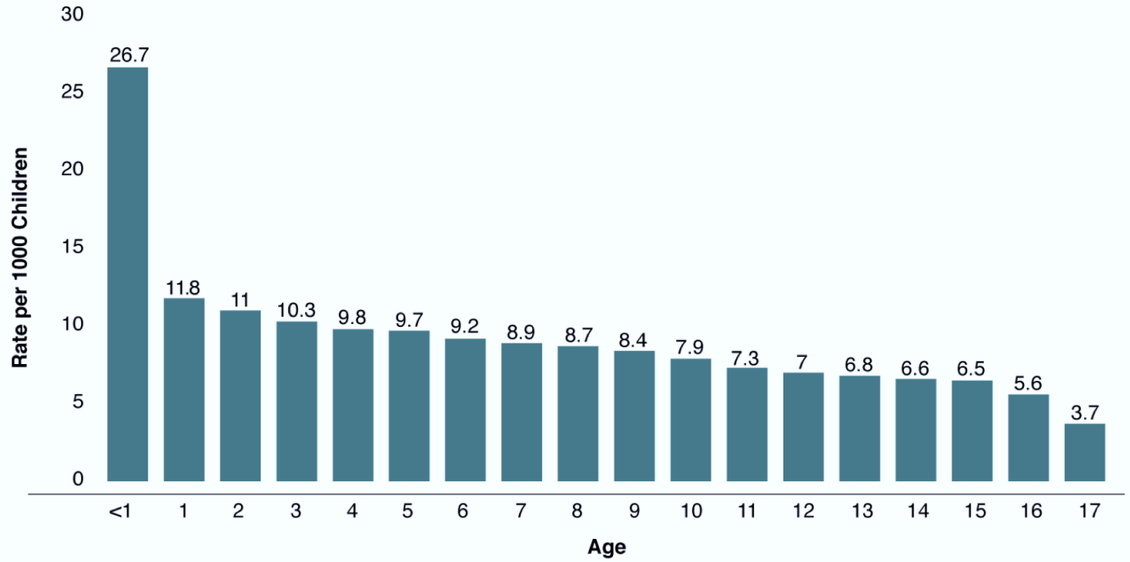
- The youngest patients are most affected and vulnerable
  - Unable to report
  - <1 year → MUCH higher rate of abuse

Epidemiology

National Child Abuse and Neglect Data System (NCANDS) 2018

Exhibit 3–D Victims by Age, 2018

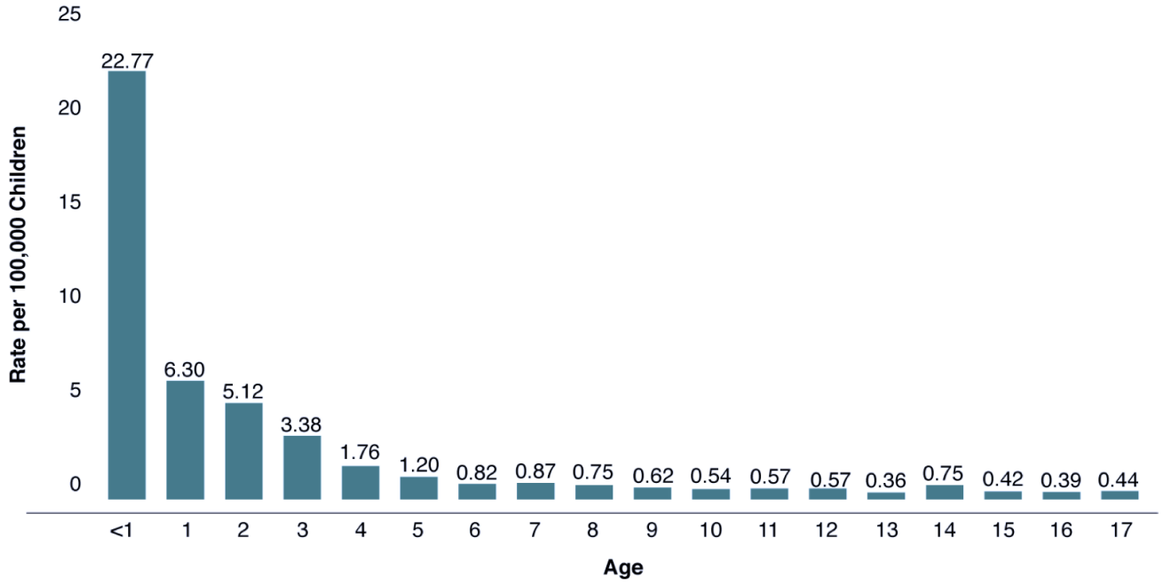
The youngest children were the most vulnerable to maltreatment



Based on data from 52 states. See table 3–5. Percentages do not sum to 100.0 due to rounding.

Exhibit 4–B Child Fatality by Age, 2018

Children <1 year old died from abuse and neglect at 3.6 times the rate of children who were 1 year old.



Based on data from 44 states. See table 4–3

Physical Abuse
IMPORTANT

- Second leading cause of mortality in infants and children
- Orthopedic surgeons often first to diagnose NAT victims
- *Unrecognized NAT returned to home:*
  - 30-50% repeat trauma
  - 5-10% risk of death

Risk Factors for NAT

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

Risk Factors for NAT

Child factors

- Young (age < 3 yr)
- First born children
- Unplanned children
- Premature infants
- Disabled children
- Psychosocial comorbidities
- Stepchildren
- Single-parent homes

Parental Factors

- Substance abuse
  - 50-80% involve some degree of substance abuse
- Families with low income
  - < $15k were 25x more likely than > $30k
- Unemployed parents
- Children of parents with psychosocial comorbidities
- Children of parents who were abused

Evaluation

- A thorough history and physical exam are essential

- Diagnosis is difficult
  - Must include sociobehavioral factors
  - Clinical findings

Evaluation

- Team approach
  - Pediatrician
  - ER physician
  - Medical social worker
  - Government child protection agencies
  - Law enforcement

- BUT the orthopedic surgeon **may be alone** in recognition

Myth

It is easy to recognize child with NAT

Evaluation

- Age of Patient
- History
- Social situation
- Other 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**?

History

- The abused child may be overly compliant and passive or extremely aggressive

- Is the affect appropriate between the child and the parents?

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 Injuries

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

Ranade et al. JAAOS 2020

Physical Examination

Undress the child!

Harris. JPEDHC 2020

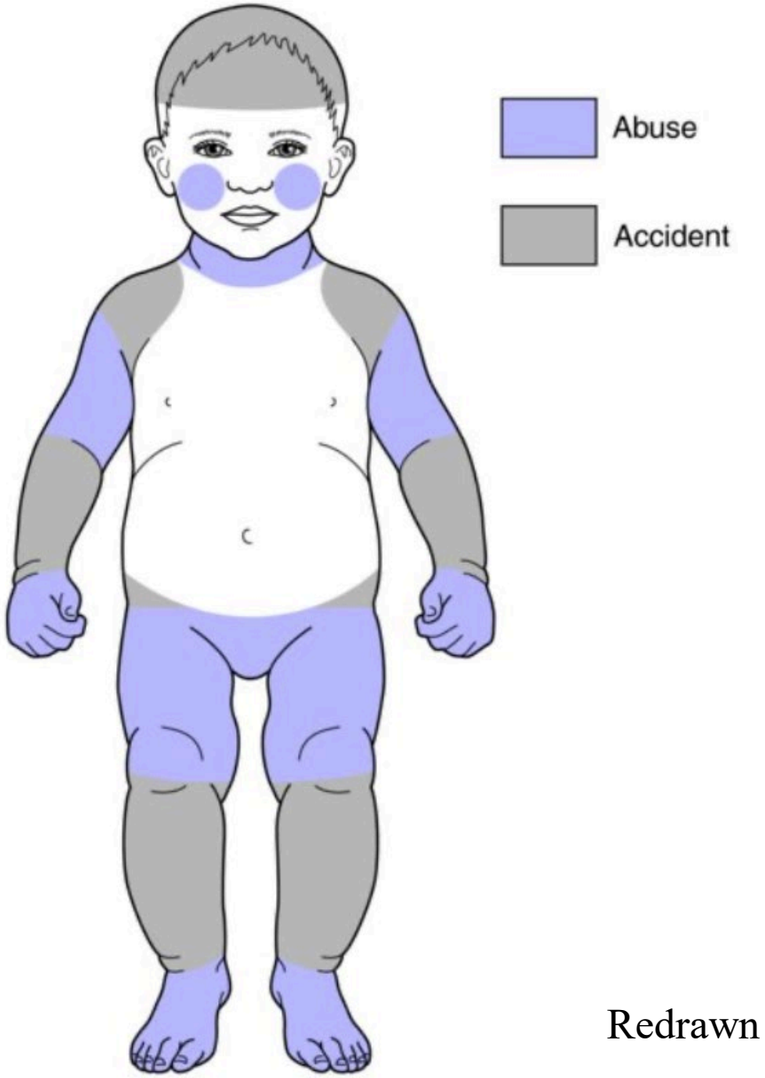
Physical Examination

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

Physical Examination

Abusive vs Accidental BRUISING



Redrawn from original courtesy of Samir Abedin, MD.

Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Radiographic Evaluation

- Skeletal survey for children with suspicion of NAT
  - Highly detailed radiographs that follow guidelines set for by the American College of Radiology are necessary

- “Babygram” is unacceptable - does not provide necessary detail to identify fractures

Radiographic Evaluation

- AAP Section on Radiology:
  - *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)

Utilization of Imaging Modalities in Suspected NAT

Advanced Imaging Modality	American College of Radiology Recommendations	American Academy of Pediatrics Recommendations
Tc-99m whole-body bone scan	Use when skeletal survey is negative with a high clinical concern as an adjunctive exam. **Not** a alternative skeletal survey. Used as a problem solving study not first line.	In setting of a fracture can be used to complement a skeletal survey, **not** substitute for one. Less sensitive than skeletal survey for classic metaphyseal lesions.
CT head without contrast	Exam of choice in suspected abusive head trauma (AHT). Emergent in setting of head trauma, neurologic changes <24 months. 3-D volume rendering increases sensitivity.	Emergent in setting of head trauma. Study of choice
MRI Head without contrast	Non-emergent cases.	Non-emergent cases

Utilization of Imaging Modalities in Suspected NAT		
Advanced Imaging Modality	**American College of Radiology Recommendations**	**American Academy of Pediatrics Recommendations**
MRI Spine	Non-emergent cases when imaging head may be considered – presence of spine fracture is almost 10% when positive skeletal survey.	Non-emergent cases when imaging the head to diagnose occult injury
CT Abd/Pelvis with contrast	Emergent in setting of abdominal trauma. CT Abd/Pelvis without contrast not recommended.	Emergent in setting of abdominal trauma.
Ultrasonography		Head: Via the anterior fontanelle helps to clarify the nature of extra-axial fluid collections. In conjunction with CT or MRI. Appendicular Skeleton: US may be indicated in epiphyseal separations.

Utilization of Imaging Modalities in Suspected NAT		
Advanced Imaging Modality	**American College of Radiology Recommendations**	**American Academy of Pediatrics Recommendations**
Skeletal Survey	• Primary imaging for detecting fractures. Initial imaging for pts <24 months old • Signs of intrathoracic or intra-abdominal visceral injury • Child with neurologic signs/symptoms, complex skull fracture, apnea, multiple fractures, spine trauma, and facial injury • Older children >2: skeletal survey is low yield, targeted imaging in suspected injury based off patient report of pain • *Not part of guidelines:* • Lateral radiographs of long bones increases detection of metaphyseal lesions by 50%. • A repeat performed 2 weeks after initial exam can provide additional information about presence and age of NAT – many perform	• Non-ambulatory infants with bruising • Ambulatory infants and toddlers with suspicious bruising • Children <2 years old with abdominal trauma • Children <3 with fracture concerning for NAT due to pattern, historical inconsistency or other red flag history • Little value in children older than 5. • Children with head trauma

Radiographic Work-Up

Skeletal Survey

- AP/LAT skull
- AP/LAT axial skeleton and trunk
- AP bilateral arms, forearms, hands, thighs, legs, feet

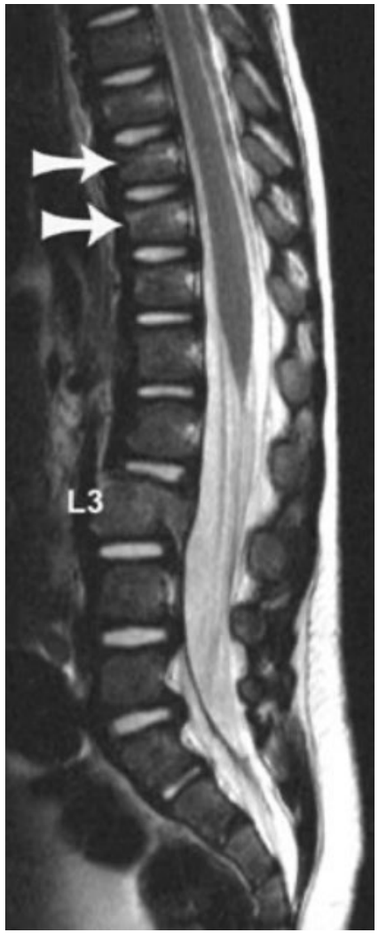
Bone Scan

- Usually reserved for highly suspicious cases with negative skeletal survey
- Good at picking up rib and vertebral fractures

Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Imaging

- Skeletal Survey includes AP/LAT of skull & spine
- MRI of the spine is obtained on a case-by-case basis
- Consider if already obtaining an MRI to evaluate for traumatic brain injury from suspected NAT
- This may help evaluate for ligamentous injury



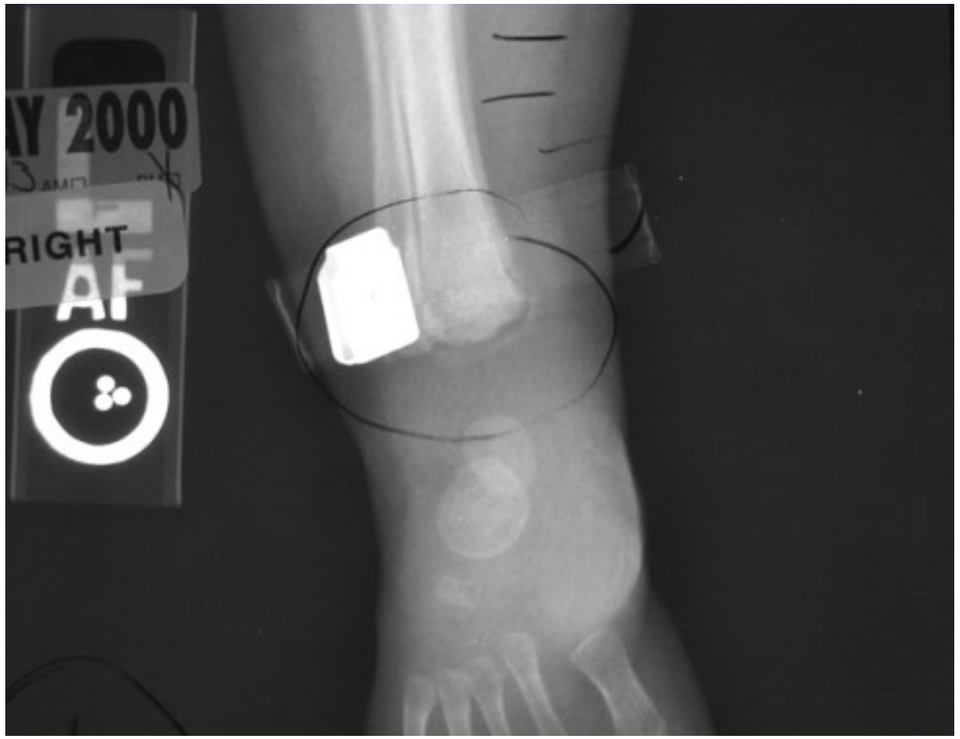
Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Fractures

- 2nd most common presentation of NAT
  - **Bruising is most common injury**

- Fracture pattern is typically similar to accidental trauma

- More common in younger children (demanding, nonverbal, defenseless)
  - Children < 1 yr, up to 70% associated NAT
  - Children < 3 yr, 40% w/ NAT



Fractures

- 65% of abused children present with a single long bone fracture

- Long bone fractures in pre-ambulatory infants in absence of bone disease
  = NAT(until proven otherwise)

Fractures

- Fracture pattern is not specific (spiral, transverse, etc.)
  - Transverse fractures are more common than spiral fractures in NAT
- Multiple fractures at **different stages** of healing is **highly specific**

Specificity of Radiologic Findings in NAT

- **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 NAT but Low Specificity:**
  - Clavicular fractures, long bone shaft fractures, linear skull fractures

Kocher & Kasser. JAAOS 2000

Fractures in Different Stages of Healing

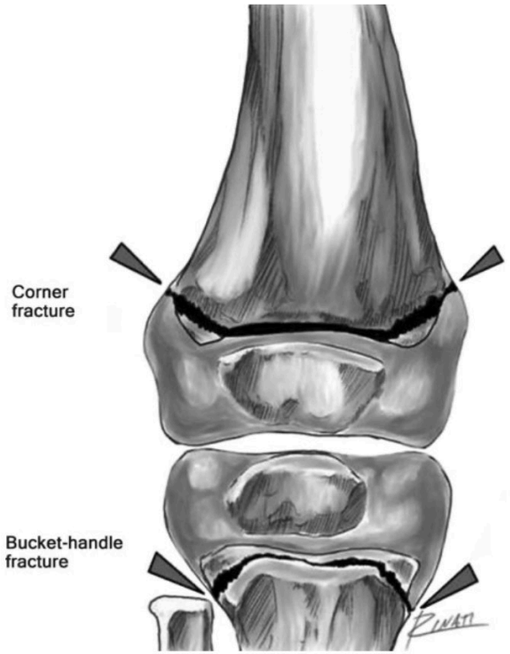
- Present in 70% of physically abused children < 1 yr

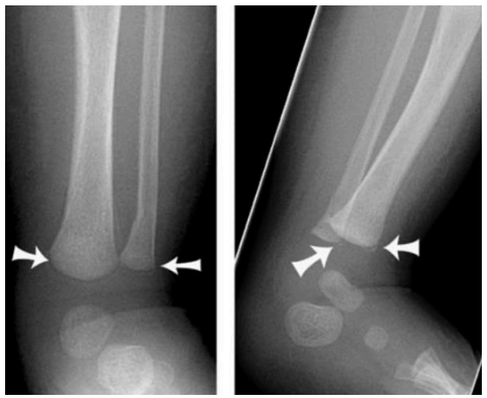
- Present in 50% of all abused children

Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Fractures of NAT - High Specificity

- Classic metaphyseal lesions (CML)
  - Formerly known as a metaphyseal corner fracture or bucket-handle fracture
- Femur: < 1-year-old (any pattern)
- Humeral shaft: < 3-year-old
- Sternal fractures
- Posterior rib
- Digit fractures in non-ambulatory

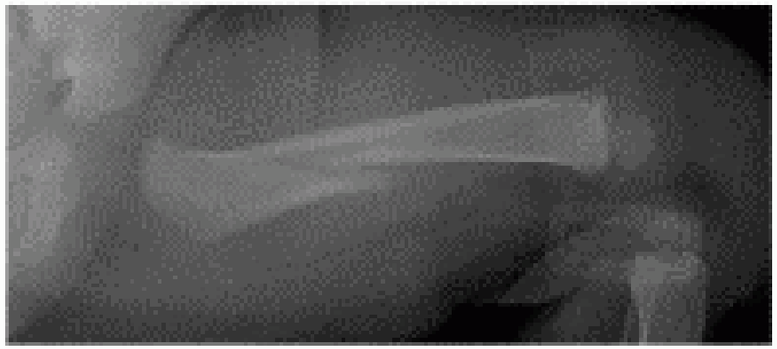




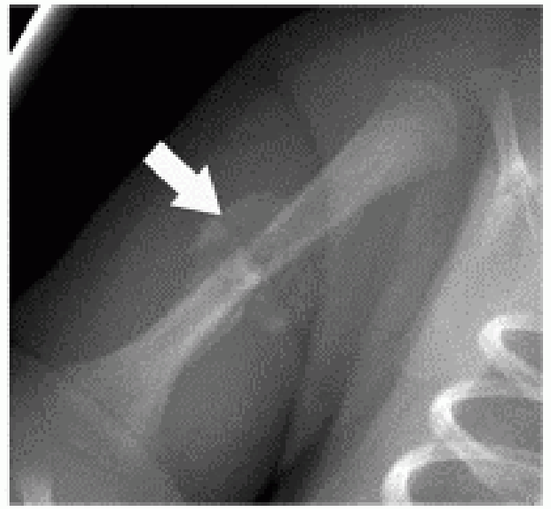
Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Myths

- **Myth:** Spiral fractures have a high association with NAT



- **TRUTH:** Both transverse and spiral fractures are seen in NAT
  - Transverse is more common in NAT cases
  - Spiral fractures are common in accidental trauma
    - Bone is weakest in tension/torsionfailure mechanism
    - ***Fracture configuration is <u>NOT</u> specific for NAT***



Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Facts

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

Femur Fractures

- Femur fractures in children < 1 year
  - NAT (60-70%)

- Femur fractures in children > 1 year
  - Accidental (60-70%)

2009 AAOS Clinical Practice Guidelines
Treatment of Pediatric Diaphyseal Femur Fractures
(updated 2015)

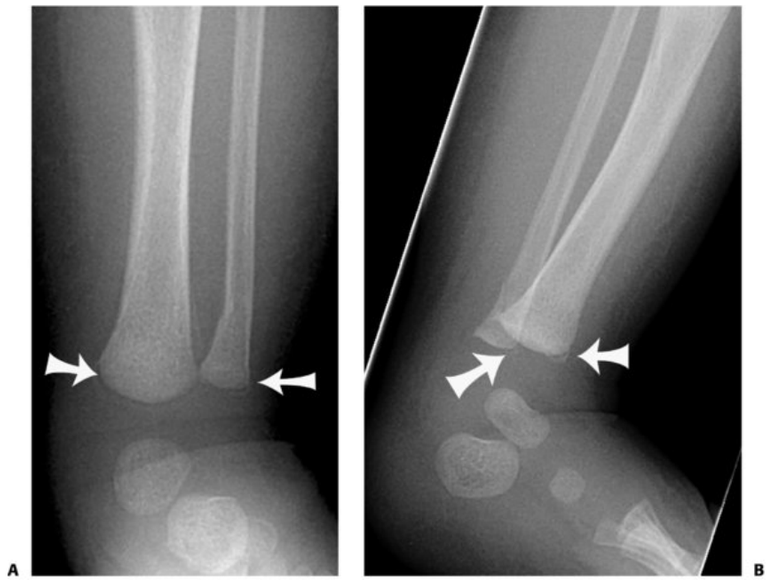
- Strong evidence supports that children younger than 36 months with a **diaphyseal femur** fracture be evaluated for child abuse.
  - Level 2 evidence – Strong recommendation
  - Based on 3 large population-based studies
    - 2 reported: 14% and 12% of fractures were result of abuse in children zero to 12 months, and zero to 3 years, respectively

2009 AAOS Clinical Practice Guidelines
Treatment of Pediatric Diaphyseal Femur Fractures
(updated 2015)

- Emphasis on history and physical in evaluation
- Selective use of a skeletal survey
- Despite this, Oetgen et al. showed poor utilization of this guideline with only 48% of this population being evaluated for NAT

Classic Metaphyseal Lesion (CML)

- Pathognomonic of NAT
- Less common than diaphyseal fractures
- More specific for NAT



Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

CML

- Traction/rotation mechanism of injury
- Planar fracture through **primary spongiosa**

Marine MB et al. Pediatr Radiol 2019

https://obgynkey.com/growth-plate-anatomy/

Fractures in Unusual Locations

- Requires a violent blow or traction injury
  - Distal clavicle
  - Transphyseal Distal humerus
  - Scapula
  - Acromial tip
  - Proximal humeral metaphysis

Abzug JM et al. JAAOS 2016

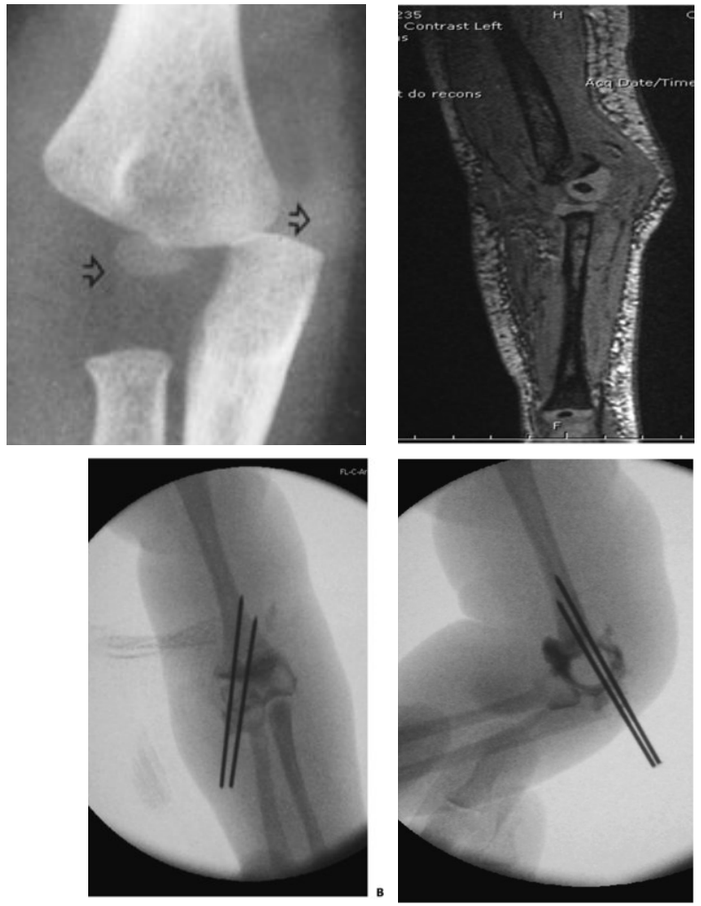
Distal Humeral Transphyseal Fractures

- Typically seen in children <3
- A result of birth trauma, accidental trauma or NAT
  - A detailed history - high index of suspicion for NAT
- Often will be reported as an elbow dislocation
- Supakul et al reported >50% were missed by initial radiology

Note medial translation of the forearm

Distal Humeral Transphyseal Fractures

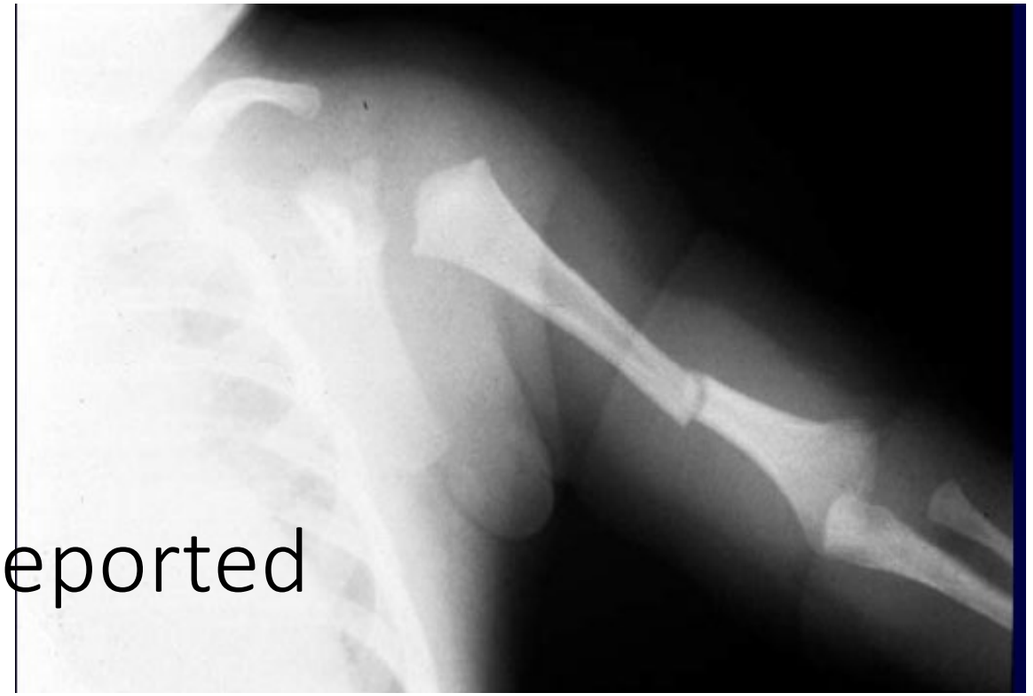
- Usually unstable fractures that require operative care
- Arthrogram with percutaneous vs. open pinning may be required
- With prompt recognition and management, outcomes are generally excellent



Abzug JM et al. JAAOS 2016

Humerus Fractures

- Diaphyseal fractures in children < 3 yr
- Highly suggestive of NAT
  - As high as 18% has been reported

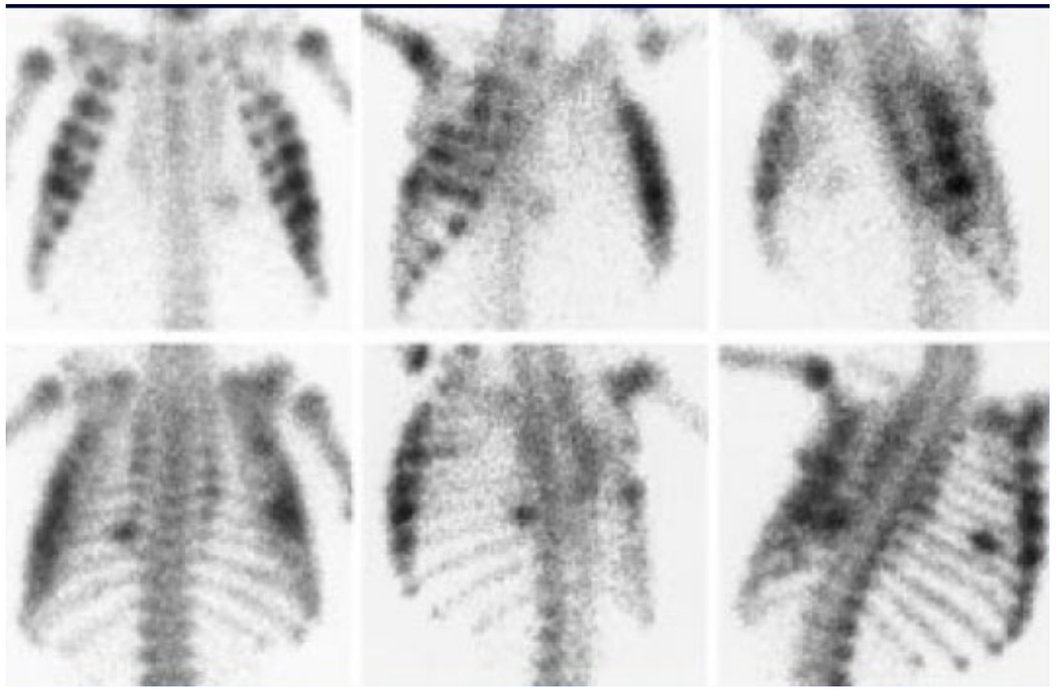


Rib Fractures

- 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

Rib Fractures

- Indicator of severe trauma due to relative compliance of rib cage
  - Associated with high risk of mortality
- 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
- Fracture or avulsion of spinous processes is fairly specific to abuse
  - Most in lower thoracic and upper lumbar spine
  - May be multiple levels
  - Secondary to hyperflexion and hyperextension with shaking

Spine Fractures

- Knox et al, 2014
  - 726 cases of NAT – Spine injury present in 1.5%
  - 11/342 spine injuries were NAT – 3.2%
    - All patients were under 2 years
    - Average age of 7 months
  - Of patient under 2 years, NAT was the most common mechanism of injury (38%)
  - 8/11 patients had injuries to the patients were cervical
    - 7 of the 8 were atlantoaxial or atlanto-occipital

Arkader A, Schwend RM, Chapter 6: Pathologic Fractures and Nonaccidental Injuries. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2020.

Management - NAT Suspected

- Professional, tactful, nonjudgmental approach
- 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

- Medical records are part of a 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 of Non-Accidental Trauma

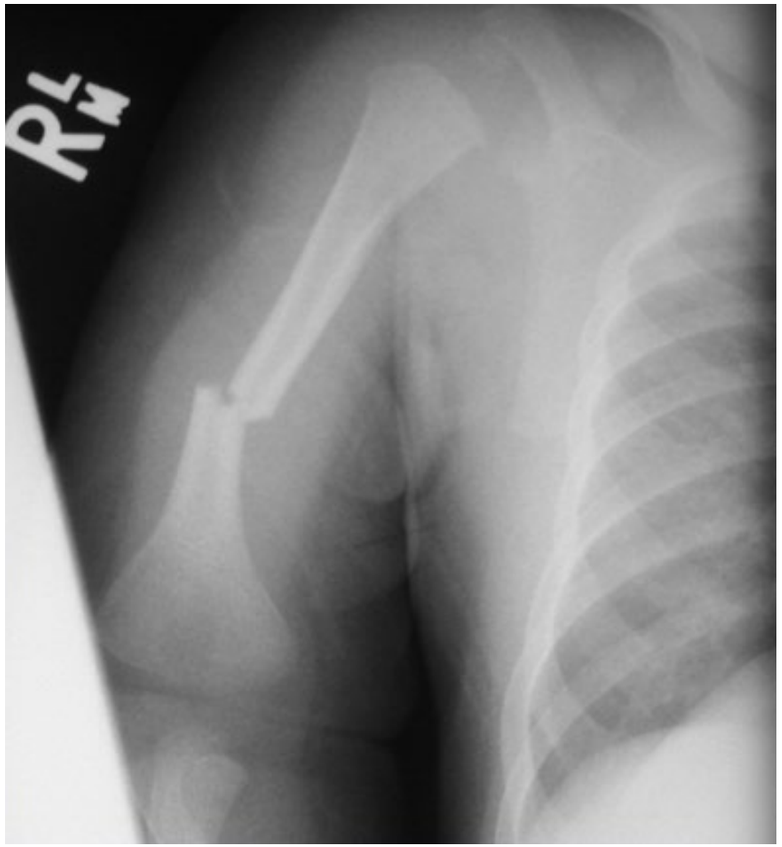
Diagnosis	Findings
Accidental Injury	Age, mechanism of injury, no bruising and associated injuries, no delay in presentation, no fractures in other stages of healing
Normal radiographic variants	Angulation of ossifying metaphysis, cortical irregularity, spurring, juxtaphyseal variants
Birth Trauma	Obstetric history, callus within 2 weeks of birth, humeral and clavicular fracture common, distal humeral physeal separation can occur
Osteogenesis Imperfecta	Family history, short trunk, marked deformities of lower extremities, triangular facies, thin skin, muscle atrophy, osteopenia, blue sclera, poor dentition (dentinogenesis imperfecta), wormian bones
Rickets	Potentially family history, potentially exclusively bottle fed, physeal widening, metabolic abnormalities, deformity or deviation from mechanical axis LE, osteopenia, Looser's lines, laboratory anomalies

Differential Diagnosis of Non-Accidental Trauma

Diagnosis	Findings
Caffey Disease	Family history, diffuse periosteal elevation, mandibular radiographic changes, irritability, inflammation and swelling, stiffness of joints
Leukemia	Metaphyseal lucencies, diffuse osteopenia most common radiographic finding, sclerotic bands in older children, systemic findings, laboratory abnormalities, bone-marrow biopsy findings
Congenital syphilis	Metaphyseal erosions, periosteal bone formation, serologic tests, pseudoparalysis
Congenital insensitivity to pain	Infection, joint destruction, neurologic abnormalities, family history
Coagulation disorders	Bruising, coagulopathy, laboratory abnormalities

Summary

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



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

Summary

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

References

- Akbarnia BA, Akbarnia NO. The role of the orthopedist in child abuse and neglect. Orthop Clin North Am 1976; 7: 733-42.
- Kocher MS, Kasser JR. Orthopaedic aspects of child abuse. Journal of the American Academy of Orthopaedic Surgeons 2000; 8 (1): 10-20.
- Kovler ML, Ziegfeld S, Ryan LM, Goldstein MA, Gardner R, Garcia AV, Nasr IW. Increased proportion of physical child abuse injuries at a level I pediatric trauma center during the Covid-19 pandemic. Child Abuse & Neglect. Online before print. 2020. 104756, ISSN 0145-2134, https://doi.org/10.1016/j.chiabu.2020.104756.
- Ranade SC, Allen AK, Deutsch SA. The Role of the Orthopaedic Surgeon in the Identification and Management of Nonaccidental Trauma. Journal of the American Academy of Orthopaedic Surgeons 2020;28(2): 52-65.
- Harris, Tomika S.. "Bruises in children: normal or child abuse?" *Journal of pediatric health care : official publication of National Association of Pediatric Nurse Associates & Practitioners* 24 4 (2010): 216-21 .
- U.S. Department of Health and Human Services AfCaF, Administration on Children, Youth and Families, Children's Bureau: *Child Maltreatment 2018.* https://www.acf.hhs.gov/sites/default/files/cb/cm2018.pdf. Accessed August 23, 2020.
- Tenenbaum S, Thein. R, Herman A, et al. Pediatric nonaccidental injury: are orthopedic surgeons vigilant enough? *J Pediatr Orthop.* 2013;33:145-51.
- Abzug JM, Ho CA, Ritzman TF, Brighton BK. Transphyseal Fracture of the Distal Humerus. J Am Acad Orthop Surg. 2016 Feb;24(2):e39-44. doi: 10.5435/JAAOS-D-15-00297. PMID: 26808044.
- Supakul N, Hicks RA, Caltoum CB, Karmazyn B: Distal humeral epiphyseal separation in young children: An often- missed fracture-radiographic signs and ultrasound confirmatory diagnosis. AJR Am J Roentgenol 2015;204(2):W192-W198.
- Knox JB, Schneider JE, Cage JM, Wimberly RL, Riccio AI. Spine trauma in very young children: a retrospective study of 206 patients presenting to a level 1 pediatric trauma center. J Pediatr Orthop. 2014 Oct-Nov;34(7):698-702.
- Daniels AH, Sobel AD, Eberson CP. Pediatric thoracolumbar spine trauma. J Am Acad Orthop Surg. 2013 Dec;21(12):707-16.

References

- Schwend RM, Blakemore LC, Lowe L. Chapter 7: The Orthopedic Recognition of Child Maltreatment. In: Waters P, Skaggs D, Flynn J, eds. Rockwood and Wilkins' Fractures in Children, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.
- Leaman LA, Hennrikus WL, Bresnahan JJ. Identifying non-accidental fractures in children aged <2 years. *J Child Orthop.* 2016;10: 335-41.
- Wulczyn F. Epidemiological perspectives on maltreatment prevention. *Future Child.* 2009;19:39-66.
- Jevsevar DS, Shea KG, Murray JN, Sevarino KS. AAOS clinical practice guideline on the treatment of pediatric diaphyseal femur fractures. *J Am Acad Orthop Surg.* 2015;23:e101.
- Oetgen ME, Blatz AM, Matthews A. Impact of clinical practice guideline on the treatment of pediatric femoral fractures in a pediatric hospital. *J Bone Joint Surg Am.* 2015;97:1641-46.
- Blatz AM, Gillespie CW, Katcher A, Matthews A, Oetgen ME. Factors Associated With Nonaccidental Trauma Evaluation Among Patients Below 36 Months Old Presenting With Femur Fractures at a Level-1 Pediatric Trauma Center. *J Pediatr Orthop.* 2019;39(4):175-80.
- Murphy R, Kelly DM, Moisan A, Thompson NB, Warner WC, Bzeaty JH, Sawyer JR. Transverse Fractures of the Femoral Shaft Are a Better Predictor of Nonaccidental Trauma in Young Children Than Spiral Fractures Are. *J Bone Joint Surg Am.* 2015;97:106-11.
- Adamsbaum C, De Boissieu P, Teglas JP, Rey-Salmon C. Classic Metaphyseal Lesions among Victims of Abuse. J Pediatr. 2019 Jun;209:154-159.e2.
- Marine MB, Hibbard RA, Jennings SG, Karmazyn B. Ultrasound findings in classic metaphyseal lesions: emphasis on the metaphyseal bone collar and zone of provisional calcification. Pediatr Radiol. 2019 Jun;49(7):913-921. doi: 10.1007/s00247-019-04373-w. Epub 2019 Mar 28. PMID: 30923870.

References

- Hansen KK, Prince JS, Nixon GW. Oblique chest views as a routine part of skeletal surveys performed for possible physical abuse--is this practice worthwhile? *Child Abuse Negl.* 2008;32(1):155-159.
- Hedlund GL, Frasier LD. Neuroimaging of abusive head trauma. *Forensic Sci Med Pathol.* 2009;5(4):280-290.
- Langford S, Panigrahy A, Narayanan S, et al. Multiplanar reconstructed CT images increased depiction of intracranial hemorrhages in pediatric head trauma. *Neuroradiology.* 2015;57(12):1263-1268.
- Prabhu SP, Newton AW, Perez-Rossello JM, Kleinman PK. Three-dimensional skull models as a problemsolving tool in suspected child abuse. *Pediatr Radiol.* 2013;43(5):575-581.
- Barber I, Perez-Rossello JM, Wilson CR, Silvera MV, Kleinman PK. Prevalence and relevance of pediatric spinal fractures in suspected child abuse. *Pediatr Radiol.* 2013;43(11):1507-1515.