Non Accidental Injury

A Radiological Approach

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Abuse

- Physical abuse: Indirect trauma and shaking
  Direct eye trauma
  Smothering
  Poisoning
- Induced illness: Munchausen syndrome by proxy
- Sexual abuse
- Neglect
- Emotional abuse

Munchausen syndrome by proxy (**MSbP**)

- Physical
- psychological
- Behavioural
- mental health problems in others

Shaken Baby Syndrome

physical non-accidental injury to infants

- acute encephalopathy
- subdural and retinal hemorrhages
- other inflicted injuries

Inconsistent inappropriate history

In the United States, roughly one of every 100 children is subjected to some form of inflicted injury is responsible for approximately 1,200 deaths per year.

•rib fracture

• metaphyseal fracture

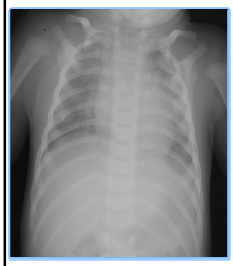
•interhemispheric extraaxial haemorrhage

•shear-type brain injury

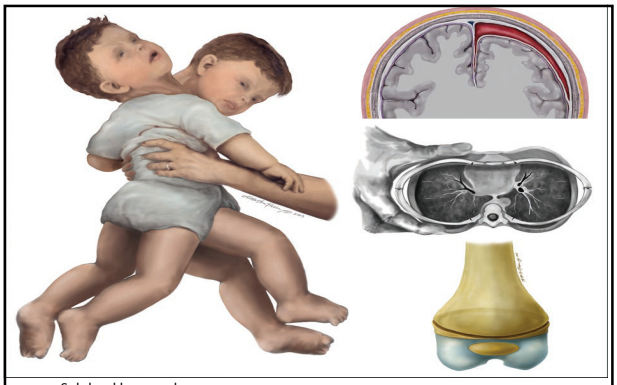
• vertebral compression fracture

•small bowel hematoma and laceration.

Rib Fracture



Metaphyseal Fracture



- Subdural haemorrhage
- shear-type brain injury,
- rib fracture
- metaphyseal fracture

Children at risk

- Colicky or irritable baby
- Handicapped child
- Premature infants
- Child of a former relationship

Detection

metaphyseal fracture
•High quality
•small field-of-view

rib fractures appear as linear lucent areas

skull injuries-shaking or trauma
•X-rays best for detecting fractures
•computed tomography
•magnetic resonance imaging best depict intracranial injury.

In the United States in the year 2000

• 1,200 children died

•less than 1 year of age

•rate of victimization decreases as age increases birth to 3 years of age

Referral of a non accidental injury patient

-relevant information MUST be identified in the radiological request form

-possibility of NAI

-current clinical problems

-past medical history

-when possible family or social history

The Role of the Radiographer within the legislative Framework:

The radiological request should be manually archived or scanned into and stored electronically in the Radiology Information Systems (RIS). This will aid the radiologist to manage the child and assess how extensive their investigation needs to be.

The Role of the Radiographer from a Radiological Point of View:

•Two radiographers
•highest possible standard,
•with a nurse present /both the parents(unless prohibited)
•parent fully informed by the senior clinician of the x-rays being carried out.

-A full Skeletal Survey is usually performed in children under the age of two; in over two, clinical, social and physical findings are taken into consideration.

Skeletal Survey:

•A standard series of radiographic images that will visualise the entire skeleton, to allow detection
•occult bony injuries
•further information about clinical suspected injuries
•dating of bony injuries
•underlying skeletal disorder

The Skeletal Survey is usually the first imaging investigation unless there in an urgent head injury involved, in which case, computed tomography(CT) will be taken first.

It is critical that the Skeletal Survey is carried to a high technical standard for
-diagnosis
-multi-disciplinary meetings
-court proceedings

Recommended Procedures for NAI Skeletal Survey:

•correct identification must be confirmed by two radiographers
•analgesia appropriate dose prior to x-ray visit
•one of the radiographers-a senior radiographer
•nurse or both parents should be present(unless prohibited)
•all images reviewed by a consultant radiologist prior to child leaving

Radiographic Principles:

•high quality diagnostic radiography taking into consideration:

1.positioning technique,
2.exposure factors,
3.appropriate restraining methods

•all radiographs should have:

1.correct name
2.side marker
3.date and time

•name of radiographers performing Skeletal Survey should be recorded

Protocol for Non Accidental Imaging

- AP and lateral skull (incl C-Spine on lateral)
- CXR for ribs and oblique's
- AP AXR (separate film to CXR) incl the pelvis
- AP both upper limbs incl wrist to shoulder
- PA hands incl wrists
- Lateral forearms
- AP both femora incl hips and knees
- AP right tb/fib-knee to ankle
- AP left tb/fib-knee to ankle
- Coned AP view of right ankle
- Coned AP view of left ankle
- Both feet
- Lateral thoraco-lumbar spine

Skeletal Injury in infants:

fractures are highly specific for abuse:

- metaphyseal fractures are the most common long bone fracture
- rib fractures are more common than long bone fractures

Case

- 9 week old male presents to A & E with seizures
- Well until one hour previously
- Being fed by father, started to choke and vomit.
- No previous medical history
- No history of trauma

- Very flat and hypotonic
- Unresponsive to voice or pain (Glasgow coma scale 9/14)
- Shallow respirations
- Differential diagnosis: Sepsis
  Intracranial bleed
  non accidental injury
- Extensive retinal hemorrhages
- Ventilated and admitted to ICU
- *After discussion with parents they reported that chest compressions had been undertaken*

Radiology

- Callus formation 5th, 6th and 7th ribs
- Displaced fracture of 11th rib
- CAT scan: Right sided subdural hematoma
  Blood in interhemispheric fissure
- MRI scan: Subdural hematoma
  Interhemispheric hematoma
- Skeletal survey: Tibial fracture
- Callus present on x-rays at presentation indicate that the fracture occurred at least seven days prior to the date of x-ray

Rib fracture

- In infants without metabolic bone disease rib fractures are highly unusual outside the setting of child abuse

Metaphyseal fractures

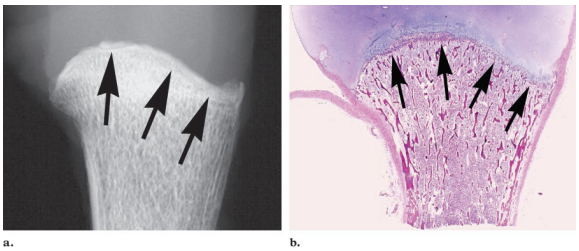
- Classic metaphyseal injury (CML) most frequently seen at distal femur and proximal humerus
- Found in 39 -50% of abused children less than 18 months
- CML is a series of micro fractures across the metaphysis. The orientation of the fracture tells us that it results from a shearing injury across the bone.
- Not a feature of falls or blunt trauma

Rim of bone separated from the tibial shaft by the mataphyseal fracture lucency giving appearance of a bucket handle

NAI – imaging

- Subdural haematoma
  - Acute on chronic
- Hypoxic-ischaemic injury
- Cerebral contusion

- Bucket handle fracture
- Classical metaphyseal lesion (Kleinman)



a. b.

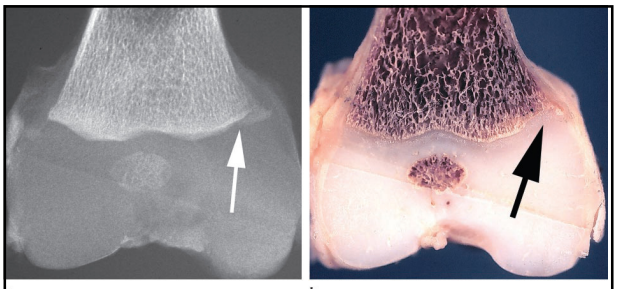
Acute CML in a fatally abused 2-month-old child

humerus shows the subtle lucency of the CML

(Case courtesy
of Paul K. Kleinman, MD, The Children's Hospital, Boston, Mass.)

The forces that lead to CML:

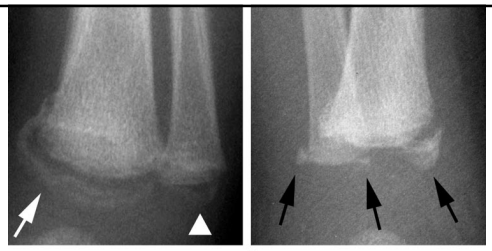
- manual to-and-fro manipulation of the extremities
- shaking the infant while he is held around the chest, limbs whiplashing back and forth and sustaining horizontal shear forces
- CML is seen almost exclusively in children less than 2 years of



a. b.

CML in a fatally abused 7-weekold distal femur

•shows irregular lucency of the medial femoral metaphysis

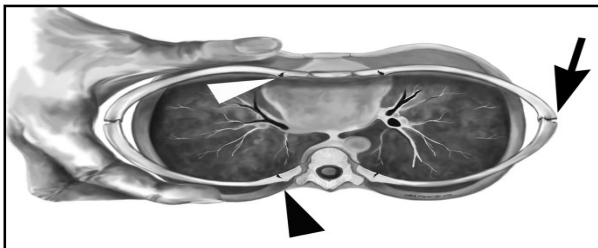


a. b.

CML in an abused 2-month-old girl

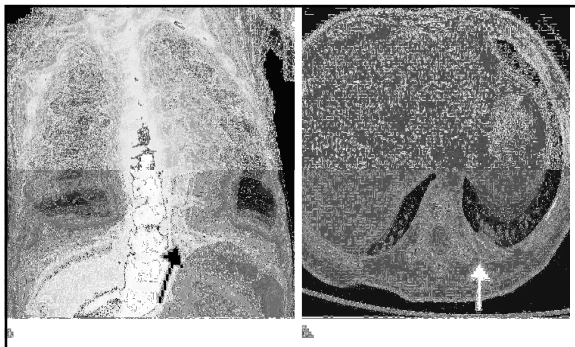
AP radiograph of the ankle shows
•a rim of bone separated from the tibial shaft by the metaphyseal fracture lucency,
•giving the appearance of a bucket handle. A CML of the distal fibula is also faintly seen (arrowhead)

Lateral radiograph depicts the tibial and fibular fractures

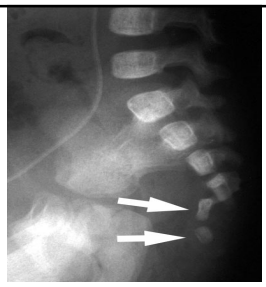


Rib fracture
•tight squeezing.
•Midthorax

•Hyperextension of the posterior rib ends over the transverse process, with fracture of the ventral cortex
•Anteriorly,
the chest wall compression: inward bending of the anterior ribs and fracture



Healing posterior rib fracture in an abused 2-month-old girl.
•**AP CXR shows focal**
widening of the posterior left ninth rib (arrow).
•**Axial CT scan of the chest windowed for bone detail shows the**
posterior rib fracture with callus (arrow)



Sacral fracture dislocation

•abused 2-month-old girl

•fifth sacral vertebra and coccyx are anteriorly displaced.
•The injury was originally explained as resulting from a changing table fall;
•mother's boyfriend later confessed to slamming the child down in a sitting position

Spiral femoral fracture

•3 month-old boy. Lateral radiograph shows a displaced, spiral fracture of the femur.

Spiral long bone and spine fractures deserve special mention:

•unusual injuries
•imply mechanisms of force that are unusual in infants
•result of torsional forces
•uncommon in infant nonambulatory

•Once a child is walking:

•spiral fractures of the tibia ("toddler's fracture") are quite common,
•not suggestive of abuse.

spinal fracture in an infant:

Suggestive of abuse

Thoracolumbar compression fracture caused by shaking (extension and flexion)

•compression deformities

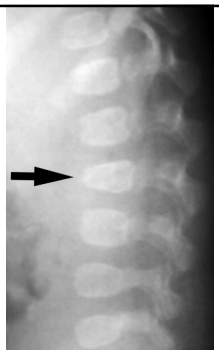
•vertebral body injury -readily apparent irrespective of the age

•avulsion of the posterior interspinous ligament

• interspinous ligament avulsion

•Occult since it is a cartilaginous and soft-tissue

•calcification



Vertebral body compression

•a shaken 3-month-old
•Lateral radiograph of the lower thoracic and upper lumbar spine anterior
•wedging of the second lumbar vertebra

Skull Fracture

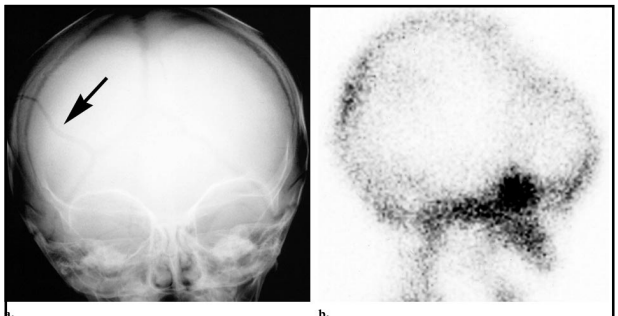
•accidental and Non accidental injury

•less than 2 years of age 29%–33

•homicides 41%

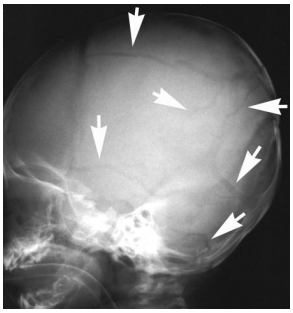
•poor correlation of skull fracture and underlying haemorrhage or brain injury

•deformation(in bending) of the infant skull injures the subjacent brain and meninges without fracture.



a. b.

- **AP skull radiograph depicts a linear, right parietal** skull fracture
- **Lateral TC-MDP scan of the head appears normal.**



Complex skull fractures

•**Abused** 3-month-old girl

•Lateral SXR reveals multiple skull fractures

Radiologic Appearance

Radiography of the skull is preferred over CT,SCINTIGRAPHY

•fractures parallel to the section orientation are missed at CT

•Four views of the skull

1.AP
2.BOTH LATERALS
3.TOWNES

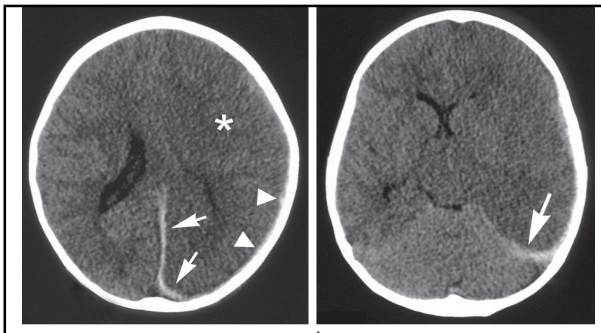
•Scintigraphy insensitive to detection of skull fractures

Interhemispheric/Extraaxial Haemorrhage/Epidural hematoma

•Subdural haemorrhage (SDH)

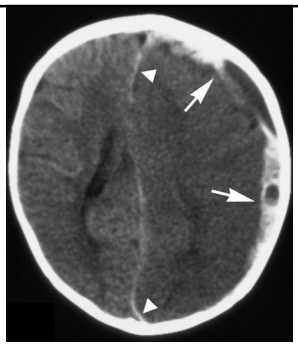
•Subarachnoid haemorrhage (SAH)
common abusive injuries

•Epidural hematoma
more often accidental than inflicted and may result from relatively short falls.

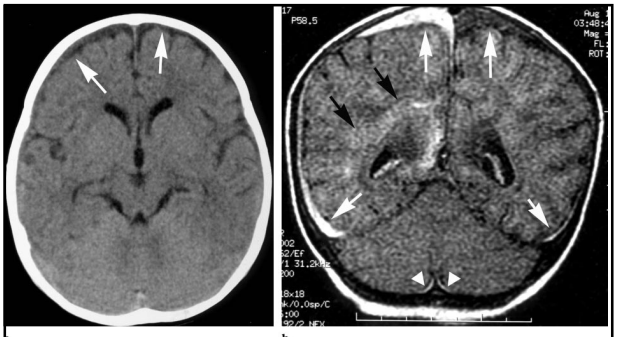


a. b.

Extraaxial haemorrhage and oedema in a fatally abused 3-year-old boy
- **Axial unenhanced** CT scan
- **reveals diffuse left hemispheric** oedema
- **high-attenuation blood in the posterior interhemispheric fissure**
- **(b)Axial CT scan reveals high-attenuation extraaxial blood along the left (arrow) left hemispheric oedema.**



Mixed attenuation SDH and cerebral oedema in an abused 8-month-old infant
•Axial unenhanced CT
•lateral ventricles depicts a mixed attenuation SDH along the left convexity (arrows).
•thin interhemispheric extraaxial haemorrhage(arrowheads) and left cerebral oedema.



a. b.

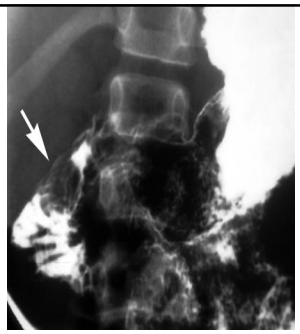
Multiple SDHs in a head-injured 4-month-old boy
- **(a) Axial unenhanced CT scan of the brain obtained**
- **frontal horns reveals subtle increased attenuation of the extraaxial fluid over both convexities**
- **(b) Coronal MR image**

reveals high-signal-intensity SDH over the left convexity and high-signal intensity SDH over the right (white arrows).

Ultrasonography (US)

•Investigated means to visualize the extraaxial spaces and brain in infants

•useful for discrimination of subtle abnormal occurrences of subarachnoid spaces from low-attenuation SDH, which may be difficult at CT.



Duodenal hematoma in a 6-year-old boy
•beaten by a caretaker
•Barium study of the stomach and duodenum
•Mass in the lateral wall of the descending duodenum

Small Bowel Injury

•Most commonly only injured abdominal organ in child abuse is the small bowel and presents as:

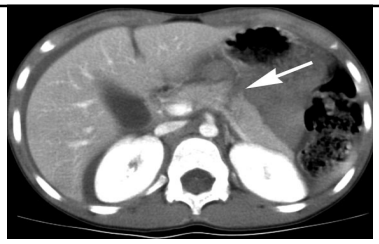
1.Hematomas

2.Lacerations

3.mesenteric injury

4.Strictures

• due to the rich vascular supply of the duodenum



Pancreatic laceration

•2-year-old girl who was beaten by a caretaker

•Axial enhanced CT scan of the upper abdomen

•Linear defect in the ventral body of the pancreas.

Conclusions:

Child physical abuse is an unfortunately common occurrence
• manifest clinically as:
1.metaphyseal fracture
2. neurologic injury
3. anterior/posterior rib fracture
4. Interhemispheric/ extraaxial haemorrhage

•Careful observation of radiologic findings and their correlation with the proposed:
1.mechanism
2. developmental capabilities
3. clinical status

• Imperative in the evaluation of any child, lest we overlook an important clue to injury and return a child to an abusive environment

On Children
Kahlil Gibran

Your children are not your children.
They are the sons and daughters of Life's longing for itself.
They come through you but not from you,
And though they are with you yet they belong not to you.
You may give them your love but not your thoughts,
For they have their own thoughts.
You may house their bodies but not their souls,
For their souls dwell in the house of tomorrow,
which you cannot visit, not even in your dreams.
You may strive to be like them,
but seek not to make them like you.
For life goes not backward nor tarries with yesterday.
You are the bows from which your children
as living arrows are sent forth.
The archer sees the mark upon the path of the infinite,
and He bends you with His might
that His arrows may go swift and far.
Let your bending in the archer's hand be for gladness;
For even as He loves the arrow that flies,
so He loves also the bow that is stable.

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