Identifying and interpreting fractures, burns and head injuries suspicious for abuse

Hosanna Au, MD, FRCPC
Paul Kadar, MD, FRCPC
Sarah B. Schwartz, MD, MEd, FRCPC

Objectives
At the end of this session, participants will be able to:

1. Understand the medical assessment of children seen for physical abuse concerns.
2. Describe features of fractures, burns, and head injuries that raise suspicion of physical abuse.
3. Compare and contrast features of injuries that are accidental vs. suspicious for abuse.
4. Recognize the importance of collaboration and communication between medical and forensic investigators to enable medical interpretation of injuries.
5. Understand the importance of applying the limits of medical knowledge into injury interpretation.

Fractures

- common manifestation of child abuse
- may be found incidentally on X-rays done for another reason
- majority of nonaccidental fractures occur in children under 18 months old, few accidental fractures in this age group

Fractures Red Flags

- age/developmental level - fractures in nonambulatory (not walking) children
- location - metaphyseal, ribs, scapula, vertebrae, sternum
- pattern - multiple fractures, complex skull fractures
- age of injury - delay in seeking medical attention, fractures of different ages

Long bone (limb) fractures - types

- spiral/oblique - twisting/torsional force
- transverse - bending force
- greenstick - bending force
- buckle - compressive force

Causes of long bone (limb) fractures in children:

- Injury:
  - Birth
  - Accidental
  - Non-accidental

- Medical conditions:
  - Infection: osteomyelitis
  - Metabolic bone disorders: rickets (Vitamin D deficiency)
  - Inherited/genetic bone conditions: osteogenesis imperfecta
  - Bone tumours
  - Others
Long bone shaft fractures

- Require significant force application in child with normal bones
- Do not occur during normal child care
- Do not occur in non-ambulatory infants without significant causative incident

Long bone fractures – symptoms:

- initially cry/scream
- then variably irritable
- decreased movement/use of limb
- crying with movement of affected area (i.e. diapering, changing, bathing)
- swelling

Toddler’s Fracture of the Tibia: an exception

- Spiral fracture of the tibia (shin bone)
- Common in the toddler age group
- Twisting fall with foot planted (less force required than typically expected)
- May not be immediately noticed – falls are common in this age group, may only have mild limp

Dating of fractures

*Range of dating only possible based on x-ray*

**Acute fractures:**
- No bone healing noted on x-ray
- Soft tissue swelling
- Within 7 days

**Healing Fractures:**
- Periosteal reaction, callus formation on X-ray
- At least 7 days old

Rib fractures in infants

- Most are likely due to forceful compression of rib cage during forceful squeezing or shaking
- Require significant force, do not occur during normal handling of child

Causes of rib fractures in infants

- Nonaccidental injury
- Accidental injury:
  - MVA
  - Fall from significant height
- Birth injury
  - Few case reports – large baby, difficult delivery
- Rarely caused by CPR
Rib fractures – symptoms:
• initially painful leading to crying/ screaming
• may be few symptoms
• rarely bruising

Rib fractures – dating:
Appearance on x-ray provides only range of possible ages

Acute fractures:
• No healing bone
• Within 7 days old

Healing fractures:
• Callus formation
• At least 7 days old

*Acute fractures may be difficult to visualize on x-ray and may not be seen until healing forms

Skeletal Survey
(aka x-rays of all the bones in the body)
• ~20 x-rays to evaluate for fractures, that may or may not have any external signs such as bruising, swelling, or pain symptoms
• Done in all children under 2 years old when concerns for physical abuse are raised & in older children when indicated

Repeat skeletal survey
• Performed at ~2 weeks following initial assessment in all cases of suspected physical abuse
• May demonstrate fractures which were not visible or subtle on initial x-rays

Fractures: Summary
• The assessment of fractures requires
  – A detailed history of the reported events
  – A detailed history of symptoms
  – Evaluation of possible medical conditions
  – Evaluation for other possible injuries (skeletal survey and possible CT of the head, eye examination, blood tests)

Burns
• 4th most common cause of accidental childhood death in Canada
• Majority of burns in young children are scald injuries primarily occurring in homes
• Tap water injuries are most common in children under the age of 2
• 10% of burns in childhood are inflicted
Types of Burns

- Scald
  - hot liquids, splash, immersion
- Contact
  - hot object
- Flame
- Electrical
- Chemical

Describing a Burn

- Location
- %BSA
  - % of body surface area
  - used to describe the amount of skin that has at least a second degree burn/partial thickness
- Depth
- Pattern

Classification of Burns

- First degree/superficial thickness
  - Surface of skin
  - Reddened, painful
  - Heals spontaneously
  - E.g. sunburn

Classification of Burns

- Second degree/partial thickness
  - Partial-superficial, partial-deep
  - Redness, swelling, blistering
  - Extremely painful
  - Often requires hospitalization, complex burn care, skin grafting
  - Permanent scarring

Classification of Burns

- Third degree/full thickness
  - Entire skin burned
  - White leathery appearance
  - Not painful since pain nerves burned away
  - Prolonged hospitalizations, complex burn care, skin grafting
  - Permanent scarring

Factors Affecting Burn Depth

- Time
- Temperature
- Location
- Clothing
- First Aid applied
Relationship between temperature and duration of exposure producing full thickness burns in children
Feldman, 1983

<table>
<thead>
<tr>
<th>Temp ( F)</th>
<th>Temp ( C)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>49</td>
<td>30 sec</td>
</tr>
<tr>
<td>130</td>
<td>54.4</td>
<td>10 sec</td>
</tr>
<tr>
<td>135</td>
<td>57</td>
<td>4 sec</td>
</tr>
<tr>
<td>140</td>
<td>60</td>
<td>1 sec</td>
</tr>
<tr>
<td>149</td>
<td>65</td>
<td>0.5 sec</td>
</tr>
</tbody>
</table>

Factors Affecting Burn Depth

- Typical Canadian homes have tap water temperatures of 60°C (140°F) which can cause a full thickness burn in children in ONE second!

Factors Affecting Burn Depth

- Location
  - Thicker areas of skin, e.g., heels may withstand more heat before burning
  - Skin against a surface, e.g., bottom of tub, is spared

- Clothing
- First Aid applied

Medical Assessment

- Specific details of the injury event
- Symptoms experienced by the child
- Appearance of burn, changing?
- Time to seek medical attention

- Pattern of injury (spill, flow, immersion)
- Body parts involved
- Depth of the burn

Burns – Red Flags
Maguire, 2008

- Features on information gathering that are highly suspicious for intentional injury
  - History incompatible with injury seen
  - History incompatible with developmental age
  - Sibling blamed for causing injury
  - Numerous previous accidental injuries
  - Previous abuse
  - Domestic violence
Burns – Red Flags
Maguire, 2008

• Features of the burn that are highly suspicious for intentional injury
  – Clear margins
  – Symmetrical burns to extremities
  – Isolated to lower extremities and/or buttocks
  – Associated unrelated injury, e.g., fractures

Interprofessional Approach

Medical Assessment
- Description of the injury event
- Appearance of the burn injury
- Does the description of the injury event fit with the injury seen? (pattern, clinical features)
- Does the description of how the injury occurred fit with the description of the environment in which it occurred?
- Does the description of how the injury occurred fit with the developmental abilities of the child?

Investigative Information
- Social risk factors
- Previous CAS/police involvement
- Max temp at water tank, and at faucet
- Time to max temperature
- Type of home, gas or electric
- Changes with other water use, e.g., flush
- Assessment and photos of environment in which injury occurred

Abusive Head Trauma
An interactive, case based discussion will be used to highlight key points.

Summary

• Fractures, burns and head injuries can occur accidentally, or can be inflicted
• Certain features of injuries raise suspicion for abuse
• Careful medical assessment to consider all diagnostic possibilities is necessary
• Collaboration to share information is important to provide the best possible opinion

• Call us to consult!
  – 416-813-7500 if urgent, ask for the SCAN clinician on call
  – 416-813-6275 if non-urgent during business hours