Child Physical Abuse 102: AHT, fractures, burns, mimics, and the less-common patterned injuries

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A message about inclusivity:

- I have created and reviewed this content through a diversity, equity, and inclusion lens and have attempted to avoid any potentially racist, sexist, ableist, ageist, or otherwise stereotyping content.
- If you identify ways that I could do better, or places where I have failed and need to remove or change content, please contact me at melissa.currie@louisville.edu. Thank you.

Objectives:

- Review common presentations for abusive head trauma and its medical evaluation
- Review basics about the evaluation and assessment for fractures
- Recognize multiple types of burns, including accidental, inflicted, and mimics
- Become familiar with some less-common patterned injuries

Abusive Head Trauma

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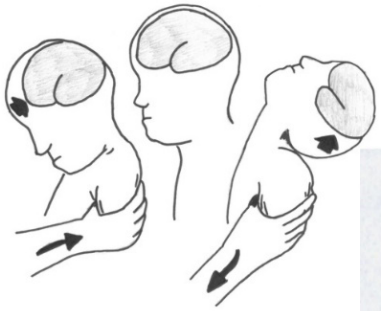
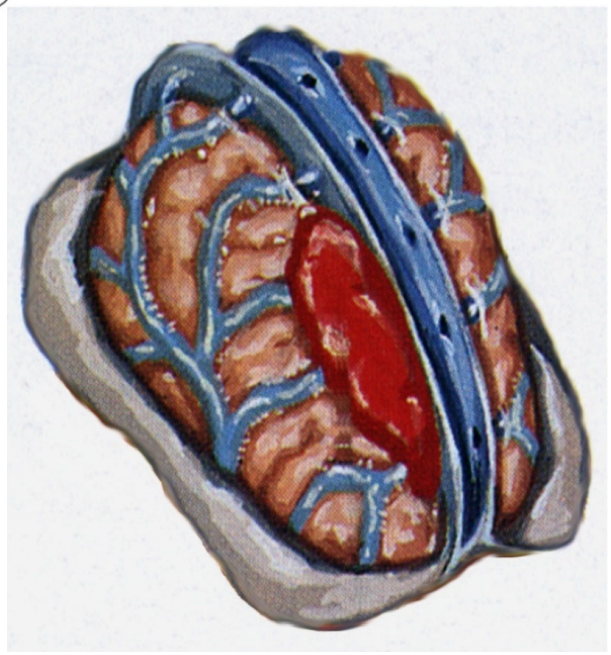
Incidence/Prevalence

- Abusive head trauma is the most common cause of morbidity (disability) and mortality (death) in physical child abuse.
- Abusive head trauma usually occurs in children younger than 1 year of age, but older children can be victims as well.
- It is the most common cause of death from brain injury in children less than one year of age.

How does shaking cause injury?





- Bridging veins stretch, rupture, and bleed, leading to subdural bleeding.
- Brain tissue is distorted/stretched during the event, causing damage to nerve cells and brain tissue (either temporary or permanent damage).
- Subdural bleeding is visible on CT scan and MRI.

How PAHT can present…

- Infants with bruises
- Enlarging head (out of proportion to body)
- Vomiting without diarrhea
- Irritability/extreme fussiness/“colicky”
- Lethargy, unusual sleepiness, poor responsiveness, or seeming “spaced out”
- Seizures/tremors

How PAHT can present…

- Sudden limpness/loss of tone
- Breathing difficulty/gasping for breath/stopped breathing
- Brief Resolved Unexplained Event (BRUE)
- Incidental finding (occult injury)
- Bright red blood from the mouth of infants

The Medical Evaluation for AHT/Occult Trauma

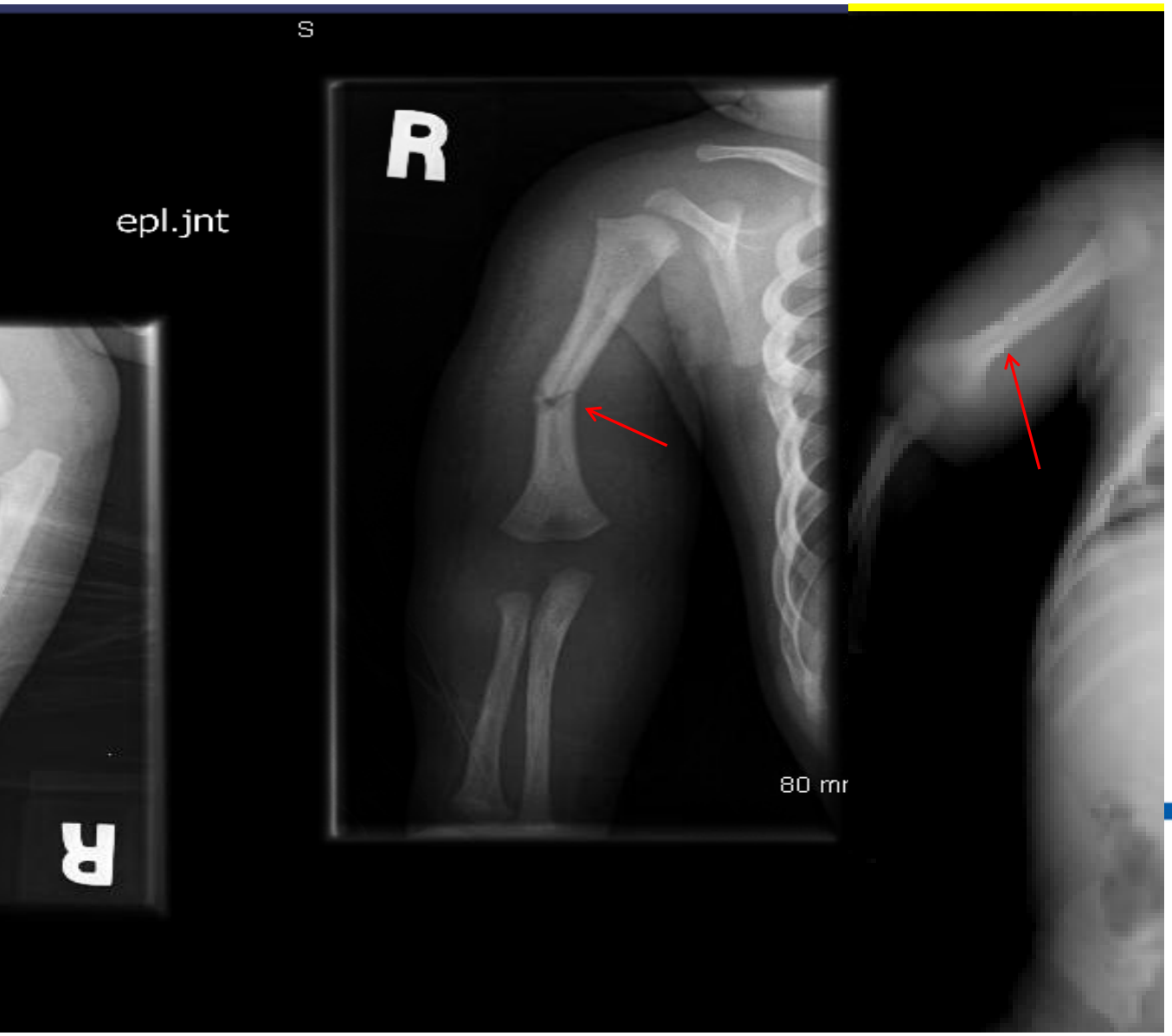
- Head CT (looking for subdural bleeding, brain swelling)
- Skeletal survey and follow-up skeletal survey in 10-14 days
- Ophthalmology dilated funduscopic exam (to look for retinal hemorrhages)
- Trauma and bleeding labs to screen for signs of internal injury or bleeding disorder
- MRI of the brain and spinal cord if CT is abnormal OR if there are significant concerns for AHT (MRI can demonstrate subtle brain injury that CT can miss)
- **Photograph all visible injuries and call CPS if reasonable cause to believe child was maltreated. Also cause police if evidence a crime was committed.**

More on the Medical Evaluation

- Head CT – usually in children under 1-2 years of age unless other indicator of possible head injury
- Skeletal survey for children less than 2 years/older in rare circumstances
- AST, ALT, amylase, lipase, CBC, PT, PTT, urine dip, +/- CK if extensive bruising is present
- Abdominal CT **(not ultrasound!)** for AST/ALT >80 **or** abdominal bruising, tenderness

Common Missteps

- Abnormal head CT is not followed by an MRI
- Babygram instead of skeletal survey
- No follow-up skeletal survey
- Inadequate description/documentation of retinal hemorrhages
- OAT labs not done, or abd CT not done for AST>80
- Poor-quality or too few photographs: we need to see the borders of the injuries
- Attempts to “date” bruises



Side-by-side comparison of babygram to single image of complete skeletal survey

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Forensic vs. Clinical Significance

- Most of us have been taught to identify clinically significant injuries—those for which we can affect the outcome by providing some sort of treatment or monitoring
- In child maltreatment, it is equally as important to identify injuries with forensic significance (ALT>80*)—even if not clinically significant

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***Utility of Hepatic Transaminases in Children With Concern for Abuse.** Lindberg, Shapiro, et al. ***Pediatrics*; originally published online January 14, 2013**; DOI: 10.1542/peds.2012-1952

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AHT Outcomes – about 25-30% will die. If they live,

- They may now require tube feeding
- They may now be on multiple medications (for seizures and to prevent contractures and reflux)
- They may now require speech, occupational, and/or physical therapy
- They may be blind or deaf
- They may need to follow up with multiple specialists
- They are at significant risk for long term developmental problems and cerebral palsy

Supporting the Survivor

- **Establish a medical home.**
- Monitor closely for developmental issues (First Steps), emotional/ behavioral issues (esp. attachment problems), hormone problems (panhypopituitarism), learning disabilities
- **Older siblings that might have witnessed or otherwise experienced violence may need ongoing therapy/counseling**

Fractures

Fractures

Highly specific

Posterior rib fx

Classic metaphyseal lesion/fracture

Scapula fracture

Sternum fracture

Relatively nonspecific

Clavicle

Long bone spiral, buckle or oblique

Simple linear parietal skull fx

Concerning

Any fracture in a child 12 months or younger

Any unexplained fracture

Anterior or lateral rib fracture

Fracture Basics

- While there are certain kinds that are very specific for abuse, most fractures can occur accidentally or from abuse—it all depends on the history.
- Things to know from the history:
  - child's developmental ability
  - where, when and how it happened
  - was it witnessed?
  - how did child react?
  - for reported falls, in what position was child found?
  - did child ever walk/use the limb normally after incident?
  - did anyone hear or feel a "pop"?

Skull Fractures

- Can be plausible if there is a history of a significant impact to the head
- More concerning when fractures are complex (that means branched, instead of a single linear crack), depressed (one or more pieces are pushed inward toward the brain), or diastatic (the fracture edges are separated), as those require higher energy/forces
- A skull fracture with no history to explain it is very concerning, particularly in children who are not independently mobile
- Regardless of plausibility, any skull fracture in a child 12 months or younger justifies a complete occult trauma evaluation!

Simple Linear Skull Fracture

Note that this fracture does not cross a suture line.

Skull Fractures - Complex

- Multiple
- Branched (complex)
- Diastatic (edges separated, implies increased intracranial pressure)

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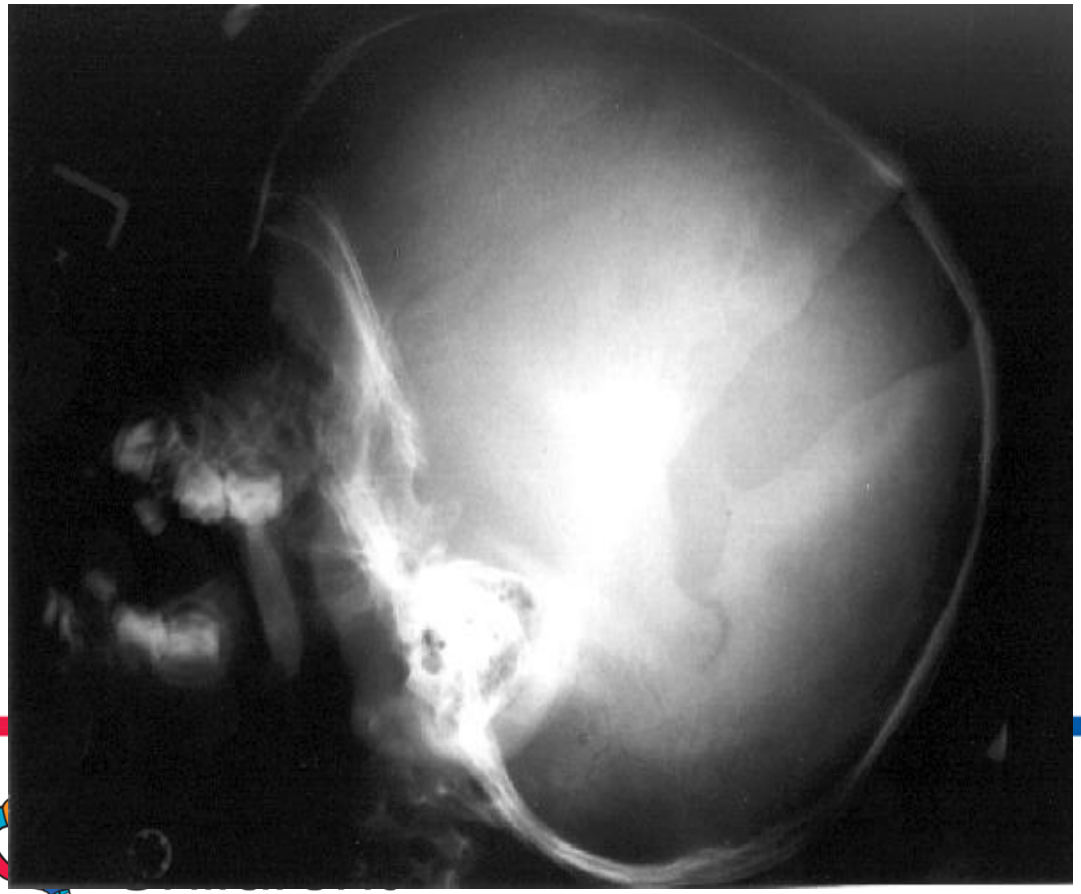
Diastatic Fractures



Diastatic fractures involve separation of the edges of the fracture caused by increased intracranial pressure (swelling inside the head)

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Case One:

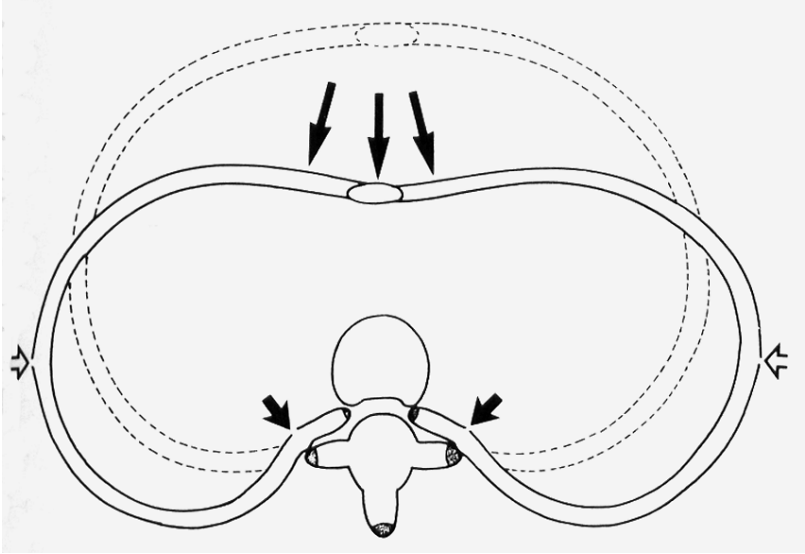
- 4 mo dropped on floor by mom. Simple linear skull fracture. Skin exam normal. Skeletal survey normal (except skull fracture.) Head CT normal (except skull fracture.) OAT labs normal. No other red flags.
- Great! It was probably just an accident!

Case Two:

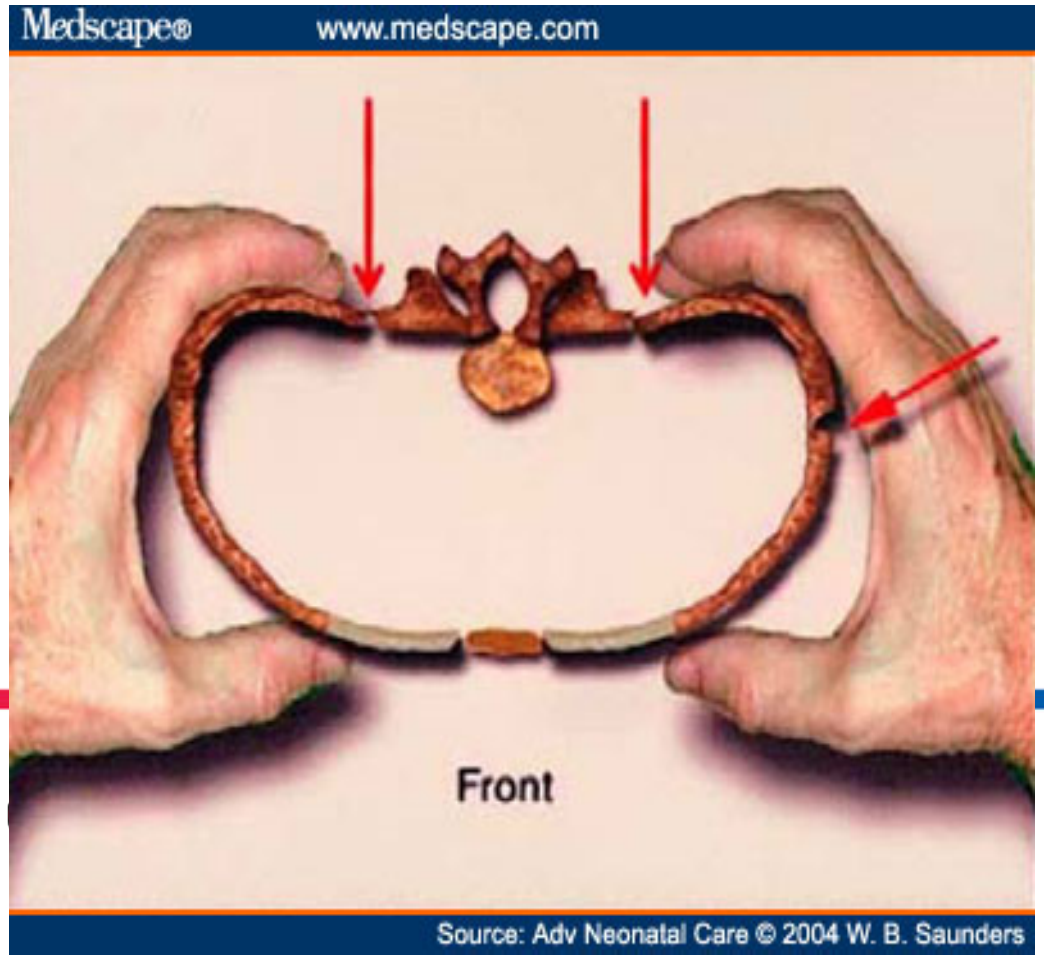
- 4 mo with swelling noticed on head this morning when she woke up. Head CT shows simple linear skull fracture. No history of trauma reported. Mom and Dad are only caregivers. No bruising on exam, but history of “easy bruising.”
- Be very, very concerned! No history for serious injury (skull fracture) is highly concerning. And babies shouldn’t have bruises. Skeletal survey showed healing posterior rib fractures. It’s abuse. And *healing* rib fractures indicate that it has happened before.

Rib Fractures

- Posterior rib fractures are caused by severe anteroposterior chest compression
- Back is *unsupported,* so that ribs bend back over transverse processes
  - They are *not* a result of direct impact
- Highly specific for physical abuse
- Can also see lateral and anterior rib fractures



Mechanism of Injury –rib fractures



Squeezing is a well-documented mechanism of posterior and lateral rib fractures (see fractures at arrow point) in infants.

*Note: anterior and lateral rib fractures can occur from a direct blow to the chest as well. Not posterior.

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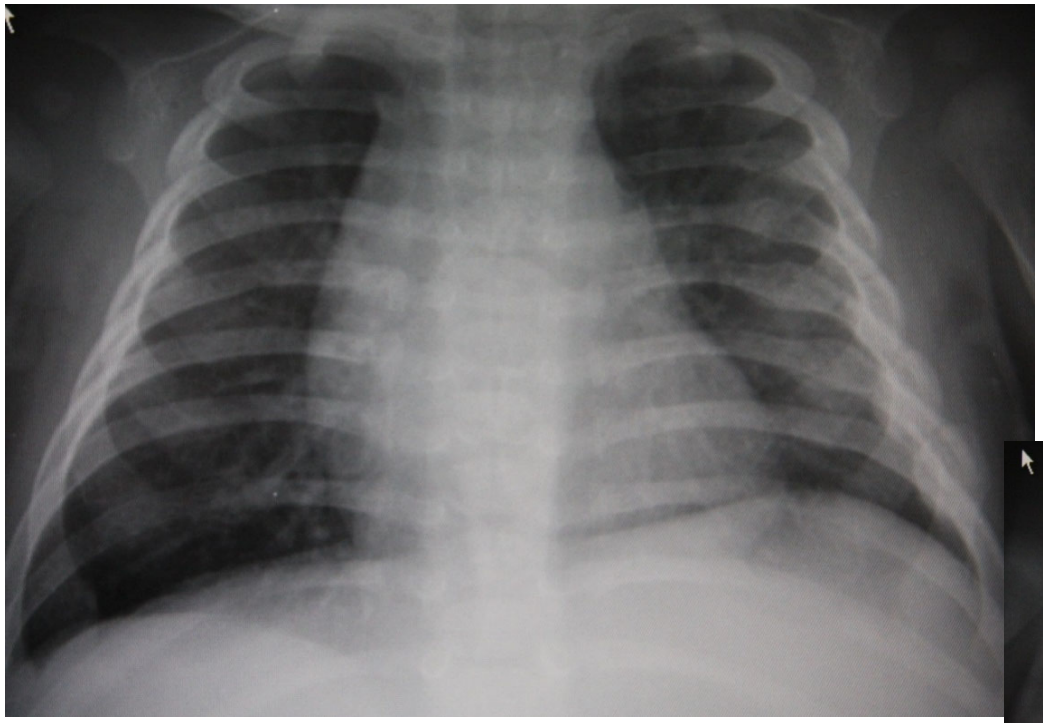
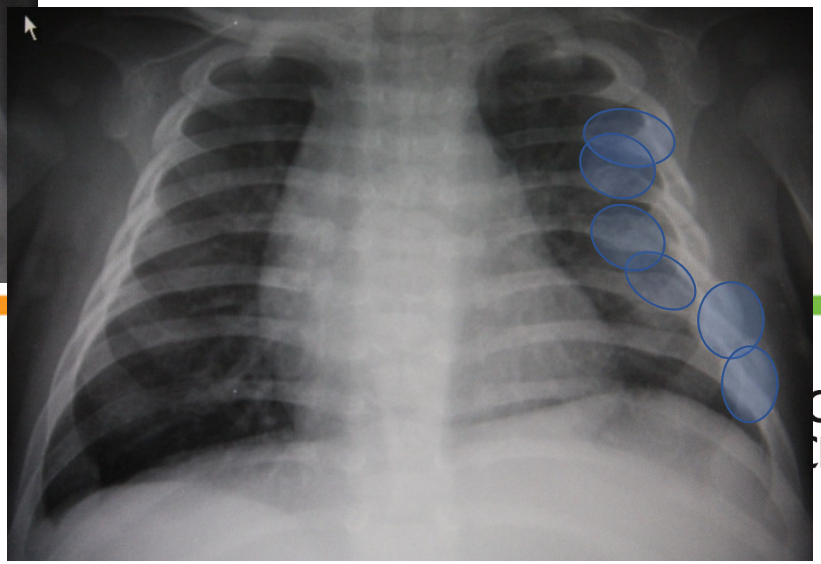
Rib fractures on x-ray





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Long Bone Fractures

- *Spiral* requires a twist.
- *Transverse* requires a bend.
- *Oblique* is a combination of bending and twisting.

•Young children will NOT walk/bear weight on a displaced femur fracture (spiral, transverse, or oblique)!

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Long bone spiral fractures…depending on age of patient:

- In nonmobile infants, spiral fractures of long bones are VERY concerning
- In cruising toddlers, spiral fractures of tibia are VERY common (“Toddler’s fractures”)

Classic Metaphyseal Fracture

- Also known as bucket handle or corner fracture
- Highly specific for abuse in otherwise healthy infants
- Very unusual in accidental injury, OI, birth
- Involves shearing force applied across a joint
- Implies twisting, yanking, flailing of extremity

Classic Metaphyseal Fracture

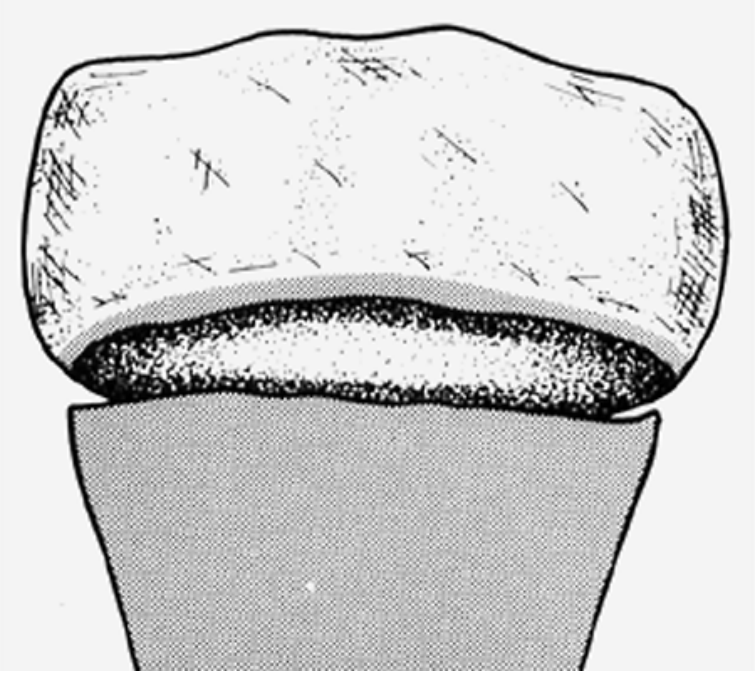
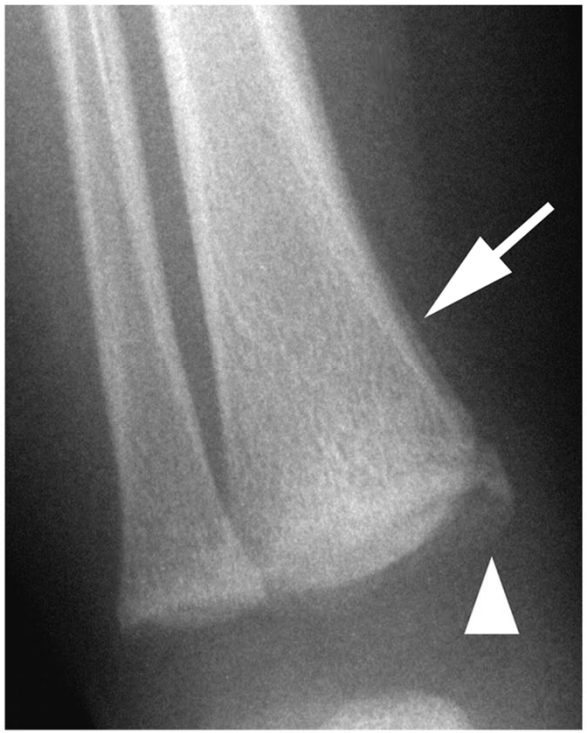


Figure 7a. Tibial CML in an abused 10-week-old girl.



Lonergan G J et al. Radiographics 2003;23:811-845

RadioGraphics

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How do we look for fractures?

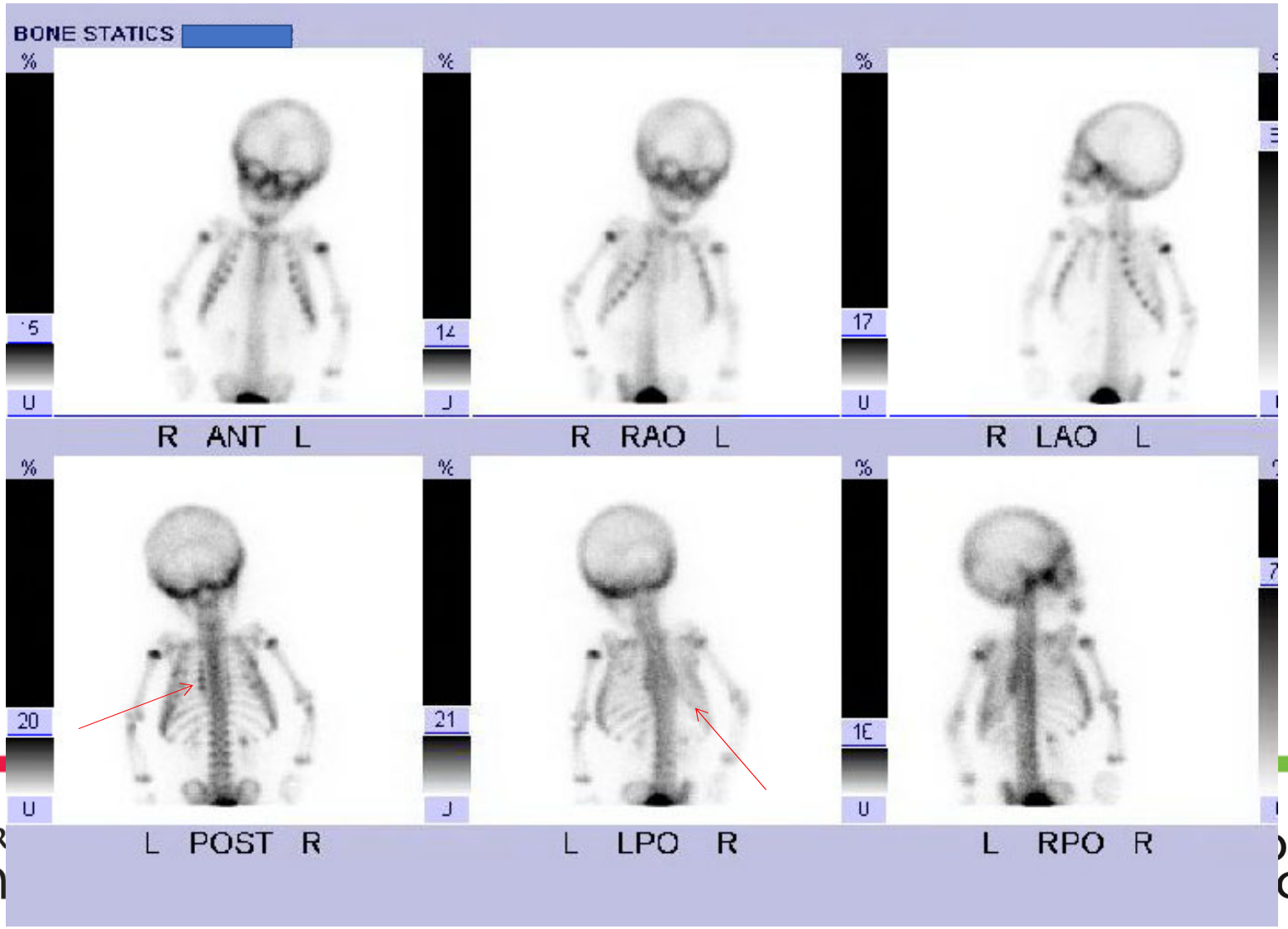
- Skeletal surveys show more metaphyseal lesions (19-21 images total)
- Bone scans show more acute rib fractures
- Neither is perfect
- If suspicion is high, we sometimes get both if necessary for safety planning
- Follow-up skeletal survey in 10-14 days
- Babygrams are NOT sufficient
- ALL children under 1 year with any fracture should have a skeletal survey.
- We rarely do skeletal surveys over 2-3 years of age.

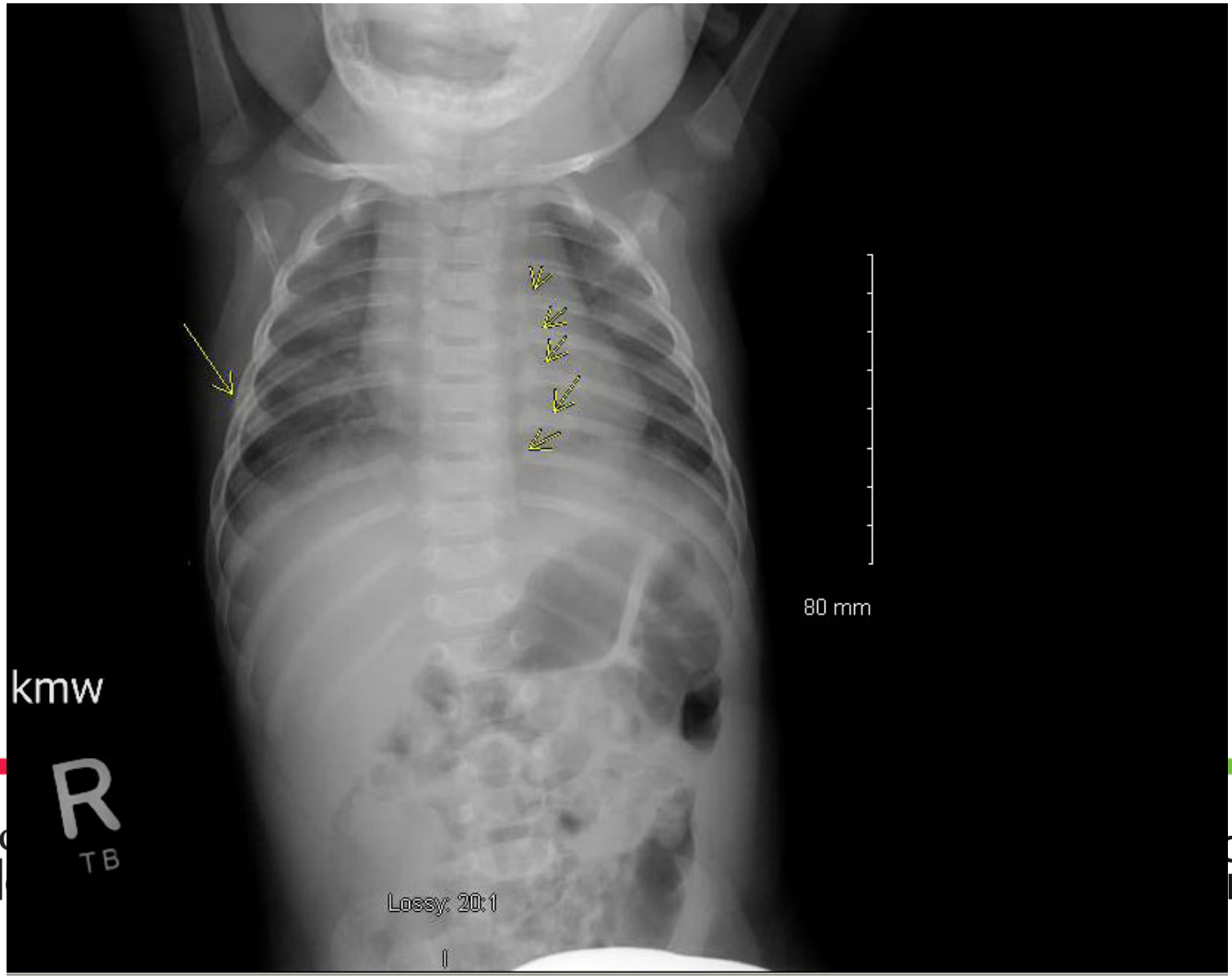
Nuclear Medicine Bone Scan

- Can be complementary to skeletal survey but doesn't replace it
- Strengths: Can pick up relatively acute rib fractures, allows for earlier diagnosis of some subtle long bone fractures
- Weaknesses: Misses most metaphyseal fractures (because those areas already have increased uptake), misses most skull fractures, time-consuming, usually requires sedation, positive findings need to be confirmed with plain radiographs

Scenario

- 2 month old transferred from outlying hospital with history of bleeding from mouth, fussy, poor oral intake
- “perfectly fine” until 3 days prior to visit
- Subtle facial bruises become apparent after admission to the hospital
- Skeletal survey, head CT, labs all completely normal


BONE STATICS
R ANT L
R RAO L
R LAO L
L POST R
L LPO R
L RPO R


80 mm
kmw
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Important: Follow-up Skeletal Survey

- Rib fractures are one of the most commonly missed abusive fractures when they are NEW.
- That is why it is critical to bring children back for a repeat skeletal survey in two weeks—even when the initial one is normal.
- If a follow-up skeletal survey is indicated, then the workup isn't finished until that has been performed.
- The follow-up version is usually "limited", meaning it excludes skull, lateral spine, pelvis

Dating Fractures - Caution

- In general, it takes at least 8-14 days* before callus (healing bone) appears on x-ray. That's why we do repeat skeletal surveys in 14 days.
- Dating a fracture is one of the most important steps in determining the plausibility of the caregiver history.
- When the date of the history does not coincide with age of fracture – be suspicious of abuse.
- In very young children, signs of old fractures can sometimes disappear entirely after 3-6 months.
- Subtle or hairline fractures may be difficult to see on an X-ray.
- Skull fractures can't be dated.
- CMLs often heal without callus.

Burns

Mechanism of Injury

Four main factors determine the severity of a burn:

1. Time of exposure
2. Temperature of exposure
3. Type of exposure
4. Thickness of skin and vascularity in the affected area

(Currie's 5th factor: Adequacy of post-burn cooling/first aide)

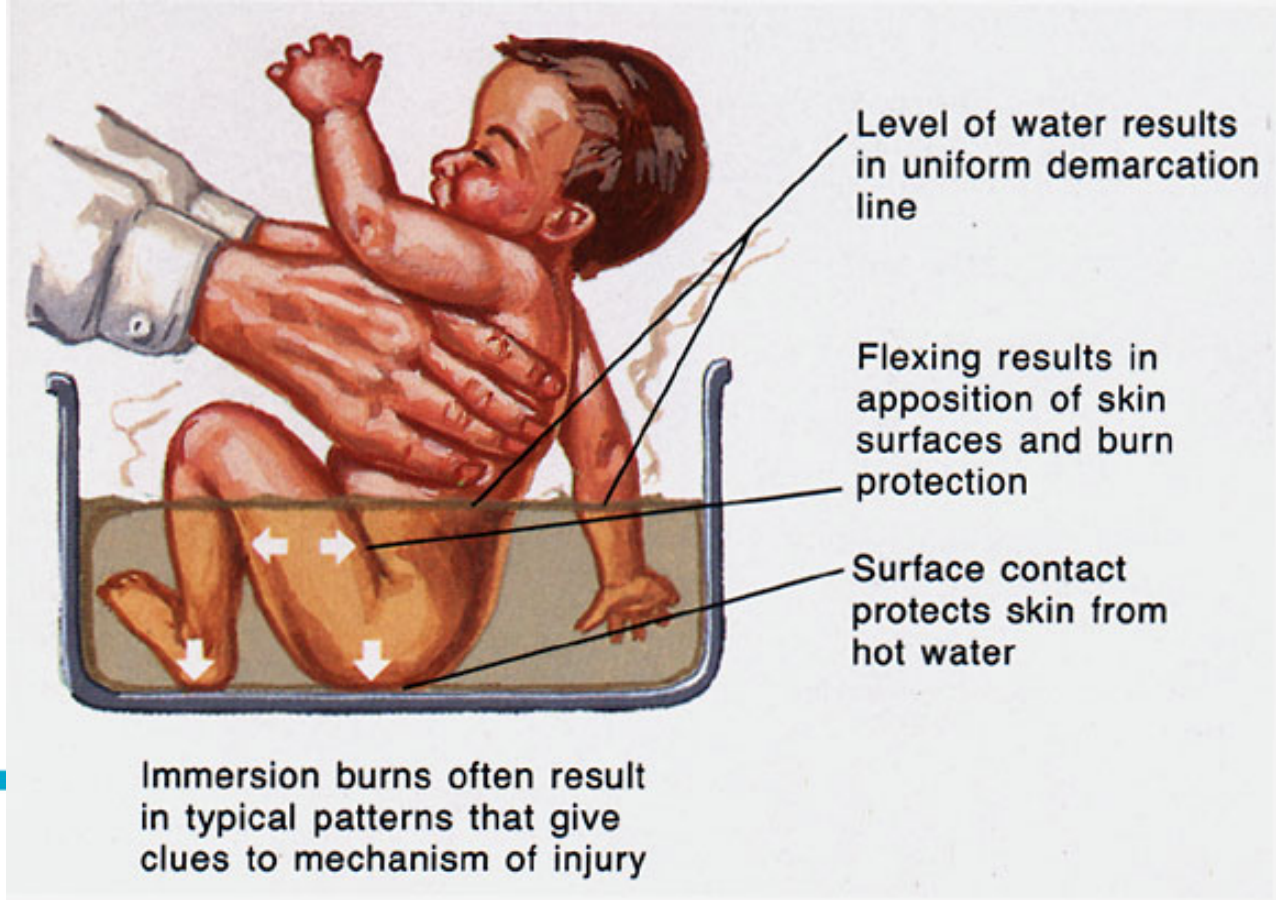
Children's skin has higher water content
and is thinner overall with a thinner cornified/keratinized layer,
making it more susceptible to burn injury.

Types of Burns

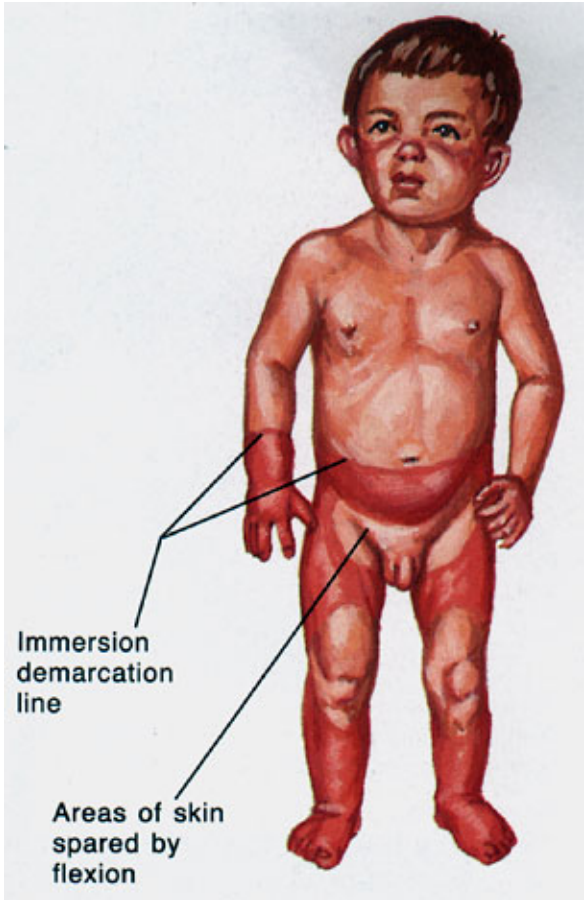
- Immersion
- Splash/Flow
- Contact
- Caustic
- Flame
- Electrical

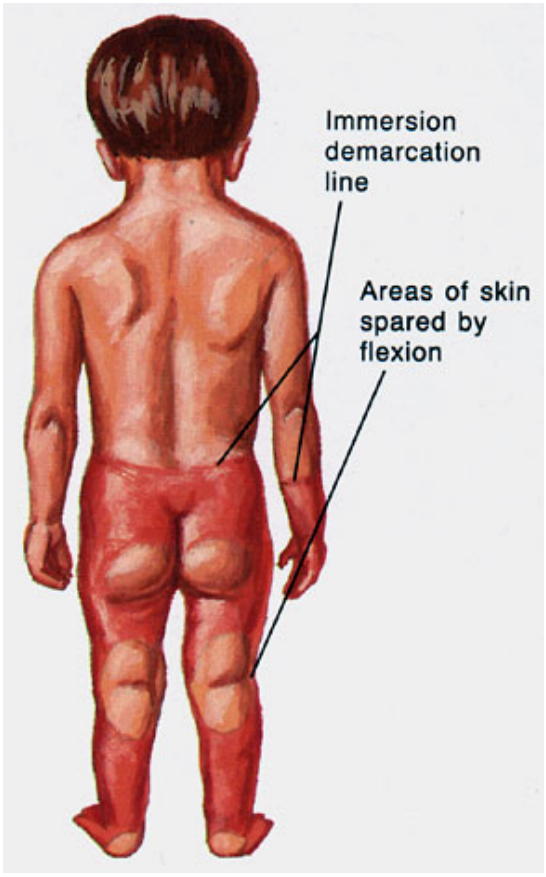
All types can be accidental or inflicted.

Immersion burns



Immersion burns often result in typical patterns that give clues to mechanism of injury


Immersion
demarcation
line
Areas of skin
spared by
flexion


Immersion
demarcation
line
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Immersion Burns: Accidental vs. Inflicted

ACCIDENTAL

- Splash marks
- Varying depth of burn
- Indistinct borders
- Burns in flexion creases

INFLICTED

- Uniform depth of burn
- Very distinct borders
- Buttocks, perineum, extremities
- Characteristic spared areas (flexion creases)
- Few splash marks

Immersion Burns

Note the area of sparing where body creases protected the skin from burns.

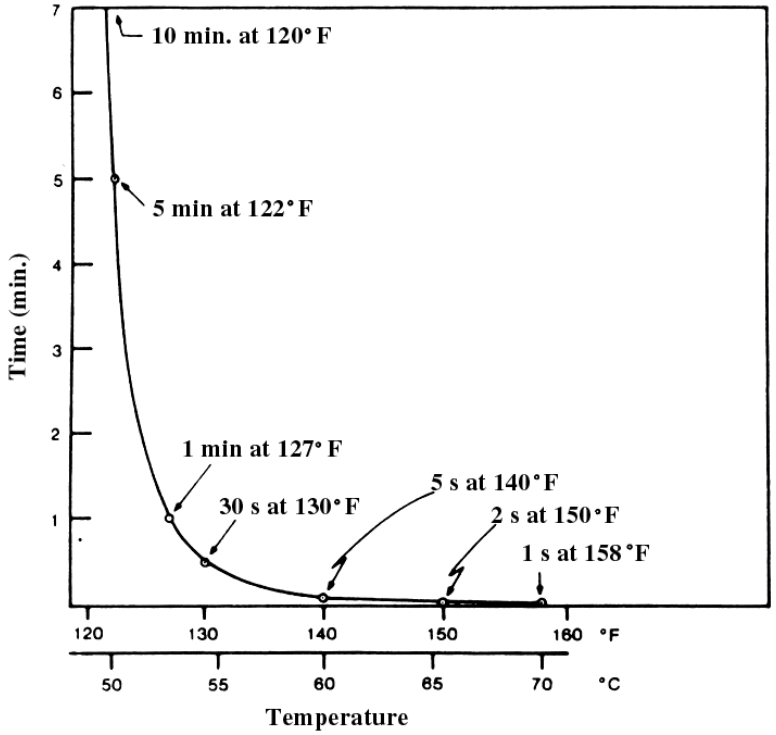
Source: Visual Diagnosis of Child Abuse, American Academy of Pediatrics

Accidental immersion burn

Playing in bathroom. Clogged sink with toilet paper. Turned hot water. Hot water overflowed the sink. Mom came in and yelled to get the toilet paper out of the sink but didn't realize the water was hot. Child stuck her hand in to get the toilet paper and quickly withdrew due to heat. Water temp was about 130.

H_2O Temperature vs. Burn Time

- Bathwater is about 100 degrees.
- Hot tubs are around 104 degrees.
- When measuring water temp, have a hot water heater company do it with a professional thermometer…candy and meat thermometers aren't accurate! [Caveat: Instant read meat thermometers might be acceptable.]
- Need to know temp of water immediately, after 10s, 20s, 30s, and time to reach max temp.



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Early photos

- Superficial (1st degree) burns can fade rapidly, and that alters the border of the burn
- Debridement changes the borders of the burn
- Wound dressing/ointments obscure photograph detail and borders
- Splash marks and drip marks can also fade

All of this can negatively affect the accuracy of our assessment regarding plausibility.

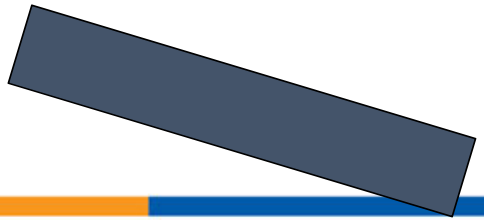
Flow Burns

- Irregular margins
- Non-uniform depth
- Fluid flows to dependent regions
- Accident: child usually looking/reaching up, so flexion creases tend NOT to be spared

• 2 year with accidental flow burn
• Note burn is deepest at point of initial contact with fluid (this spill came from behind)
•Child backed into a folding table with hot soup sitting to be served at family gathering
•Soup fell on back of his neck, shoulders, then cooled as it ran down the front
•Note the drip marks
•Note the tapering of burn as fluid flows downward
•He did not have a shirt on at time of injury

- Another accidental flow/splash burn
- Note direction of drip marks
- This 3-year-old was lying on her belly on kitchen floor with crayons/coloring book.
- Her brother tripped and dropped pot of spaghetti he was taking to the sink to drain.
- Note that if the history had indicated she was standing up, the drip marks would have contradicted this.
- The dressing in the photograph is a biological dressing impregnated with human cultured skin cells—sort of a synthetic skin graft (from 20 years ago.)

- Flow burn to head and face (ramen noodles)
- No medical care sought for four days
- So this might not be inflicted, but it IS medical neglect.

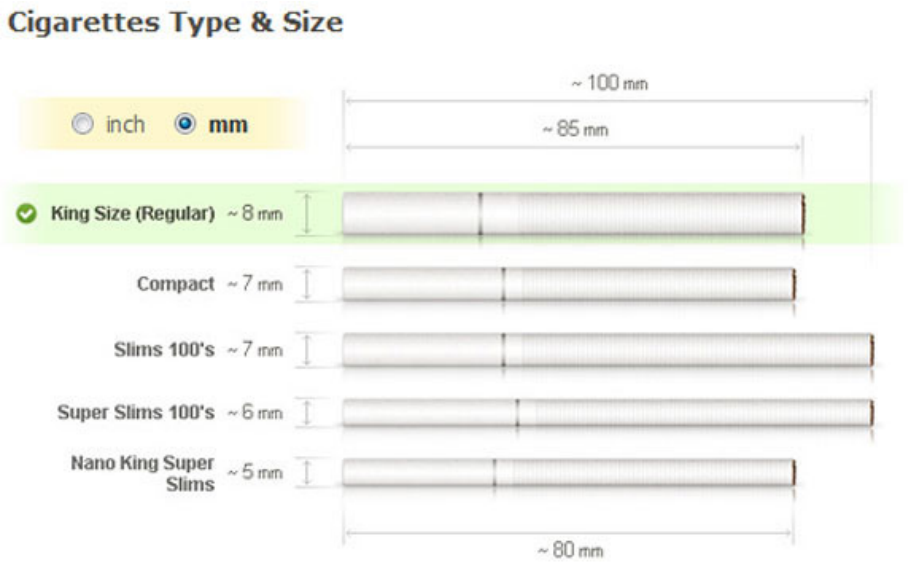


One more thing about flow and/or immersion burns of diaper area

Beware of potty training as an inciting event…always take a detailed history. If potty training was involved in any way in perineal burns in a toddler, beware.

Inflicted Cigarette Burn

- Most cigarettes are 5-7mm diameter
- Cratered center
- Heaped edges
- Sharply demarcated
- Ask about brand



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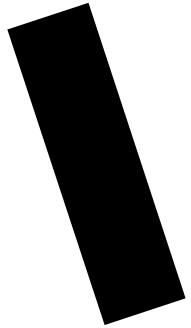
Important questions to ask

- What, if anything, was the child wearing when the incident occurred? ***Clothing can completely change the expected pattern of a burn.***
- Why/how was incident discovered? A noise? A sibling seeking help? The victim's cry? ***Be suspicious when adults report that a child never cried during/after a burn.***
- What position was child found in? Was child actively trying to get away from whatever was causing the burn?
- What is child's developmental abilities? Is it consistent with the history? (ex: knobs vs. levers)
- What did caregiver do after, for first aide, etc?
- How long ago did burn occur? **We can be fooled by borders of healing burns, in which the superficial components have resolved.**

Burn/Bruising Mimics

Hypersensitivity Reaction*

Lime juice, celery
(phytophotodermatitis)



Photos courtesy of Dr. Jordan Greenbaum

Case study

- 12 day old infant presented for concerns of a bruise mother noted on her forearm
- Skeletal, trauma labs, and head CT were unremarkable
- No other skin findings noted
- Mother reported no known trauma

Which of the following should providers do first?

A. Mom seems appropriate; workup was negative. Send the patient home with mom to follow up with pediatrician. It's just a bruise!

B. Make a CPS report and admit the child for safety until CPS can visit the bedside. This child cannot go home, as this is unexplained bruising in an infant.

C. Mother has to know what happened to this baby! Do not leave mother alone with the baby in the room.

D. Obtain additional history before deciding whether to report to CPS.

D. Obtain additional history before deciding whether to report to CPS.

- This injury location is common with self-inflicted “sucking injury” in infants
- Due to patient’s age, we need to get a complete occult trauma workup and a full history of the progression of the injury from the caregiver
- We need to ensure child’s mouth can reach the “bruising”
- If workup is negative and mouth can reach the area, PPS would be comfortable calling this self-inflicted and discharging with mother with no CPS involvement.

Thank you for your attention.

Questions?