Burns

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What is a burn?

- A burn is thermal injury to the skin
- Some or all of the different layers of cells in the skin are destroyed by hot liquid, hot solids, or a flame
- Radiation (including ultraviolet), electricity, and chemical damage to the skin are also considered burns

Burn incidence and prevalence

- 126,035 children under 19 were evaluated in emergency departments for burn injuries in 2013
- 1,100 children die each year from fire and burns
  - Nearly half of the children who died were 4 years of age or younger
- As many as 25% of burns are inflicted
- Scald burns are more common among young children
- Tap water burns most often occur in the bathroom
  - Such burns tend to be more severe and cover a larger portion of the body than other scald burns

Classification of Burn Injuries

<table>
<thead>
<tr>
<th>Degree</th>
<th>Description</th>
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<tbody>
<tr>
<td>Superficial</td>
<td>Superficial layer of the epidermis</td>
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<tr>
<td>Partial thickness</td>
<td>Extends into the dermis causing blistering and tissue loss</td>
</tr>
<tr>
<td>Full Thickness</td>
<td>Entire dermis, appendages, nerves destroyed, no pain</td>
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<tr>
<td>Fourth Degree</td>
<td>Extends into the muscles, bones and joints</td>
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Time required to sustain full-thickness burn

<table>
<thead>
<tr>
<th>Water temp (degrees F)</th>
<th>Time</th>
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<tbody>
<tr>
<td>120</td>
<td>10 minutes</td>
</tr>
<tr>
<td>122</td>
<td>5 minutes</td>
</tr>
<tr>
<td>127</td>
<td>1 minute</td>
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<tr>
<td>130</td>
<td>10 seconds</td>
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<tr>
<td>135</td>
<td>4 seconds</td>
</tr>
<tr>
<td>140</td>
<td>1 second</td>
</tr>
<tr>
<td>149</td>
<td>0.5 second</td>
</tr>
</tbody>
</table>

Features of abusive burns

- Burns often involve lower trunk, buttocks, perineum, arms, and legs
  - Can appear as “stocking” or “glove” burns
- More likely to have clear demarcation (division) between burns and normal skin, with absence of splash marks
- Uniformly severe burn
- Can see sparing (uninjured skin) of buttocks, soles of feet, flexor creases


Inflicted immersion burn with buttock sparing

This is a similar pattern of injury as seen in the previous photo, with an absence of splash or drip marks, and severe injuries affecting the thighs, perineum, and upper buttocks without any history of injury. An important difference is sparing of the most prominent portion of the buttocks; the sparing is caused by holding the child in hot water with the buttocks against the cooler surface of the tub.

Classic immersion injury pattern: Stocking and distribution

Note the symmetric severity of injuries affecting both feet. There is a notable absence of splash or drip marks, and a clear separation of injured from non-injured tissue. There is sparing at the anterior ankles bilaterally, an indication that the child’s feet were dorsiflexed (bent upward) at the time of immersion into hot water.

Accidental immersion burn

Although the distribution of injury is similar to that of the children in the previous two photos, note the lesser (and variable) severity of injury, along with the lack of clear demarcation between injured and non-injured skin, particularly on the thighs.

Classic immersion injury pattern: Glove distribution

Note that this child has symmetrically severe bilateral burns to the hands, with a clear demarcation between injured and uninjured tissue. No drip or splash marks are present. This pattern is inconsistent with the provided history of a burn sustained while washing hands.

Classic pattern of immersion burn affecting buttocks

Child 2 years old, no history of injury provided. Greater than 24 hour delay in seeking medical attention. Note that the burn is confined to the buttocks with sparing of the gluteal crease (crease between buttocks), and a clear demarcation (dividing line) between injured and non-injured skin. The absence of drip or splash marks, and the symmetrical severity of the burn, also heightens suspicion for abusive trauma.
Pourover burn

These burns are more severe at the site of impact (right side of face), and become less severe on the chest, as the liquid cooled. Drip and splash marks are readily apparent on the child’s chest, indicating that he was not wearing a shirt at the time of the incident. This could be an accidental injury, provided that the child has the age and developmental ability to have injured himself.

Cigarette burn

This burn has characteristic features of a cigarette burn, with a measurement of 7 to 8 mm in diameter: circular (or near-circular) shape, and more severe area of central burn. Cigar/cigarillo burns have a similar pattern, but the diameter and exact shape varies. Such burns are caused instantaneously when the lighted cigarette contacts the skin, as the tip has a temperature measuring several hundred degrees. Depending upon the history of injury, one cigarette burn with a full impression mark can be accidental, but multiple burns with full impression marks are diagnostic of abuse.

Lighter burn

This burn has a shape which corresponds to the top of a lighter. Such injuries are caused instantaneously upon contact with the skin, as the temperature of the metal where the flame emerges heats to several hundred degrees. This is a full impression mark, which, as with cigarette burns, can be accidental, depending upon the history of injury. However, multiple burns with full impression marks are diagnostic of abuse.

Burns from heater grate

This child sustained burns on the soles of her feet from being forced to stand on a heater grate for hours. The air coming from the grates of a forced air heating system can reach temperatures well over 100 degrees Fahrenheit. Severe injuries can be caused by forcing a child to stand over a heating grate.

Burn from contact with curling iron

The barrel of a curling iron reaches a temperature of several hundred degrees, and sustains high temperatures for a prolonged period even after being unplugged. A full impression mark of the barrel heightens suspicion of abuse, as with this non-ambulatory child.
Iron burn

Iron burns are often caused by accidental injury in young children, as it is a common practice to allow children to play in areas where a heated iron is used, or has recently been unplugged. This burn has an impression of the tip of the iron, with steam holes easily seen.

Burn from contact with hot iron

Although it can be seen that an iron caused the burn seen on the left leg of the child pictured above, based on the triangular shape and steam holes present on the thigh burn, it is difficult to discern how the child may have been positioned at the time of the injury.

Inflicted iron burns

When this child presented for medical care, the father stated that the child was left alone in a room with a hot iron while father answered the telephone. When father returned to the room, he found that the child had these injuries. The injuries are clearly inconsistent with the stated history; when confronted with this fact, father admitted that he had grown frustrated with the child and placed the iron onto his back multiple times.

Other types of burns

- Radiation burns – commonest is sunburn
- Chemical burns – acid, alkali, peppers, garlic; can cause internal injury with forced ingestion, or external injury with prolonged skin contact
- Electrical burns – combination of heat and electrical forces
- Microwave burns
Bruises

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Anatomy of skin

- Skin is a complex, multi-layered structure
- When injuries resulting in bruises occur, there is disruption of blood vessels in the dermis and subcutaneous tissue which causes the vessels to leak blood, resulting in a visible bruise
- Most bruises are the result of injuries to the subcutaneous tissue

Bruises

- Bruises are caused when soft tissue is compressed between two hard surfaces and blood vessels leak blood into the tissue
- Swelling develops due to inflammation, and resolves over first two to three days after injury
- Not a skin injury, but a blood vessel injury

Why are we concerned when we see bruises in a non-ambulatory infant?

- Previous injuries are common in children who present with severe abuse
  - One study found that 27.5% of infants classified as definitely abused had a previous injury suspicious for abuse reported in their medical history
  - In 41.9% of cases, medical providers were aware of the previous injuries
- Any bruise without a plausible explanation in a non-ambulatory child (child who does not crawl, pull to stand, or walk) is highly suspicious
- Intervention with less severe injuries may prevent future (and more serious) injuries

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Extensive facial bruising in deceased infant

Facial bruises were noted on this 8 week old child the day before her death.

Facial bruises in 5 week old child

Multiple facial bruises without a plausible explanation are seen in this infant.

Forehead, cheek bruises in head-injured 6 week old infant

Although many consider bruises a minor injury, any bruise in a non-ambulatory child is a marker for serious future injury.

Locations of accidental and abusive bruises


Accidental
- Lower legs
- Lower arms
- Chin
- Forehead
- Cheekbones
- Hips
- Elbows
- Ankles

Inflicted
- Upper arms
- Thighs
- Chest
- Abdomen
- Genitals
- Buttocks
- Face (fleshy areas)
- Ears
- Neck

Bruise incidence and prevalence

- Bruises uncommon in infants <6 months old; when bruises are seen in young infants, a plausible explanation must be provided to explore the possibility of abusive trauma
- “Those who don’t cruise rarely bruise”
  - In other words, a child who cannot crawl, pull to stand, or walk isn’t likely to cause injuries through their own activity
- Three characteristics separate abusive from accidental bruises:
  - LOCATION
  - PATTERN
  - AGE AND DEVELOPMENTAL ABILITIES OF CHILD


Accurate dating of bruises by color is not possible because:

- Color varies with depth of bruise and skin color
- Rate of healing varies with location on body
- Timing of bruise appearance depends on depth
  - superficial bruises appear early
  - deep bruises may take days to appear

Patterned injury

This injury was caused by the end of a belt, with the buckle also leaving an impression mark, on the right side of the child’s back. To the left of this patterned injury is a healing linear abrasion. The clarity of the impression mark, and the fact that the abrasion is healing, points to more recent injury. The color cannot be used as a factor in determining the likely age of injury.

Myths about aging of bruises

• Bruise with yellow is >18 hours; bruise with yellow, green, or brown is old
  • This is untrue; studies have shown that there is low inter-rater reliability in estimation of color of bruises
  • Any color can be present in new, intermediate, or old bruises
• Red, blue, or purple color means bruise is fresh
  • This “conventional wisdom” is also untrue. Red, blue, or purple color can be present anytime from one hour after injury to resolution of injury
• Bruises of the same age on the same person can vary in color

What is a patterned injury?

• Patterned injuries are injuries which have the shape and/or size of the object used to inflict injury
• A variety of shapes are seen, depending on the object
• Some classic injury patterns are:
  – Paired semicircles (human teeth)
  – Oval/circular marks (adult fingertips or knuckles)
  – Linear (belt)
  – Loop (cord)

Patterned injury:

Human bite mark, recent

This is a classic injury pattern, with paired semi-circles composed of rectangular bruises caused by each tooth; there is often a suction bruise at the center, as pictured here. The clarity of the impression marks, and the presence of abrasions and swelling, point to more recent injury.

Patterned injury:

Human bite mark – not recent

This injury again has the classic pattern of a bite mark, with paired semicircles. However, with this injury, the separate bruises caused by each tooth cannot be seen, as the bruise has faded. Also, no abrasions or other signs of acute injury can be seen. These features indicate a less recent injury.
Some people attempt to explain bites in children as being caused by an animal bite. However, as can be seen above, an animal bite is substantially different in appearance from a human bite. An animal bite has puncture wounds caused by canines (long, sharp teeth) puncturing the skin. With a bite from a large animal, there may also be crushed tissue or licks at the site of trauma.

Patterned injury: Densely clustered petechiae

Petechiae are caused when small blood vessels under the surface of the skin (capillaries) rupture. This can be caused by blunt trauma to the area, or can result from increased pressure from excessive vomiting or coughing. This finding can also be caused by strangulation due to decreased venous return. Any time there are densely clustered petechiae ending abruptly or at a ligature mark, strangulation is a likely cause.

Patterned injury: Grab marks

The shape (oval) and size (approximately 1.5 cm in diameter) of bruises on this toddler’s upper arm is characteristic of the injury caused by an adult’s fingertips or knuckles.

Patterned injury - Pattern of bruises consistent with widespread buttock trauma

This distribution of injuries, with extensive bruises on the buttocks and sparing of the gluteal crease, is a pattern characteristic of widespread blunt force trauma to the buttocks. This pattern follows anatomic lines, likely caused by stress from impact (perhaps crimping of skin along gluteal crease with forceful impact, or from shearing blood vessel rupture at the junction of the affected and unaffected blood vessels), rather than from the shape of the object.

Pinch marks

Pinch marks are another classic injury pattern most often consisting of paired semicircular marks.

Pinch marks
Pinch marks can also look as they do above, with a bruise having a crimped semicircular edge on the back of this child’s ear.

Patterned injuries: Grip or squeeze injuries
This injury type is caused by a forceful grip which squeezes tissue between the fingers, resulting in blood vessel rupture in a linear pattern in the affected areas.

Patterned injuries: Linear/overlapping injuries

The object used

Patterned injuries: Loop marks

The potential culprits
Patterned injury on infant’s back

Injury location is also an important consideration in determining whether an injury is likely to be accidental, or likely to be inflicted. This injury on an infant’s back is suspicious for inflicted trauma because it is outside the expected distribution of accidental trauma.

Common excuses given to account for bruises in an infant

- The baby bruises easily, and so do I
- He slept on a pacifier
- His sibling/the dog/his father plays rough with him
- He hits himself in the face with his own hands
- He hit himself with a bottle or toy
- He crawled into something

Analysis of common excuses

- The first excuse (“the baby bruises easily, and so do I”) implies that there is an inherited (familial) condition which results in easy bruising
- Even in people with bleeding disorders, there is some impact which causes bleeding to occur
- A qualified medical professional can help distinguish whether there is some inherited condition which increases bruise likelihood
- None of the excuses given provides a history of blunt force trauma sufficiently forceful to account for bruises

The significance of ear and eye bruises

- Eye and ear bruises are the result of direct impact to the affected areas
- Unless there is a plausible history which accounts for the injury, these injuries are highly suspicious for abuse, particularly when patterned
  - “Fell on the floor” is not a sufficient history, as falling onto a flat surface would not injure a recessed surface (such as the eye), or a structure on the side of the head (such as the ear)
- When bilateral (affecting both sides), more than one impact took place

Ear bruising in 11 month old

No history of injury was offered to account for ear bruising in this critically ill infant

Eye bruising in toddler

This child had a reported fall to the floor from a bed. He impacted a foam toy which was located on the floor. This history was inadequate to account for his eye injury.
Lacerations and abrasions

- Abrasions are caused by forcible removal of the uppermost layers of skin with an object sufficiently sharp or rough in texture.
- Lacerations result from forceful contact of the skin with an object sharp enough to pierce the skin.
- When these injuries are encountered in a child too young to be ambulatory, they are highly suspicious for abuse.

Frenular tear, nasal abrasion in 1 month old
Explanation offered was that child’s face had gotten caught in a pocket zipper.

Abrasion on 2 month old infant’s cheek
The abrasion pictured above was seen on the face of a fatally injured infant.

Facial laceration in a 1 month old
This 1 month old infant presented for care with multiple abusive injuries. When examined, she was noted to have this healing facial laceration which occurred at 2 weeks of age without an adequate explanation.

Other injuries

Cauliflower ear

- Blunt trauma to ear causes auricular hematomas (collections of blood within ear).
- Depending on location of bleeding, permanent damage to ear may result from disruption of blood supply to ear cartilage, and formation of fibrous (scar) tissue.
Cauliflower ear

Fatty necrosis due to chronic tissue injury
This unusual finding is due to death of fat cells as a result of chronic mechanical injury to the area (likely repeated beatings with a rigid object). This injury is permanent.

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Forensic analysis of child sexual abuse

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Evaluation of potential sexual assault

• History of injury (interview of patient, caregiver)
• Physical exam
• Forensic evidence collection
• STI testing
• Prophylaxis of STIs, pregnancy

Forensic evidence collection

• Collected within 72 hours of assault
• Contains:
  – Instructions
  – Swabs for body fluid collection
  – Slide for smear/wet prep
  – Comb for pubic hair collection
  – Envelopes for hair and debris
  – Envelopes for clothing worn during assault
  – Tubes for blood collection
  – Seal to prevent evidence tampering

Recommended guidelines for evaluation of sexually transmitted infections (STIs) in sexual assault

• Child has or had symptoms of an STI
• Suspected assailant is known to have or be at high risk for an STI
• Sibling or household member has STI
• Family requests testing
• Prevalence of STI in community is high
• Evidence of penetration or ejaculation

Neisseria gonorrhoea

• Biology:
  gram negative intracellular diplococcus, may be found in vagina, rectum, oropharynx, conjunctivae, urethra

Neisseria gonorrhoea: Epidemiology

• direct contact with infected persons
• no fomite transmission
• can cause neonatal disease
• incubation period 2-7 days

### Neisseria gonorrhoea: Clinical Presentation
- 45% children are asymptomatic
- Can cause vaginitis, anorectal infection, and pharyngitis in children; plus salpingitis, prostatitis, urethritis, in teens
- Wide range of infection rate among sexually abused children: 2.5-28%
- Within 7 months 87% of infected prepubertal children are disease free without treatment
- Diagnosis of GC in children outside the neonatal period is diagnostic of sexual contact

### Chlamydia trachomatis: Epidemiology
- Perinatally and sexually transmitted
- No fomite transmission
- Can cause neonatal infections
- Incubation period at least one week
- Most common US STI
  - prevalence high (>10%) in sexually active adolescent females
  - 4 million new infections per year in US

### Chlamydia trachomatis: Clinical Infections
- High rate of asymptomatic infections
  - 70% of women without symptoms
  - 50% of men without symptoms
  - women < 20 years most susceptible
  - infections in males most often urethral, can also be rectal

### Trichomonas vaginalis
- Biology: flagellated protozoan
- Epidemiology: exclusively sexually transmitted in teens and adults; possible neonatal disease; no fomite transmission; should be reported as abuse; incubation period averages one week, range 4 to 28 days
- Clinical syndrome: vaginitis with pruritis; can infect urine
- Diagnosis: test for RNA on a urine sample
- Treatment: metronidazole, also treat contacts
Herpes simplex: Epidemiology

- Virus enters mucosal surfaces through an epithelial break
- Sexual transmission most common in childhood genital herpes
- Autoinoculation is possible
- No fomite transmission
- Incubation period 2 days to 2 weeks

Herpes simplex: Clinical syndrome

- Systemic signs (fever, headache, malaise, inguinal adenopathy, nausea) with first infection
- Initial outbreak accompanied by pruritis and swelling
- Papules and vesicles develop, then ulcerate in 1 - 3 days
- Lesions found on vulvae, vagina, cervix, rectum

Herpes Simplex Virus: significance of subtypes

- HSV-1 or HSV-2 can be found in the oral or genital region
- Viral culture and typing should be done on all suspicious lesions
- Must be reported; link to sexual abuse probable for type 2, and possible for type 1

Laboratory testing in sexual assault

Urine
- Testing of gonorrhea, chlamydia, Trichomonas testing using nucleic acid amplification techniques
- Pregnancy, if post-pubertal
- Drug screen, if applicable

Secretions
- Vaginal/rectal/oral cultures as appropriate for GC and chlamydia
- Wet prep for trichomonas, candida, bacterial vaginosis
- InPouch for Trichomonas
Serologic testing in sexual assault

- **Syphilis**
  - usually tested in cases of sexual assault
  - must be serially tested
- **Hepatitis**
  - Type B tested more often prior to universal immunization
  - must be serially tested
  - other subtypes tested as needed

**Herpes**
- Assists in establishing timing of infection exposure when lesions present, if done soon enough after exposure

**HIV**
- usually tested for in assaults
- suspicion similar to that for hepatitis
- must be serially tested
- uncommon in child abuse

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<tr>
<th>STI</th>
<th>Sex Abuse?</th>
<th>Suggested Action</th>
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<tr>
<td>Gonorrhea</td>
<td>Diagnostic</td>
<td>Report</td>
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<tr>
<td>Chlamydia</td>
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<td>Syphilis</td>
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<tr>
<td>Trichomonas</td>
<td>Highly suspicious</td>
<td>Report</td>
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<tr>
<td>Condyloma</td>
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<td>Report</td>
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<tr>
<td>Herpes</td>
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Examination findings in sexual assault

Hymenal Bruising
- Prepubertal
- Pubertal

Healing injuries

Comparison of acute and healed exam findings
Hymenal transections in adolescents

Single

Multiple

Anal injuries

Acute

Healed
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Fractures

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Types of forces, illustrated

Bending load, illustrated

Torsion, illustrated

Deformation

- Deformation is one of the possible effects of a force acting on a body; the other effect of force acting on a body is acceleration (like in the classic physics equations)
- Factors influencing deformation are strength, elasticity, and geometry of object
- Deformation permanent once elastic limit of object is reached
- When deformation exceeds ultimate failure point, mechanical failure of structure results (fracture, in our case)
Properties of mature vs immature bones

• Adult cortical bone strongest in compression, weaker in tension, weakest in shear loading
• Immature bone weakest in compression
  – An edge effect exists in the transition from cortex to metaphysis, making the metaphysis more susceptible to failure in compression

Mechanical properties of mature and immature bone

• Children’s bones have lower mineral content than adult bone, and are more elastic, but less stiff
• Children’s bones can absorb relatively more energy before permanent deformation and fracture occurs
• Explains some fractures that are unique to children (i.e., greenstick, buckle (torus) fractures)

What is a fracture?

• A fracture is a disruption in the bone due to externally applied forces
• Fractures have multiple configurations which can give important information about the type of force causing the fracture
• Understanding this relationship between type of force and fracture type can permit an experienced clinician to determine whether the fracture history is consistent with the injury
• Bruises are often not present at the fracture site because many fractures occur via indirect forces

Evaluation of fractures

• There is no single fracture type which is diagnostic of abuse
  – Rib, metaphyseal fractures highly associated with abuse
• Diagnosis of abuse depends upon age and developmental ability of child, along with history of injury
  – When fractures occur in a child who is not ambulatory (able to get around on their own), there is a heightened suspicion for abuse in the absence of a plausible explanation for the injury

Screening for skeletal trauma

Skeletal survey
  – detects occult skeletal injury
  – includes all extremities individually, hands and feet, 2 views of the chest/spine, 2 views of the skull
  – Recommended for all infants < 2 years old
  – used occasionally in children 2-5 and not indicated over 5 years old
  – One x-ray of the entire body is not sufficient for diagnosis of fractures

Inflicted Fractures

Bone has a complex structure composed of compact bone, spongy bone, marrow, and periosteum. The periosteum is a thin membrane overlying the bone which contains blood vessels and nerves. When a bone is fractured, there is disruption of the periosteum which causes bleeding into the area surrounding the fracture, and severe pain at the fracture site.


Type of force applied can be deduced from fracture configuration


Fracture types which are very highly associated with abuse

Metaphyseal fractures
These are subtle fractures which can be overlooked by a non-pediatric physician, as they occur in the non-calcified portion of a developing bone and do not show up well on x-ray. Two can be seen on the x-ray to the right; the white arrow shows a fracture which appears to be a “bucket handle” above the proximal end of the tibia (bone in the lower leg, just below the knee), and the black arrow indicates a fracture which appears to be a chip off of the distal tibia (bone in the lower leg, just above the ankle). Despite the different appearances, these are both metaphyseal fractures.

Thackeray et al. The classic metaphyseal lesion and traumatic injury. Pediatr Radiol 2016;Feb 22 [Epub ahead of print]

Another example of a metaphyseal fracture

The white arrow indicates a fracture which appears to be a chip off of the distal femur (end of the thigh bone, near the knee). Again, this is a subtle fracture which occurs in the non-calcified area of bone, and is difficult to see on x-ray. Metaphyseal fractures usually cannot be dated by their appearance on x-ray.


Rib fractures
Rib fractures in infants most frequently occur as a result of abusive injury, which is why they are highly specific for abuse. Forceful compression of the ribcage causes fractures at the lateral (at the sides) and posterior (along the spine) ribs. Blunt trauma to the ribcage can also result in a rib fracture, but the location varies when fractures are caused by a direct blow to the chest. Although rib fractures could rarely be caused by an accident, they are almost always inflicted when seen in an infant.

Illustration of how compressive forces deform the ribcage

In the above schematic diagram of a cross-section of a chest, the dashed lines represent the uncompressed ribcage. With compressive forces represented by solid lines, the ribcage bends outward at the sides. The ribs are also forcibly pushed against the bones of the vertebral bodies, which protect the spinal cord. In this way, it can be seen that fractures occur laterally and posteriorly with ribcage compression.

Multiple rib fractures of varying ages on chest CT

In this cross-sectional CT image, multiple rib fractures can be seen. In the upper right corner of the image (black arrow), a healing rib fracture with soft callus (new bone) formation is seen. An acute (new) rib fracture is seen at the bottom of the image (black arrow). A rib fracture in an advanced state of healing can be seen on the left (aqua arrow).


Difficulty with recognition of acute rib fractures is illustrated by these x-rays of the same child at two different points in time. Although rib fractures are suspected at multiple areas, the true extent of fractures cannot be detected until two weeks later, when an x-ray reveals multiple areas of callus (new bone) formation.

Dating fractures

- Can obtain general time ranges for long bone fractures by looking at x-rays
  - e.g., few days; approximately 2 weeks; several weeks old; exception is metaphyseal fractures
- Cannot distinguish specific times from review of x-rays
  - For example, there is no way to determine whether a fracture occurred on Tuesday at 6 vs Thursday at 12 by looking at x-rays
- More precise injury timing can be obtained by finding out information regarding onset of symptoms

Dating fractures

- General timing information comes from looking at stage of fracture on radiograph
  - Subperiosteal new bone formation [SPNBF] (10-14 days)*
  - Loss of fracture line definition (14-21 days)
  - Soft callus formation (15-21 days)
  - Hard callus formation (21-42 days)
  - Remodeling (at least 3 months)

*Timeframes given are the early or peak timeframes associated with that stage of injury healing, and are not meant to be exact

Recent arm fracture in 4 month old infant
Subperiosteal new bone formation (a shadow alongside the bone) is seen at the proximal humerus (upper arm, near the shoulder joint), as indicated by the arrow above.

Healing arm fracture in 4 month old infant
The white arrow above indicates a fracture in an advanced state of healing, with hard callus formation. No history of injury was provided to account for any of her injuries.

What are fracture symptoms?
• Pain with movement or manipulation of the involved area
  – e.g., inconsolable crying with diaper changes or attempts to dress a child with femur fracture
  – Increased fussiness when picked up, crepitus (crackling under skin) of chest wall specific for rib fracture
• Onset of pain is immediately after fracture, so a careful history can provide information about when fracture occurred
• Child may be able to sleep after a fracture has occurred, but the parent usually describes a restless sleep with frequent awakening/cries as the injured area is moved during sleep

Case history
• 2 year old went out for dinner with parents and 4 year old brother
• Restaurant was busy, children and parents walked outside to wait for table
• Children started playing “WWE”, and 4 year old sat on 2 year old and twisted his leg
• Parents heard “pop”, 2 year old started screaming, could no longer bear weight on leg

Spiral fracture
When evaluated in the Emergency Department, this spiral fracture of the femur [thighbone] was found. This type of fracture occurs with torsion (twisting) of the affected arm or leg. Conventional wisdom is that spiral fractures are always abusive, because they involve twisting force, but in this instance, the injury was accidental in nature. When a child is old enough to get around on their own and independently engage in activities, they can sustain injuries on their own, and may even hurt themselves during a fall which is not witnessed by caregivers.

Case history
• 2 month old brought to hospital this morning by his babysitter, who was concerned about child not moving arm
• This morning was the first time babysitter had seen child in two days
• Parents told babysitter that child had not moved his arm in past 24 hours
• Babysitter stated that parents did not provide history of injury
Oblique fracture

This fracture was seen when the infant’s arm was x-rayed. An oblique fracture is caused by a complex combination of forces, usually bending with compression, or bending with torsion (twisting). Snatching an infant up by the arm could lead to this fracture. Grabbing a falling infant by the arm or leg in an attempt to keep the baby from striking the floor could also cause such an injury.

Vertebral compression fracture

Vertebral compression fractures are disruptions of the vertebral body (the anterior part of the bones protecting the spinal cord; see arrow in figure) which cause flattening of these normally tall bones. This type of fracture is caused by axial loading forces on the spine (severe forces which transmit vertically along the spine). Axial loading occur when a child is slammed onto their buttocks against an unyielding surface (e.g., furniture or floor). These injuries can occur through accidental means, generally in ambulatory children. A plausible accidental history could be a fall from playground equipment in which a child lands on their buttocks.

Linear skull fractures – often accidental, but not always

Complex skull fracture – high force trauma

Differential diagnosis of skeletal trauma

- Obstetric trauma
  - Clavicle fracture common, humerus or femur fracture less common, rib fracture rare
- Osteopenia of prematurity
- Nutritional deficiency
- Metabolic disease
- Infection
- Neuromuscular defects
- Skeletal dysplasia
  - Osteogenesis imperfecta
  - Hypophosphatemia
  - Osteopetrosis

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Female genital anatomy
Examination techniques

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It’s normal to be normal

- Abnormal findings in 14% of cases referred to sexual abuse evaluation program with perpetrator conviction, guilty plea, or confession
  – Adams, Pediatrics 1994;94:310-317
- 4% of 2384 children referred for sexual abuse exams had abnormal examinations
  – Heger, Child Abuse Negl 2002;26:645-659
- Physical examination abnormalities in 7% of cases resulting in felony conviction
  – DeJong, Pediatrics 1989;84:1022-1026

Why Are Sexual Abuse Exams Usually Normal?

- Genital and anal structures heal rapidly and completely
- Genital and anal structures are elastic, allowing penetration without injury
- Many sexually abusive acts do not involve injury (fondling, pornography)
- When a child says penetration occurred, the act often involves objects placed between the labia or buttocks, rather than through the hymenal ring or into the anus

Myths about sexual abuse

- Normal-appearing, well educated, middle-class people don’t molest children
- Children who are being abused would immediately tell their parents
- Children who are being abused will show physical evidence of abuse

Myths & misconceptions about the hymen

- It’s a thin covering that is broken with penetration
- It is always injured with sexual contact and cannot heal
- Some girls are born without hymens
  – All female infants have hymens in large studies (Jenny et al, 1987 - 1131 exams; Merlob et al, 1978 - 25,068 exams)
- It can be torn by horseback riding, gymnastics or with a tampon
- Its presence is proof there has been no penetration
  – Over 80% of pregnant teenagers had normal examinations in one study (Kellogg N et al, Pediatrics 2004;113:e67-e69)
14 year old who is 4 weeks pregnant (Kellogg et al, 2004)

Frog leg position

Lithotomy “Frog Leg” Position

- May be done in caregiver’s lap
- Gently retract labia vs. traction
- Down & out
- Side to side

Knee Chest Position
Qtip examination

Foley catheter examination

Annular

Annular variations

Crescentic

Redundant
High attaching

Developmental Anatomy

Hymenal appearance in infancy

Hymenal appearance in childhood

Hymenal appearance in adolescence

Anal Exam Techniques

- Supine “cannonball”
- Lateral decubitus
- Standing prone
Normal Anus

Anal Tag

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Neglect

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Forms of neglect

• Educational
• Medical
• Physical
• Nutritional

Educational neglect

• When child not enrolled in school
• Fails to attend school
• Special educational needs not being met

Medical neglect

• Nonadherence with medical recommendations
  – For example, a severe asthmatic not getting or taking prescribed medications
• Delay or failure in getting health care
  – Such as failing to treat a severe burn, infection, or other problem that a prudent caregiver should recognize
• Refusal of medical treatment
  – E.g., refusal of medical treatment on religious grounds, or because alternative treatment is preferred

Physical neglect

• Inadequate protection from environmental hazards
• Inadequate supervision
• Inadequate hygiene
• Failure to provide adequate shelter
• Inadequate clothing

Picture of dirty house
Home with multiple hazards to health and well-being, such as garbage, items piled high, dirty objects and surfaces
Failure to thrive (FTT)

- Growth failure occurs in 10% of young children
- Represents 1 - 3% of all pediatric admissions
- It crosses all socioeconomic levels
- Most failure to thrive (FTT) is mixed in etiology; even organic FTT often includes a non-organic component
- Nonorganic etiology accounts for 70%-80% of growth failure

Common dietary pitfalls in FTT

- Overdilution of formula
- Large amounts of cereal in bottle
- Excessive fruit juice, soda, or water
- Inappropriate food texture
- Infrequent feeds (quiet children)
- Lack of established feeding times
- Lack of high chair
- “Grazing” (eating small amounts through day)
- Distractions from feeding
- Feeding struggles

Social problems in malnutrition

- Family disorganization
- Social isolation
- Post-partum or other depression
- Substance abuse
- Violence
- Parental stress
- Poverty
  - food shortages at end of month
  - lack of cooking facilities
  - crowding, leading to distractions

Physical examination:
Signs of malnutrition

- Decreased pulse, temperature, BP
- Decreased activity, apathy, hypotonia
- Decreased adiposity (fat deposition)
- Prominent ribs and bone structures
- “Old” skin, pallor
- Sparse fragile hair
- Heart murmur from anemia
- Protuberant abdomen, organomegaly
Physical examination: Growth assessment

- Weight, height, head circumference, and weight for height are the growth parameters measured on growth curves
  - Head circumference is a measurement which assesses brain growth
- Doctors plot measurements on growth charts
- Serial measurements are crucial; one point on a graph is difficult to interpret
- Patterns of growth may suggest specific diagnoses

Evaluation of growth charts

- Appropriate growth chart must be used (e.g., male, female, premature, cerebral palsy, Down syndrome)
- Pattern of growth must be evaluated carefully, with consideration of underlying medical conditions
- Sudden changes must be evaluated, may provide clue to underlying problems
- There is a wide range of normal values for each age range
- Bold line in center of the shaded section is the average measurement (weight, height, or head circumference) for a child of that age

The child with failure to thrive:
1) has not taken,
2) has not been offered, or
3) has not retained adequate calories for growth.

Percent of median weight for age as an indicator of severity of malnutrition

75-90% of median = mild
60-74% of median = moderate
<60% of median = severe

For instance, a 12 month old girl who weighs 7.3 kg has a median (50th percentile) weight of 9.7 kg. She is at 75% of her median weight, indicating mild FTT.
Signs of malnutrition
Additional signs of malnutrition are the prominent hip, sacrum, and spine bones, along with a lack of subcutaneous fat. He was not being fed by his mother, despite an adequate supply of formula through WIC. By the time of his admission, his suck reflex was uncoordinated, and he required speech therapy to ensure adequate oral intake.

Growth chart for child in Case 1
This growth chart shows the length (upper chart) and weight (lower chart) for the child in Case 1. Although the child’s growth crossed growth percentiles in the first month of his life, his weight and length remained in the normal range for that time period. However, by the time of his hospital admission, he was well below the normal growth curve for weight and length. Note that the charting of his growth parameters is corrected for his 1 month of prematurity.

Growth chart for child in Case 1
This is the graph of head circumference in Case 1. Measurement of head circumference is a proxy for measuring brain growth. His head circumference crossed growth percentiles in the first month of life, but remained in the normal range. However, by the time of his hospital admission at 5 months of age (corrected age of 4 months plotted on graph), he was below the 3rd percentile for head growth. The failure of head growth indicates that the child will have permanent consequences from the malnutrition he suffered in early infancy.

Case 2:
Three year old child with kwashiorkor
Kwashiorkor is protein-energy malnutrition, most commonly seen in countries experiencing severe food shortages. Children with kwashiorkor typically have very thin arms and legs, with swelling (edema) most often seen at their stomachs and lower legs. This child was extremely weak and edematous (swollen) at hospital presentation, with severe edema affecting most of his body. He lost 7 pounds in water weight over the course of a week in the hospital, and was found to weigh 20 pounds, which is the average weight for an 8 ½ month old infant. He had been primarily breastfed until his admission. Note the prominent ribs and lack of subcutaneous fat on his arms. His hair was fine and thin, and was easily shed from his scalp. Petechiae are present because of extensive edema.

Severe edema of feet
This 3 year old child had been primarily breastfed through his entire life, with only crackers, juice, and rice introduced to his diet. He had severe edema affecting his entire body.

Lack of subcutaneous fat on buttocks
Although his mother thought he was “chubby” due to his edema, he lacked subcutaneous fat throughout his body.
This 3 year old child could not stand unassisted, could not walk, and was unable to change positions (i.e., from kneeling to standing) without assistance. He had fewer than five words in his vocabulary. The infant and toddler years are typically a time of rapid weight gain, brain growth, and linear growth. When a child suffers severe nutritional deprivation, the brain misses this critical time period of rapid growth, resulting in irreversible brain damage. This damage results in permanent consequences for the child, including cognitive impairments, emotional problems, learning disabilities, and poor impulse control. This child will have lifelong consequences of the severe neglect he experienced.

This child had never visited a doctor, and so there were no previous measurements of growth parameters for comparison. However, his weight and length were well below the third percentile for his age.

Despite the presence of cortical and cerebellar atrophy on his MRI, this child's head circumference was above the 50th (average) growth percentile for head circumference in a child of his age. However, when the head circumferences of his siblings were measured, they were at approximately the 95th percentile for their respective ages. Thus, he has comparatively less brain tissue than his immediate family members. This brain tissue loss means that he will have lifelong consequences because of his severe malnutrition.

This infant presented for care with seizures; electrolyte levels revealed that his sodium was extremely low. His mother had been adding excessive water to his formula to stretch the supply received from WIC. His weight was 10 pounds (the average weight for a one-month-old infant) at admission.

Loose skin folds are seen on his trunk and extremities. He also had a worried expression on his face, and did not want to lose sight of the examiner when turned; he kept turning his neck backward.
Growth charts for weight and length: Case 3

This growth chart reveals that, although the infant was at the average length for a two-month-old, by the time of his hospital admission at four months of age, he was at the 75th percentile for length. His growth percentile for weight has changed as well. At birth, he was at the 25th percentile for weight, but by age four months, was at less than the third percentile.

Head circumference plot: Case 3

A plot of this child’s head circumference reveals that he was at the 50th percentile at the time of his hospital admission. According to records from his pediatrician’s office, his head growth had consistently been at the 50th growth percentile throughout his life. When a child experiences failure to thrive, the first growth parameter affected is the weight. With continued nutritional deprivation, the linear growth declines. When there is severe or prolonged deprivation, the head circumference is affected, meaning that the child will suffer permanent deficits due to nutritional deprivation (such as in Case 2).

Fatal Starvation

Although rare, starvation which results in the death of a child can occur. Below are listed two references which can aid a clinician in making an assessment regarding the approximate number of days food was withheld, and in calculation of daily caloric requirements needed to prevent death.


Indications for hospitalization

- Below birth weight at 6 weeks
- Infant less than 6 months
- Head circumference falling off curve at < 6 months
- Signs of abuse/ gross physical neglect
- Failure of outpatient therapy
- Pursuit of organic diagnosis
- Home unsafe/ caretaker inadequate

Types of Nonorganic Failure to Thrive

- Neglectful
- Accidental
- Poverty-related
- Deliberate starvation

Systematic study of the causes of failure to thrive among children admitted to a hospital revealed a medical cause approximately 30% of the time.

Why can failure to thrive cause permanent neurologic deficits?

Berwick, Arch Dis Child 57:347 1982
Early brain development

- Head circumference measurements are a proxy for brain growth
- Brain growth accelerated early in life
  - Brain is ¼ adult size at birth
  - Brain is 80% of adult size by age 3
  - Brain is 90% of adult size by age 5
- Majority of brain growth in early childhood results from synaptic or dendritic growth (growth of connections between brain cells) and myelination (coating of nerve axons with waxy substance)

Dendrite formation

- At birth, neurons (brain cells) are present, but poorly connected
- A substantial portion of brain growth in early childhood results from formation of dendrites
  - Dendrites sprout from nerve cell
  - Dendrites connect (synapse) with other neurons
  - Each neuron develops hundreds of dendrites over time
- Exuberant growth period results in massive burst of synapse formation after birth
- Synapse formation continues into early childhood
- Pruning of synapses begins in middle childhood, continuing through adolescence

Myelination

- Myelination is the other process beginning early in childhood
  - Myelin is a fatty coating on the axon of the neuron
- Myelination of nerve cell axons results in faster signal processing
- This process continues into the early 20s, sometimes up to age 30
- Malnourishment is the only environmental factor known to disrupt myelination

Outcomes in failure to thrive

- Growth
- Emotional Development
- Intellectual Development

Growth

- Treated adequately most children catch up to some degree
- On follow-up most children are smaller than peers
  - 25-30% have weights and heights below the 3rd percentile
  - Some children reach near normal growth after years of intensive therapy
- Severe growth failure leads to decreased brain growth and smaller head circumference
Emotional Development

• High incidence of emotional disorders
• Significantly lower social maturity
• Significantly more behavior problems
  – Impulsive, disorganized
• Increase in psychiatric services
• Insecure attachments
• Deficits in social responsiveness

Intellectual Development

• Decreased IQ
• Significant school difficulties
• Delayed speech
• Delayed conceptual thinking
• Decreased language and reading skills
• Decreased math skills
• Repeated grades
• Poor impulse control
• Poor attention span
• Poor memory

Other Outcomes

• Impaired immunocompetency (ability to fight infections)
• Combination of neglect and FTT causes worse cognitive outcome than nutritional deprivation itself (Mackner CAN 1997)
• Early postnatal FTT is a risk factor for serious future parenting deficiencies (Skuse J Med Screen, 1995)

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Berwick, Ped Rev, 1980; Drotar, J Dev Behav Ped 1992;
Oates, Peds 1985; Corbett, J Psychol and Psychiat, 2004; Alaimo 2001 Peds
Abusive head trauma (AHT)

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Abusive Head Trauma (AHT):
Definition

- Diagnosed by presence of intracranial bleeding/cerebral edema
- Retinal hemorrhages present in about 70% of cases
- History often absent or does not explain findings
- Can have fatal intracranial injury without externally visible trauma
- Associated non-cranial injuries highly concerning for abuse

AHT:
Epidemiology

- Highest incidence in children under one year of age, with peak incidence in children aged 6 weeks to 4 months
- Peak incidence of AHT corresponds to increase in infant crying, which is a normal developmental occurrence
- Can occur in children as old as five years; adult cases in literature
- Prevalence of shaking as form of discipline as high as 2% – Random digit-dial telephone survey in North Carolina
- Many adults and teenagers do not realize the dangers of shaking

Incidence of AHT

- 1000-1500 cases in the US every year – Misdiagnosis, underreporting are likely to make the true number higher
- Estimates of incidence reveal that 95% of serious intracranial injury occurring in children under 1 year of age, and 85% of serious intracranial injuries in children under 2 years of age, are due to inflicted trauma
- At least 2000 children die from abuse and neglect every year; AHT accounts for 10-12% of child abuse and neglect deaths

AHT: Definition of terms

- Extraaxial spaces defined by: dura mater (outermost layer), dura arachnoid, and pia arachnoid layers (adherent to brain)
- Dura is double-layered membrane; outer layer (periosteal layer) adherent to inner table of skull at sutures, and inner layer (meningeal layer) with attachments to underlying dura arachnoid

Data source:
www.shakenbabycoalition.org
Anatomy of dural layers

- Inner dural layer
- Dura arachnoid
- Potential subdural space lies between the inner dural layer, and dura arachnoid
- Contains bridging veins which extend from brain surface, penetrate arachnoid, and cross subdural space into the intradural space to empty into the dural venous sinuses

Contact head injuries

- Skin/scalp/subgaleal contusion
- Skull fracture
- Epidural hematoma
- Focal subdural hematoma
- Cortical contusion

Inertial brain injuries

- Interhemispheric or diffuse subdural hemorrhages
- Concussion
- Gliding contusions or lacerations
- Diffuse axonal injury
- Injuries at the cranio-cervical junction
- Diffuse retinal hemorrhages or retinoschisis

AHT: Anatomy

- Potential subdural space lies between the inner dural layer, and dura arachnoid
- Contains bridging veins which extend from brain surface, penetrate arachnoid, and cross subdural space into the intradural space to empty into the dural venous sinuses

AHT: Biomechanics

- Shaking causes angular acceleration of brain tissue, with high peak accelerations causing damage
- Bridging veins between skull and brain are snapped, causing cerebral contusions and intracranial bleeding
- Shearing often occurs at junction of gray and white matter
- Infant brain susceptible to injury because of large head size, relatively weak neck muscles, large subarachnoid space, delicate bridging vessels


Finnie et al. Neuropathological changes in lamb model of NAHT. J Clin Neurosci 2012
AHT: Biomechanics

- Properties of infant and mature brain differ
- Some studies have shown that shaking alone not sufficient to cause injury
- Injury thresholds have been set using primate data, or (adult) human cadavers; not known if these thresholds apply to infants
- Studies using crash-test dummies show impact of head on chest, as well as on upper back with severe shaking; this may be ample force to generate serious injury

Jenny, C. et al. Development of biofidelic 2.5 kg infant dummy. Injury Biomech Research

AHT: Mechanism

- Perpetrator often holds child by chest, compressing the chest while forcefully shaking at full arm extension
- Forces involved are much greater than those involved in normal parenting
- Usually large size differential between perpetrator and victim; adult (or adult-sized person) required
- Rib and extremity fractures can result

AHT: Symptoms

- Wide range of symptoms possible
- It is not possible to predict exactly which symptoms occur after an event, but it is possible to say that the child will not be acting normally after severe injury
- A careful history can provide specific information about symptom onset
  - This is helpful to determine timing of injury
- Symptoms may begin at any point in the range of severity, and either become progressively more severe or gradually improve
- Symptoms may begin as non-specific with mild injury; with more severe injury, symptoms more often specific to brain trauma

AHT: Symptoms

- Sleepiness, lethargy
- Irritability
- Poor feeding
- Vomiting
- Alteration in level of consciousness
- Loss of consciousness
- Seizures
- Apnea
- Coma
- Death

Subdural Hematoma

Normal CT
Subdural hematoma

Diffuse axonal injury

Biomechanics of Retinal Hemorrhages

- Most likely mechanism is through vitreous traction
  - shaking produces traction on the tightly adherent vitreous, tearing blood vessels and causing bleeding into the retina

Retinal hemorrhages

Encephalomalacia

- Softening or degeneration of brain tissue after hemorrhage, inflammation or injury
- Term can also refer to a loss of brain tissue
- Can cause death of brain tissue
- If the brain tissue dies, the tissue will disintegrate, leaving a fluid-filled space
Encephalomalacia

Case information

Infant is a 3 month old male who has been ill for the past four days
- Well Monday during day, while home with mother
- Mother went to work that evening, child vomiting when she returned home at 11 pm
- Baby up all night vomiting, feeding very little
- Gradual improvement throughout the day Tuesday
- Worse on Wednesday afternoon, vomiting and lethargy noted; had been home with father during the morning while mother at school
- Never seemed to return to normal feeding or alertness Wednesday or Thursday; was home with both parents
- Started having a seizure on Friday morning, taken to doctor’s office and referred to Emergency Department

CT findings

MRI findings

Eye examination

Questions

• What happened?
• When?
• Who is the likely perpetrator?
• How many events took place?
Short-term outcomes

- Mortality from abusive head trauma is high, with figures varying from 12% - 30%
- Children with injuries from non-accidental trauma have more severe injury, and worse outcomes, than children with accidental trauma
- 25% - 33% of abusive head injury victims leave the hospital without any obvious neurologic deficit

Ewing-Cobbs 1998, Starling 2004

Long-term outcomes

- Following families long-term is difficult, since families unstable; because of confidentiality restrictions, not many studies done involving long-term follow-up
- Some studies have shown that, of those who left the hospital without apparent deficits, very few remain normal

Duhamel 1996, Barlow 2004

Long-term outcomes

- Abnormalities include behavior problems, poor vision, cognitive deficits, mental retardation, hemiparesis
- Special education required for many
- Can take years for epilepsy or behavioral and neuropsychological abnormalities to be recognized

Defense theories about AHT

- Short falls cause severe injuries
- Babies are fragile
- Injuries could happen spontaneously
- Injuries are the result of a medical condition
- AHT does not exist
- It’s head injury, but my client didn’t do it

Timing of injuries

Research suggests immediate onset of symptoms after inflicted trauma events (Nashelsky et al 1995; Starling et al 2004)
- In 52/57 cases in which perpetrator confessed to head trauma, immediate symptom onset noted
- The other five cases were either not checked on for several hours after event, or caretaker did not provide information about symptom onset

Evaluating the potential effects of a fall

<table>
<thead>
<tr>
<th>Decreased risk</th>
<th>Increased risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower height</td>
<td>Greater height</td>
</tr>
<tr>
<td>No initial velocity</td>
<td>Has initial velocity</td>
</tr>
<tr>
<td>Soft impact surface</td>
<td>Hard impact surface</td>
</tr>
<tr>
<td>Lower mass</td>
<td>Greater mass</td>
</tr>
<tr>
<td>High elasticity</td>
<td>Low elasticity</td>
</tr>
<tr>
<td>Large impact area</td>
<td>Small impact area</td>
</tr>
<tr>
<td>High moment of inertia (I)</td>
<td>Low moment of inertia</td>
</tr>
<tr>
<td>Low angular velocity (ω)</td>
<td>High angular velocity</td>
</tr>
<tr>
<td>Low angular momentum (Iω)</td>
<td>High angular momentum</td>
</tr>
</tbody>
</table>
Childhood Falls

1977 Helfer 246 cases all falls from beds, 3 linear skull fx, no deaths
1987 Nimityongskul 76 cases all falls from bed/cribs, 97% minor injuries, 1 linear skull fx, no deaths
1988 Joffe 363 cases all stairway falls, 92% minor injury, 6% distal fx, 1 concussion, no deaths
1991 Williams 106 cases all witnessed falls, 77 minor injuries, 14 severe injuries (5-40 ft), no lethal injuries: <10 feet, 1 death at 70 ft
1993 Lyons 207 cases all witnessed falls from cribs/beds, 29 minor injuries, 1 linear skull fx, no death
1991 Chadwick 317 cases reported falls, 7 deaths <4 ft (all hxs felt to be false), 0 deaths 4-10 ft, 1 death >1 ft

Childhood Falls

2008 Chadwick Meta-analysis of literature on short falls National Electronic Injury Surveillance System (NEISS) found 3 short fall deaths among 400,000 children, calculated rate 0.625 cases per million young children per year; California Epidemiology and Prevention for Injury Control Branch (EPIC) database found 6 short fall deaths per 2.5 million children in five years, or 0.48 cases per 1 million children per year

2010 Haney 122 children who fell before age 2 years 209 short falls (bed, couch, changing table; all falls 4 ft or less); 34% of falls with injuries (bruises, bumps, scars); no serious injuries

2010 Osifo 12 children ages 3 years or less Falls from varying heights, including from a staircase; into a pit; from furniture; and 3 without fall information. 2 without injuries, 4 with bruises/lacerations, 6 with moderate injuries (head injury, penetrating trauma); no deaths

2011 Shields 31264 balcony falls in children Fall heights ranged from 5 to 87.5 feet, most falls 12.5 feet or less; 2 deaths (girls ages 6 and 11 years), with fall heights ranging from 5 to 50 feet

In summary:

- If you are given a history of serious injury with a fall from short distance, history is usually factitious
- Fall from couch, bed, crib, changing table can rarely cause a linear parietal skull fracture; there is almost never a serious or life-threatening injury from such a fall
- Falls down stairs seldom result in serious head injury

Do deaths happen as a result of short falls?

- Deaths due to short falls do occur but are extremely rare
  - 0.14 - 0.22 deaths/year/100,000 children aged 0-4 years
  - 0.056 - 0.44 deaths/1,000,000 short falls in children aged 0-4 years
- Special subtypes of short falls may have a higher mortality rate, but that rate is still very low

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