The Heat of the Moment:

Burns, Child Abuse and the MDT

Jonathan Thackeray, MD | June 24th, 2009

Center for Child and Family Advocacy | Nationwide Children's Hospital
The Ohio State University College of Medicine

Disclosure

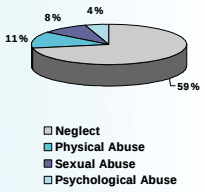
- Neither I nor any member of my immediate family has a financial relationship or interest with any proprietary entity producing health care goods or services related to the content of this CME activity.
- I do not intend to discuss an unapproved or investigative use of commercial products or devices.

Objectives

- State the epidemiology of abusive burns in children
- Distinguish between the mechanisms and clinical presentation of thermal, radiant, chemical and electrical burns
- Recognize patterns of specific burn injuries based on appearance and location
- Recognize the key components of the history, including scene investigation, that are important when evaluating a child with burn injuries

Child Maltreatment Data - 2007

- 3.2 million referrals to child protective services agencies
  - U.S.: 10.6 / 1000 children
  - MS: 9.1 / 1000 children
  - 62% of these screened in for investigation
  - 900,000 substantiated
- 13% of children experienced more than one type of maltreatment
- 1760 deaths

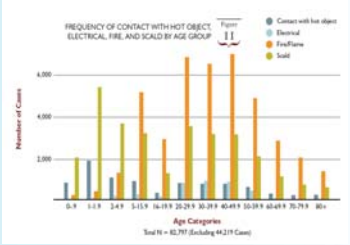


Epidemiology of Burns

- Pediatric burns cause:
  - Over 250,000 injuries per year necessitating medical attention
  - Over 15,000 hospitalizations per year
  - Over 10,000 cases of severe disability per year
  - 1100 deaths per year
  - Third leading cause of mortality in children < 5 years of age

Children's Burn Foundation 2008

Epidemiology of Burns



National Burn Repository Data 1999-2008

Burns Caused by Abuse/Neglect

- Multiple studies reporting the proportion of burns in children due to abuse/neglect
  - Range from 1% - 30%
  - More common in:
    - Lower socioeconomic status
    - Children from single-parent families
- In the U.S., scald burns from tap water are the most common abusive burn
- Abuse-related burns carry higher morbidity than accidental burns

Burns Caused by Abuse/Neglect

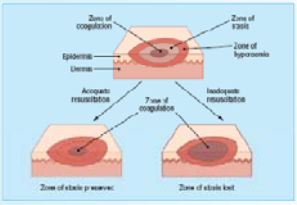
- Boys 2-3 times as likely to sustain abusive burns
- Mean age between 2 and 4 years
  - Corresponds with times of high 'demand'
    - Toilet training*
    - Enuresis
    - Excessive crying
- Children with inflicted burns 2.4-4.8 times more likely to have burns to hands, arms or legs bilaterally than children with accidental burns

Andronicus Burns 1998

- Child abuse was found in nearly half of children < 2 years with scald burns to perineum and/or genitalia

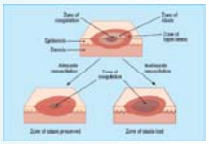
Angel J Pediatr Surg 2002

Pathophysiology



Pathophysiology

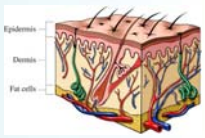
- Severity of a burn is based on:
  - Time of exposure
  - Temperature of agent
  - Type of agent
  - Heat-dissipating capacity of burned tissue (blood flow)



Figures reproduced with permission – BMJ 2004

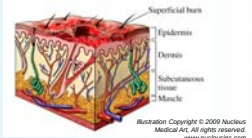
Pathophysiology

- Severity of a burn is based on:
  - Thickness of the skin
    - Varies by age, gender, and location on body
      - Thick – palms/soles
      - Thin – eyelid/genitals
    - Infant skin is often ½ as thick as adult skin
    - Reaches adult thickness by ~ 5 years of age



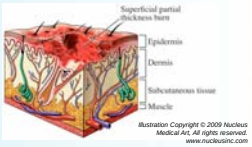
Pathophysiology

- Superficial burn
  - Damage to the epidermal layer
  - Normally heal within 5 to 7 days
  - Heals usually without scarring
  - Example: Sunburn



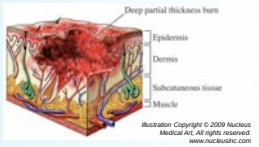
Pathophysiology

- Partial thickness burns
  - Superficial
- Dermis is 15-40 times as thick as the epidermis
- Pain and blistering
- Scarring dependent upon depth of wound



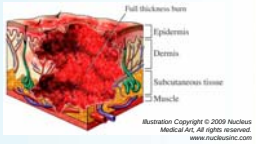
Pathophysiology

- Partial thickness burns
  - Deep
- Dermis is 15-40 times as thick as the epidermis
- Pain and blistering
- Scarring dependent upon depth of wound



Pathophysiology

- Full thickness burns
  - Total necrosis of the skin components
  - Often painless as pain innervation is destroyed
  - Skin grafting necessary for large wounds
  - Significant scarring occurs



Burns: Medical Evaluation

Diagnostic Evaluation for Abuse

- History, history, history!
  - Who, what, when, where, and how
    - Who was caring for the child?
    - What events preceded the injury?
    - What was the child's reaction?
    - What did the caregiver do?
    - When did the injury occur?
    - Where did it occur?
  - Developmental assessment of the child
  - What does the child say happened?
  - What does the caregiver say happened?
    - Keep in mind - 60% of burns for which a physician cannot match the history with the pattern of injury are later found to be accidental or negligent

Hammond South Med J 1991

Diagnostic Evaluation for Abuse

- Red Flags in the History:
  - Injury incompatible with child's developmental abilities
  - Absent, changing, or evolving history
  - Delay in seeking medical care
  - Triggering event that precipitates loss of control in caregiver
  - Family crisis or stress
  - Prior history of abuse in caregiver

Diagnostic Evaluation for Abuse

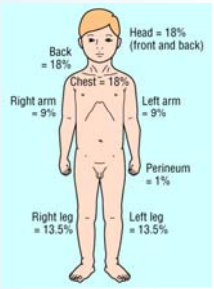
- Labs/Diagnostics
  - Skeletal survey
    - 5 (14%) of 36 burn patients had positive skeletal surveys
    - Mean age 1.8 +/- 1.5 years

Hicks Ped Emerg Care 2007

  - AST/ALT for occult abdominal injury

Diagnostic Evaluation for Abuse

- Physical Examination
  - Depths of burns
  - TBSA
  - Does the pattern of injury match the provided history?
  - Evaluation for additional injuries or evidence of neglect
  - Consideration of mimics



Potential Burn Mimics

- Moxibustion
- Phytophotodermatitis
- Infections
  - Impetigo
  - Herpetic whitlow
  - Staph scalded skin syndrome

Potential Burn Mimics

- Insect and arachnid bites
- Fat necrosis
  - Popsicle panniculitis
  - Trauma

Potential Burn Mimics

- Laxative-induced dermatitis (Senna)

Leventhal Pediatrics 2001

Types of Burn Injury

Thermal | Radiant | Chemical | Electrical

Thermal Burns

- Cause tissue damage from coagulation of tissue proteins
- Cell membrane is the most vulnerable to heat damage, but all components of the cell may be damaged
- Most commonly the result of:
  - Application of a liquid
  - Application of a hot object
  - Application of a flame (rare in young children)

Thermal

- Liquid burns
  - Scalding is the most frequent form of burn abuse
  - More than 80% of abusive scald burns are from tap water
  - Observed patterns:
    - Immersion pattern
      - "Stocking" and "glove" distribution
      - Skin-sparing patterns of immersion
    - Viscous vs. non-viscous substances

Child's Response to Immersion Burn?

- Two prevailing theories:
  - Reflex is to withdraw from the burn
    - Child would struggle, kick, flail
    - Splash marks would be evident if burn is accidental
  - Child panics and 'freezes'
    - Child holds perfectly still
    - Splash marks would be absent and child would have a symmetrical distribution of burn
- The reality is there likely exists a wide range of behavioral and pain response to burn injuries
- Because of this, patterns may *influence* the concern for inflicted injury – but should not be the sole basis for making a diagnosis

"Stocking" or "Glove" Pattern

- Sharp demarcation between injured and healthy skin
- Implies that the affected area has been immersed in a hot liquid

Sparing Pattern

- May see spared skin in areas of joint mobility
  - Elbows
  - Wrists
  - Popliteal fossa
  - Inguinal creases
- Implies either reflexive or forced flexion/extension of the area

Sparing of the flexor surface of the right ankle

Sparing Pattern

- May see sparing where skin is pressed against the surface of the container, which is relatively cooler than the liquid in which the child is immersed
  - Sole of foot
  - Palm of hand
  - Buttocks

Contact Burns

- Characterized by the configuration of the burning object
- Abusive injuries often more sharply defined than accidental ones
- May be relatively superficial
  - e.g. cigarette burns
- May be deep
  - e.g. metal iron

Cigarette Burns

- Intentional:
  - Firm contact typically produces a sharply-defined, circular, third-degree burn
  - Approximately 5-10mm diameter
  - Often on 'exposed' areas, such as hands, feet, head, and neck
- Accidental:
  - Typically causes only superficial "brush" burns
    - Short duration of exposure
    - Glowing coals insulated by layer of ash

Faller-Marquardt Foren Sci Intl 2007

Cigarette Burns

- Differential Diagnosis
  - Impetigo
  - Furunculosis
  - Small abscesses
  - Acne vulgaris
  - Insect bites
  - Varicella lesions
  - Alternative healing practices
  - Small pox vaccination

Faller-Marquardt Foren Sci Int 2007

Bullous Impetigo

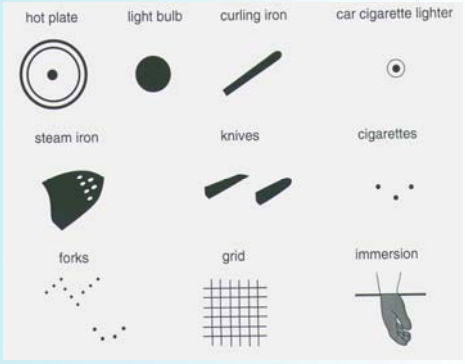
Photo courtesy of US Department of Health & Human Services

Additional Patterns

- Stun gun injury
  - Circular lesions approximately 0.5cm in diameter
  - Evenly spaced 4-5 cm apart

Frechette Pediatrics 1992

- Hair dryers
- Car seats
- Enuresis blankets



Thermal Burns – Additional Readings

- Electric stoves
  - Still J, Craft-Coffman B, Law E, Colon-Santini J and Grant J. Burns of children caused by electric stoves. J Burn Care Rehabil 1998;19:364-365.
- Electric water heaters
  - Chuang S-S, Yang J-Y, Tsai F-C. Electric water heaters: A new hazard for pediatric burns. Burns 2003;29:589-591.
- Glass enclosed fireplaces
  - Dunst CM, Scott EC, Krantz JJ et al. Contact palm burns in toddlers from glass enclosed fireplaces. J Burn Care Rehab 2004:25:67-70.
- Iron burns
  - Simons M, Brady D, McGrady M, Plaza A and Kimble R. Hot iron burns in children. Burns 2002;28:587-590.
- Oil burns
  - Mukadam S and Gilles EE. Unusual inflicted hot oil burns in a 7-year-old. Burns 2003;29:83-86.
- Radiator burns
  - Quinlan KE Home radiator burns in inner-city children. Arch Pediatr Adolesc Med 1996;150:954-957.

Radiant - Sunburn

- Sunburn
  - 70 to 85 percent of children and adolescents have reported at least one sunburn in the previous year

Gellar Pediatrics 2002
Davis Pediatrics 2002

  - Burns range from painless erythema to painful erythema with edema/blistering
  - Recent history of sun exposure
  - Characteristic pattern of burn in exposed areas

Radiant - Microwave Burns

- Standard microwave oven has a 2-5 cm depth of penetration
- Tissues with higher water content (e.g. muscle) heat to a greater extent than those with lower water content (e.g. fat)
- Cause sharply demarcated burns and "sparing" of tissue levels

Alexander Pediatrics 1987

Chemical Burns

- Cause tissue damage through chemical reactions which alter
  - Extracellular matrix
  - Cellular membranes
  - Intracellular structures and molecules
  - Production/resorption of heat
- Tend to be deep
- Alkalis > acids

Chemical Burns

- Household cleaners/solvents
  - Hydrofluoric acid
- Cement
- Alcohol-based skin cleaners
- Alternative medicine home remedies
- Meth production
  - Anhydrous ammonia
  - Hydroiodic acid

Electrical Burns

- Cause tissue damage both from
  - electroporative forces on cell membranes
  - generation of heat
    - Heat = 0.24 x $(\text{Voltage})^2$ x Resistance
    - Low voltage (domestic current)
      - Small, deep contact burns at entry/exit sites
      - Alternating nature can interfere with cardiac cycle
    - High voltage (1000V or greater)
      - Extensive tissue damage to soft and bony tissues
      - Rhabdomyolysis → renal failure
    - "Flash" injuries

Electrical Burn

Medical Management

Hospital Admission Criteria

- The following criteria indicate need for hospital admission and further management:
  - Age <10 years with 5 to 10 percent TBSA burn
  - Age ≥10 years with 10 to 20 percent TBSA burn
  - Full thickness burn 2 to 5 percent TBSA
  - High voltage injury
  - Suspected inhalational injury
  - Circumferential burn
  - Medical problem predisposing to infection (such as diabetes or sickle cell disease)
  - Concern for inflicted injury

American Burn Association

Burn Center Referral Criteria

- The following criteria indicate need to receive care in a burn center:
  - Age <10 years with >10 percent TBSA burn
  - Age ≥10 years with >20 percent TBSA burn
  - Full thickness burn >5 percent TBSA
  - Inhalational injury
  - Any significant burn to face, eyes, ears, genitalia, or joints
  - Significant associated injuries (fractures or major trauma)

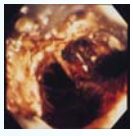
American Burn Association

Minor Burns

- Pain management
- Cooling affected area to limit injury
- Keeping affected area clean, including topical antibiotic to prevent infection
- Tetanus prophylaxis if warranted
- Follow-up for signs of infection or healing complications

Major Burns

- Resuscitation (airway, breathing, circulation) as necessary
- Cooling affected area to limit injury
- Admission/transfer to pediatric burn center whenever possible
- Careful fluid resuscitation (modified Parkland formula)
- Debridement
- Dressing changes



Complications

- Death
- Infection, burn wound sepsis
- Vascular compromise
- Contractures
- Hypertrophic scarring

Psychological Outcomes

- Limitations of current research:
  - Abuse cases frequently excluded from studies
  - Existing literature focuses primarily on adults
  - Most studies monitor short-term follow-up
    - First few months/years are the most intense period of adjustment
    - Most abused children are too young to have formulated substantial self-concept or sense of significance of injury

Psychological Outcomes

- Recurring themes in the literature:
  - Burn patients, long-term, have higher incidence of anxiety than the general population
  - Most burn survivors develop a positive self-concept with high-self esteem
    - Overall sense of self-worth similar to non-burned peers
- Implications for providers:
  - We need a heightened awareness of possibility of future anxiety or affective disorders
  - We must encourage burn patients to capitalize on their strengths in areas of personal development

Case Discussions

Perspectives from the Multidisciplinary Team

Diagnostic Evaluation for Abuse

- Role of social workers
  - Often the first to perform an in-depth interview of the child victim and the alleged perpetrator
    - Emotions run high
    - Little time to construct an alternate story
    - Story may evolve over time
    - Event reconstruction
      - How, where, when, what, and who
      - Consider use of props (dolls, sinks, bathrooms)

Diagnostic Evaluation for Abuse

- Role of social workers
  - Psychosocial Assessment
    - Risk factors associated with child abuse?
      - Single-parent family
      - Relationship discord
      - Financial stress
      - Social isolation
      - Employment difficulties
      - Substance abuse
      - Domestic violence
      - CPS history

Diagnostic Evaluation for Abuse

- Role of social workers
  - Psychosocial Assessment
    - Risk factors associated with child abuse?
      - Role reversal in childcare responsibilities
      - Disabled child
      - Inappropriate expectations of the child
      - Poor bonding
      - Chaotic, erratic lifestyle
      - Delay in seeking medical care

Diagnostic Evaluation for Abuse

- Role of law enforcement
  - Interviews of the alleged perpetrator
  - Corroboration of the history
    - Cell phone records
    - Witness accounts
    - Security camera footage
    - Receipts/Credit card usage
  - Scene investigation

Diagnostic Evaluation for Abuse

- Scene Investigation
  - Evaluation of site where burn reportedly occurred
    - Contact burns:
      - Object to match the pattern
    - Chemical burns:
      - Empty bottle or container
      - Evidence of a spill
    - Electrical burns:
      - Downed wires
      - Singe marks on carpet/furniture

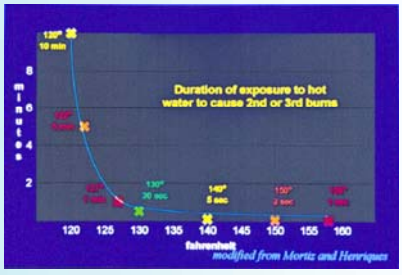
Diagnostic Evaluation for Abuse

- Bathtub burns:
  - Layout of bathroom
    - Proximity to caregivers if not present at time of injury
  - Surface of the tub
  - Evidence of injury?
    - Sloughed skin
    - Wet towels/rugs/clothes

Diagnostic Evaluation for Abuse

- What type of knob?
  - Can child reach?
  - Can child turn?
  - Separate hot/cold?
- Water temperature?
  - Water heater settings
  - Temperature when water turned on
  - Temperature x seconds later

Importance of Water Temperature



*Derived from original data from Moritz and Henriques *Am J Pathol* 1947

Diagnostic Evaluation for Abuse

- What is the height of the tub?
  - Can child enter tub alone?
    - 35% of children 10-18 months old can
      Allasio Pediatrics 2005
  - How deep is internal tub?
- Rate of filling/drainage?

Conclusions

- Up to 30% of pediatric burns may be due to abuse/neglect and tap water is the most frequent etiology of these burns
- Know the mechanism and recognize the clinical presentations of the many etiologies of pediatric burns (thermal, radiant, chemical, electrical)
- Specific patterns of burn injury may influence the concern for inflicted injury, but should rarely, if ever, be used as the sole basis for diagnosing abuse
- A detailed history, including a scene investigation, is critical when evaluating a burned child for possible abuse/neglect

Acknowledgements

- Thank you to the following colleagues who provided images used in this presentation:
- Sheila Giles, RN, CPN
- Kathi Makoroff, MD
- Megan McGraw, MD
- Philip V. Scribano, DO, MSCE
- Jennifer Tscholl, MD

References

- Alexander et al. Microwave Oven Burns to Children: An Unusual Manifestation of Child Abuse. Pediatrics 1987;79:255-260
- Allasio D et al. Immersion scald burns and the ability of young children to climb into a bathtub. Pediatrics 2005;115:1419-1421
- Andronicus M et al. Non-accidental burns in children. Burns 1998;24:552-8
- Angel C, Shu T, French D et al. Genital and perineal burns in children: 10 years of experience at a major burn center. J Pediatr Surg 2002;37:99-103. Vol. X, No. 2, p. 9
- Davis K et al. Summer Sunburn and Sun Exposure Among US Youths Ages 11 to 18: National Prevalence and Associated Factors. Pediatrics 2002;110:27-35
- Faller-Marquardt M et al. Cigarette burns in forensic medicine. Forensic Sci Int 2008;176 :200–208

References

- Frechette A et al. Stun gun injury: A new presentation of the battered child syndrome. Pediatrics 1992;89(5):898-901
- Geller A et al. Use of Sunscreen, Sunburning Rates, and Tanning Bed Use Among More Than 10 000 US Children and Adolescents. Pediatrics 2002;109:1009–1014
- Hammond J et al. Predictive value of historical and physical characteristics for the diagnosis of child abuse. South Med J 1991;84(2):166–168
- Hicks R et al. Skeletal surveys in children with burns caused by child abuse. Pediatric Emergency Care 2007;23(5): 308-313
- Leventhal J et al. Laxative-induced dermatitis of the buttocks incorrectly suspected to be abusive burns. Pediatrics 2001;107(1):178-179