Rehabilitation in the Pediatric Burn Patient

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University of Kansas, Department of Rehabilitation
Grand Rounds 16. April 2015
Disclosures

• None
Objectives

• Understand the pediatric burn etiology and treatment
• Understand the complications that arise from burn injuries
• Discuss strategies for scar management and maintenance of function in pediatric burn patients
• Understand the importance of pre- and post-burn prevention
• Recognize the need for further research regarding pediatric burn rehabilitation
Historical Perspective

• Physiatric involvement in burn care:
  • 1959 – George Koepke University of Michigan at creation of burn unit
  • 1961 – First rehab literature appeared
    • Spoke about importance of splinting and positioning
  • 1970 – Phala Helm and Steve Fisher
    • Established clinics to oversee exercise programs and wound care
  • 1978 – Special Interest Group formed with the ABA
    • Advocated for multidisciplinary approach to improving outcomes
    • Emphasize sensory, physical, and psychological function, reduction of pain, community participation and quality of life
  • 1984 – Fisher and Helm
    • Write first burn rehab textbook Comprehensive Rehabilitation of Burns
  • 1990 – Multidisciplinary teams emerged with dedicated therapists
  • 1994 – Three model burn systems formed at UTSW, UW and U Colorado
  • 2011 – 2nd Edition of Burn Rehabilitation published in PM&R Clinics of NA
  • 2014 – ABA conference has only 1% attendance by physiatrists
Case

• AK is a 5 year-old girl with no significant past medical history. She presents to the emergency room with her parents after “burning her arm.” The girl is sobbing in pain.

• What questions do you want to ask?
Case

- **Timing:**
  - Occurred 24 minutes prior to presentation

- **Mechanism of Injury:**
  - She tried to lift a pot of boiling water to see if eggs had finished boiling

- **Location of Injury:**
  - RUE and hand, small burn on chest wall; family says water also landed on jeans

- **Joints involved:**
  - Elbow and 2\textsuperscript{nd} MCP joint of R hand

- **Depth:**
  - Family does not know, but say it is at least “second degree”

- **First Aid:**
  - Family put the burned arm immediately under cooled water and rolled up sleeve on shirt. Her jeans were not removed.

- **Milestones:**
  - The patient met all developmental milestones
Definition

- Burns are the injury of skin or other tissue caused by heat (e.g., hot liquids [scalds], hot solids [contact burns], flames), ultraviolet/infrared radiation, radioactivity, electricity, chemicals or cold.
Epidemiology

- 2012: estimated 135,000
- 2001-2012: unintentional burns were the 14th leading cause of nonfatal injury.
- Children < 5 years-old represented 20% of all pediatric burn cases from 2003-2012.
- 2009: 3rd leading cause of death from unintentional injury in children age 1-9 years.
<table>
<thead>
<tr>
<th>Rank</th>
<th>&lt;1</th>
<th>1-4</th>
<th>5-9</th>
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<td>Unintentional Poisoning 3,917</td>
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*The two causes are: Unintentional Natural/Environmental and Unintentional Poisoning.

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC using WISQARS™.
Epidemiology

- Over ½ of all burns and 80% of contact burns occur in the home
- Higher incidence in disabled children
- Higher incidence in minorities
- Boys : Girls - 1.27:1 in 2012
- The overall number of fatalities from burns has decreased roughly each year from 1999-2010.
Epidemiology by Race

0-0.9 years

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1-1.9 years

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<td>Asian</td>
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<tr>
<td>Unknown</td>
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2-4.9 years

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5-15.9 years

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<td>Hispanic</td>
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<td>Other</td>
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<td>Asian</td>
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<tr>
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<td><strong>TOTAL</strong></td>
<td>16,880</td>
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Risk Factors for Mortality

- Inhalation injury – can increase risk up to 21 times
- Young age
- Burn size – starting at $\geq 40\%$ TBSA from 0-15.9 and 50% from 16-19.9 years old
- Sepsis or multi-organ failure

- Worse outcomes seen in patients treated in hospitals without certified burn units for larger TBSA burns
Etiology

From birth to 19.9 years old (2003-2012):

• Scald injury (44.9%): most common for children less than 5 years old
• Fire/flame (25.4%): most common in the adolescent age group
• Hot object contact (13.5%)
• Electrical (1.7%)
• Chemical (1.2%)
• For children less than 5 years old, 74% of burns are from scald or contact with hot objects.
Etiology by Burn-type

1-1.9 years

<table>
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<tr>
<th>Etiology</th>
<th>Cases</th>
<th>% of Valid</th>
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<tbody>
<tr>
<td>Scald</td>
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<td>Contact with Hot Object</td>
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<td>Fire/Flame</td>
<td>863</td>
<td>6.2%</td>
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<td>Burn, Unspecified</td>
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<tr>
<td>Chemical</td>
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<tr>
<td>Electrical</td>
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<tr>
<td>Other, Non Burn</td>
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<td>Inhalation Only</td>
<td>27</td>
<td>0.2%</td>
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<tr>
<td>Radiation</td>
<td>10</td>
<td>0.1%</td>
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<tr>
<td>Skin Disease</td>
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<td>0.0%</td>
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<tr>
<td>Unknown</td>
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<td>14,662</td>
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Total N=13,851 (Excluding 811 Unknown/Missing)

2-4.9 years

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<td>Scald</td>
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<tr>
<td>Fire/Flame</td>
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<tr>
<td>Contact with Hot Object</td>
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<tr>
<td>Burn, Unspecified</td>
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<tr>
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Total N=11,406 (Excluding 942 Unknown/Missing)

5-15.9 years

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Total N=15,591 (Excluding 1,289 Unknown/Missing)
Normal Pediatric Skin Physiology

- **Skin:**
  - **Purpose:**
    - Regulates temperature
    - Protects against infection
    - Fluid retention
    - Cosmesis
  - Thinner epidermal layer than adults, less keratinized
    - Results in quicker absorption
    - More sensitive to temperatures (e.g. bathtub water)
    - 5 seconds at 60° C (140° F) will cause full thickness burn (<6 yo)

- **Body Surface Area:** larger in children
  - The smaller the child, the larger the difference
  - Can result in more rapid fluid/heat loss than in adults
Total Body Surface Area

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<td>9</td>
<td>9½</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Thigh</td>
<td>5½</td>
<td>6½</td>
<td>8</td>
<td>8½</td>
<td>9</td>
<td>9½</td>
<td></td>
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<tr>
<td>R. Leg</td>
<td>5</td>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td>L. Leg</td>
<td>5</td>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
<td>7</td>
<td></td>
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<tr>
<td>R. Foot</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Foot</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Cause of Burn ____________________________
Date of Burn ___________________________
Time of Burn ___________________________
Age ___________________________
Sex ___________________________
Weight ___________________________
Height ___________________________
Date of Admission _______________________
Signature ____________________________

**Figure 14.8** Lund and Browder burn chart.
Total Body Surface Area

1-4:
- 19%
- 9.5%
- 32%
- 9.5%
- 15%
- 15%

5-9:
- 15%
- 9.5%
- 32%
- 9.5%
- 17%
- 17%

10-14:
- 13%
- 9.5%
- 32%
- 9.5%
- 18%
- 18%

Adult:
- 10%
- 9%
- 36%
- 9%

(Rule of nines)
Depth

Figure 14.7  Classification of burns by severity.
**Depth**

- **First degree:**
  - **Superficial:** injury to outer layer of epidermis only
    - Red, painful; heals in 3-7 days

- **Second degree:**
  - **Superficial partial thickness:** deeper layers of epidermis without injuring dermal appendages
    - Red, painful, blisters, blanches; heals in 7-21 days
  - **Deep partial thickness:** includes dermal appendages but not past the basal membrane
    - May be painful, less blisters, can require graft; 14-21 days

- **Third degree:**
  - **Full thickness:** injury to epidermis and dermis into subdermal tissue
    - Pale, not painful; requires graft
Pathophysiology of Burn

- **Thermal:**
  - Healthy skin is disrupted, leading to water permeability, capillary leakage, and significant fluid loss
  - With fluid and protein shifts, edema develops
  - Massive cell destruction leads to shock and a hypermetabolic state, with TBSA > 40%.
  - Given the large surface area to mass ratio, children are also at risk for hypothermia

- **Electrical:**
  - Current is conducted greater in high-water content tissues (blood vessels, nerves, muscles) and generates heat, which is retained in deep tissue and can lead to further injuries (ie, compartment syndrome)
  - Can also cause cardiac arrhythmias
History (acute)

- Review injury mechanism, location, and prior treatment.
- Inconsistencies between history and presentation may indicate non-accidental injury.
- Document developmental history, including current abilities and previous/current therapies or interventions.
- Review of systems should include the following:
  - Vision and hearing
  - Swallow
  - Cardiovascular and respiratory limitations to exercise
  - Bowel and bladder function
  - Pain
  - Musculoskeletal limitations (including weight-bearing status and range of motion restrictions)
  - Sensory deficits
  - Mental health status
Exam (acute)

- **Primary survey:**
  - ABCDEF: airway, breathing, circulation, disability, exposure/environment, fluids
  - Remove child from source of injury, clothing/jewelry
  - Protecting affected areas with sterile dressings.
  - Suspected inhalation injuries: at risk for airway compromise up to 48 hours after exposure and early intubation is recommended.
  - FACES (5-11 yo) of VAS (12+) for pain scale
- **TBSA is determined to assist with early fluid resuscitation.**
  - Use Lund-Browder burn chart in younger children
  - Record carefully the areas involved, including exposure of joints/bones/muscles/tendons, burn depth, and burn patterns.
Other Studies

- Prealbumin
- No need for cardiac enzymes
- ECG for electrical
  - If low-voltage (< 1000 V) and normal, can be sent home if no other admission criteria
- Skeletal Survey, if abuse suspected
- Head Imaging, if TBI suspected
Case
Treatment

- **Superficial:**
  - Moisturizing cream
  - Antibiotic ointments not generally needed, due to intact dermis

- **Superficial Partial Thickness:**
  - Pain control
  - Debridement if necessary
  - Non-adhesive dressing
  - Daily or twice daily dressing changes, depending on depth
  - Can also use silver nitrate dressings if concern for infection
  - Polymixin/bacitracin antibiotic ointment 1-2x daily
  - Continue analgesia, particularly around dressing changes
**Treatment (Deep or Full Thickness)**

**Acute:**
- Resuscitation mediates fluid losses, shock, and potential organ damage.
- Early escharotomy/debridement helps prevent blood loss and infection.
- The use of skin substitutes (allografts, xenografts, synthetic grafts) can decrease healing time and pain.
- Topical antibiotics/creams (ie, silver sulfadiazine) are used to facilitate healing. Additional antibiotics are reserved for those with evidence of systemic infection.
- No standardized pain control guidelines

**Subacute:**
- Nutrition (nasogastric, oral)
- Cardiopulmonary support is weaned as able.
- Autograft is performed as able.
- To mediate the hypermetabolic state, anabolic medications may be initiated.
- Begin compression garments
Other Consequences of Burn

• **Acute:**
  • **Anoxic brain injury**
  • **Amputation**
  • Cardiac abnormalities
  • *Hypermetabolism*
  • Pneumonia
  • *Thermal dysregulation*
  • Wound infection and sepsis

• **Subacute/Chronic:**
  • *Contracture*
  • *Heterotopic ossification*
  • *Hypermetabolism*
  • *Hypertrophic scarring*
  • *Low bone mineral density*
  • *Neuropathies*
  • Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)
  • **Scoliosis**
  • *Thermal dysregulation*
Other Consequences of Burn

• Acute:
  • **Anoxic brain injury**
  • **Amputation**
  • Cardiac abnormalities
  • *Hypermetabolism*
  • Pneumonia
  • *Thermal dysregulation*
  • Wound infection and sepsis

• Subacute/Chronic:
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  • *Neuropathies*
  • Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)
  • **Scoliosis**
  • *Thermal dysregulation*
Contracture

- Contractures of the fingers and hands can cause significant functional impairment
- Common causes:
  - Pain
  - Immobility
  - Poor positioning
  - Damaged structures
- The position of comfort is the position of contracture!
- Use custom-molded orthoses
- Adapt orthosis to fluid/edema

<table>
<thead>
<tr>
<th>AREA INVOLVED</th>
<th>CONTRACTURE PREDISPOSITION</th>
<th>CONTRACTURE PREVENTING POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior neck</td>
<td>Flexion</td>
<td>Extension, no pillows</td>
</tr>
<tr>
<td>Anterior axilla</td>
<td>Shoulder adduction</td>
<td>90° abduction, neutral Rotation</td>
</tr>
<tr>
<td>Posterior axilla</td>
<td>Shoulder extension</td>
<td>Shoulder flexion</td>
</tr>
<tr>
<td>Elbow/forearm</td>
<td>Flexion/pronation</td>
<td>Elbows extended, forearm supination</td>
</tr>
<tr>
<td>Wrist</td>
<td>Flexion</td>
<td>15–20° extension</td>
</tr>
<tr>
<td>Hands</td>
<td>Hyperextension</td>
<td>70–90° flexion</td>
</tr>
<tr>
<td>MCPs</td>
<td>Flexion</td>
<td>Full extension</td>
</tr>
<tr>
<td>Ips</td>
<td>Finger flexion, thumb opposition</td>
<td>All joints full extension, thumb radially abducted</td>
</tr>
<tr>
<td>Palmar burn</td>
<td>Flexion</td>
<td>Straight, no lateral or anterior flexion</td>
</tr>
<tr>
<td>Chest</td>
<td>Lateral/anterior Flexion</td>
<td>Extension, 10° abduction, neutral rotation</td>
</tr>
<tr>
<td>Hips</td>
<td>Flexion, adduction, external rotation</td>
<td>Extension</td>
</tr>
<tr>
<td>Knees</td>
<td>Flexion</td>
<td>Extension</td>
</tr>
<tr>
<td>Ankles</td>
<td>Plantarflexion</td>
<td>90° dorsiflexion</td>
</tr>
</tbody>
</table>

MCPs, metacarpophalangeals; IPs, interphalangeals.
Positioning

- Abduction, external rotation
- Supination
- Extension/hyperextension
- Straight alignment
- No external rotation
- No flexion
- Straight
- Dorsiflexion
Special Cases: Hand Burns
Other Consequences of Burn

• Acute:
  • **Anoxic brain injury**
  • **Amputation**
  • Cardiac abnormalities
  • *Hypermetabolism
  • Pneumonia
  • *Thermal dysregulation
  • Wound infection and sepsis

• Subacute/Chronic:
  • *Contracture
  • **Heterotopic ossification**
  • *Hypermetabolism
  • *Hypertrophic scarring
  • *Low bone mineral density
  • *Neuropathies
  • Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)
  • **Scoliosis
  • *Thermal dysregulation
Heterotopic Ossification

- Pubmed search: *pediatric heterotopic ossification burn*
  - Only 7 search results
  - 2 Case Reports
  - 2 Review Articles
  - 1 About a different disorder
  - 1 Retrospective study – amputation in burn and stump overgrowth
  - 1 Surgical removal – no control, 9 patients, 7 follow-up

- Most common site is the elbow

- Treatment:
  - Active ROM and AAROM
  - No stretching – can precipitate HO
  - Alternate splinting
  - Surgical removal
Other Consequences of Burn

- **Acute:**
  - **Anoxic** brain injury
  - **Amputation**
  - Cardiac abnormalities
  - *Hypermetabolism*
  - Pneumonia
  - **Thermal dysregulation**
  - Wound infection and sepsis

- **Subacute/Chronic:**
  - *Contracture*
  - *Heterotopic ossification*
  - **Hypermetabolism**
  - *Hypertrophic scarring*
  - **Low bone mineral density**
  - *Neuropathies*
  - **Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)**
  - **Scoliosis**
  - **Thermal dysregulation**
Encountered on the acute rehab unit
Can lead to 2x normal resting energy expenditure
20% TBSA: unable to meet their nutritional needs with oral intake alone.
Requires enteral nutrition, but will not keep up with anabolism
It can persist for up to 2-3 years after burn
  • Affects growth
    • Growth is less than aged-matched peers at 2 years.
    • Lower LBM, muscle strength and bone density
Hypermobulism Treatment

- **Pharmacologic**
  - **Insulin:**
    - Used during acute burn phase
    - Lowers pro-inflammatory and increases anti-inflammatory cytokines
  - **Oxandrolone:**
    - 0.1 mg/kg/day
    - Best effects in 7-18 yo
    - Can benefit up to 5 years after burn
    - For severe burns:
      - Oxandrolone + Exercise x 12 weeks more effective than either treatment alone
  - **Propranolol:**
    - Blunts catecholamine-mediated pathways
    - Safe in kids $\geq$ 30% TBSA burns
    - Reduces resting energy expenditure by 20% during first 6 months
    - 4 mg/kg/day is well-tolerated
Hypermegaloblastosis Treatment

- Non-pharmacologic
  - Early Exercise program:
    - Has shown to improve outcomes
    - Strengthening focuses on opposition of the contractile forces of scarring
      - Should involve active or active-assist exercises when possible.
    - Circumferential burns require attention to both agonist and antagonist muscle strengthening
    - Lowers pro-inflammatory and increases anti-inflammatory cytokines
    - Modifications may be required if cardiopulmonary restrictions are present.
  - Exercise benefits shown to persist, but children still not equivalent to non-burned aged-matched peers with regards to LBM, BMC and muscle strength
  - No other treatment guidelines
  - Some exercises may need to be modified in severe pediatric burns due to inability to thermoregulate
  - Technology to help preserve ROM
Conservative treatment:
   • Start physical therapy program immediately

Avoid using very intense or maximal resistance training or testing

Gradual progression is of utmost importance to avoid injury and to promote exercise adherence

Post-op exercises involving autografted skin over joints:
   • Stop for 4–5 days

Escharotomies, fasciotomies, heterografts, and synthetic dressings:
   • Not contraindications for exercise

Early mobilization to decrease edema, proper exercise techniques, and accurate documentation of function are more important than the type of wound closure

Should participate in a post-discharge, structured and supervised exercise program

Exercise Notes
Other Consequences of Burn

- **Acute:**
  - **Anoxic brain injury**
  - **Amputation**
  - Cardiac abnormalities
  - *Hypermetabolism*
  - Pneumonia
  - *Thermal dysregulation*
  - Wound infection and sepsis

- **Subacute/Chronic:**
  - *Contracture*
  - *Heterotopic ossification*
  - *Hypermetabolism*
  - **Hypertrophic scarring**
  - *Low bone mineral density*
  - *Neuropathies*
  - Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)
  - **Scoliosis**
  - *Thermal dysregulation*
Scar Classification

**Mature:**
- A light-colored, flat scar

**Immature:**
- Red, sometimes itchy or painful, and slightly elevated
- Remodeling
- Mature normally over time and become flat, and assume a pigmentation that is similar to the surrounding skin, although they can be paler or slightly darker

**Linear hypertrophic:**
- Surgical/traumatic
- Red, raised, sometimes itchy
- Confined to the border of the original surgical incision
- Occurs within weeks after surgery.
- May increase in size rapidly for 3–6 months and then, after a static phase, begin to regress
- Generally mature to have an elevated, slightly rope-like appearance with increased width, which is variable
- Maturation process up to 2 years
**Scar Classification**

- **Widespread hypertrophic:**
  - Burn scar
  - Widespread red, raised, sometimes itchy
  - Hypo- or hyperpigmented
  - Remains within the borders of the burn injury.

- **Minor keloid:**
  - A focally raised, itchy scar extending over normal tissue
  - Firm, rubbery or shiny
  - Can develop up to 1 year after injury
  - Does not regress on its own
  - Simple Surgical excision is often followed by recurrence

- **Major keloid:**
  - Large, raised (>0.5 cm) scar
  - Possibly painful or pruritic
  - Extends over normal tissue
  - Can continue to spread over years.
Hypertrophic Scarring

• Very common problem after deep burn injury
• Risk Factors:
  • Wound healing > 21 days
  • Deep burns
  • Age
  • Pigmentation
  • Family history
  • Scar location
• Dermis proliferates
• Excessive collagen fibers and extracellular matrix are laid, providing contractile and rising forces
• Although there are a multitude of treatments, there is a paucity of evidence in the adult and pediatric populations
# Hypertrophic Scar Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Scoring system</th>
<th>Attributes analyzed</th>
<th>Deficiencies</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver Scar Scale</td>
<td>0 to 13</td>
<td>Vascularity, height, thickness, pliability, and pigmentation</td>
<td>Lacks patient perception, pigmentation subscale less applicable to large, heterogeneous scars, operator-dependent errors. Excludes pain and pruritis.</td>
<td>Used widely in literature for outcome measure in burn studies.</td>
</tr>
<tr>
<td>Visual Analog Scale with scar ranking</td>
<td>0 to 100</td>
<td>Vascularity, pigmentation, acceptability, observer comfort plus contour and summing the individual scores</td>
<td>Photo-based scale does not include patient assessment</td>
<td>Simpler than VSS Assessments of intra- and interrater reliability easier to conduct</td>
</tr>
<tr>
<td>Patient and Observer Scar Assessment Scale</td>
<td>5 to 50</td>
<td>VSS plus surface area, patient assessments of pain, itching, color, stiffness, thickness, relief</td>
<td>Items represented may not adequately express patient’s perceptions and concerns</td>
<td>Focuses on scar severity from clinician’s and patient’s points of view</td>
</tr>
<tr>
<td>Manchester Scar Scale</td>
<td>5 (best) to 18 (worse)</td>
<td>VAS plus scar color, skin texture, relationship to surrounding skin, texture, margins, size, multiplicity</td>
<td>Arbitrary assessment and weighting of items</td>
<td>Applicable to a wider range of scars, uses descriptors related to clinical significance instead of physical measurement alone.</td>
</tr>
<tr>
<td>The Stony Brook Scar Evaluation Scale</td>
<td>0 (worst) to 5 (best)</td>
<td>VAS plus width, height, color, presence of suture/staple marks</td>
<td>Photo-based scale does not include patient assessment Not designed for long-term scar assessment</td>
<td>Specifically developed to assess short-term appearance of repaired lacerations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scar characteristic</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascularity</td>
<td>Normal 0</td>
</tr>
<tr>
<td></td>
<td>Pink 1</td>
</tr>
<tr>
<td></td>
<td>Red 2</td>
</tr>
<tr>
<td></td>
<td>Purple 3</td>
</tr>
<tr>
<td>Pigmentation</td>
<td>Normal 0</td>
</tr>
<tr>
<td></td>
<td>Hypopigmentation 1</td>
</tr>
<tr>
<td></td>
<td>Hyperpigmentation 2</td>
</tr>
<tr>
<td>Pliability</td>
<td>Normal 0</td>
</tr>
<tr>
<td></td>
<td>Supple 1</td>
</tr>
<tr>
<td></td>
<td>Yielding 2</td>
</tr>
<tr>
<td></td>
<td>Firm 3</td>
</tr>
<tr>
<td></td>
<td>Ropes 4</td>
</tr>
<tr>
<td></td>
<td>Contracture 5</td>
</tr>
<tr>
<td>Height</td>
<td>Flat 0</td>
</tr>
<tr>
<td></td>
<td>&lt;2 mm 1</td>
</tr>
<tr>
<td></td>
<td>2-5 mm 2</td>
</tr>
<tr>
<td></td>
<td>&gt;5 mm 3</td>
</tr>
<tr>
<td>Total score</td>
<td>13</td>
</tr>
</tbody>
</table>

The Vancouver Scar Scale
Hypertrophic Scarring

- **Standard:**
  - **Pressure therapy:**
    - Compression garments worn 23 hours daily
    - Should provide 24 mm Hg of pressure to overcome capillary pressure
    - Pressures > 40 mm Hg can cause adverse effects
    - Unknown mechanism of action (MOA)
    - Compliance issues in children
    - Most evidence is anecdotal
  - **Silicone**
    - Used in conjunction with pressure therapy
    - MOA thought to soften scar tissue by maintaining hydration and decreasing tension
    - Only Class 3 evidence to support its use
    - Can increase pruritus, cause skin maceration, rash
    - Poor compliance
Hypertrophic Scarring

- **Other treatments:**
  - Surgical excision and grafting
  - Steroid (topical or injections)
  - Massage
  - Radiation
  - Laser therapy

- **No good evidence for one treatment versus another**
Other Consequences of Burn

- **Acute:**
  - **Anoxic brain injury**
  - **Amputation**
  - Cardiac abnormalities
  - *Hypermetabolism*
  - Pneumonia
  - *Thermal dysregulation*
  - Wound infection and sepsis

- **Subacute/Chronic:**
  - *Contracture*
  - *Heterotopic ossification*
  - *Hypermetabolism*
  - *Hypertrophic scarring*
  - *Low bone mineral density*
  - **Neuropathies**
  - Other complications associated with burn location (ie, eyes, hands, mouth, genitalia)
  - **Scoliosis**
  - *Thermal dysregulation*
**Neuropathy**

- **Pubmed search:**
  - Terms pediatrics, burn and neuropathy or child burn neuropathy, pediatrics, nerve compression burn, brought no results
- **Medline search with same terms produced no results**
- **Amour and Billmire 2009:** neuropathies more common with severe edema or compartment syndromes

### Table 3. Compartments Vulnerable to Rhabdomyonecrosis and/or Peripheral Nerve Damage following Large-Volume Fluid Resuscitation or Muscle Ischemia-Reperfusion Injury

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Nerves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper extremity</td>
<td></td>
</tr>
<tr>
<td>Deltoid</td>
<td>N/A</td>
</tr>
<tr>
<td>Biceps</td>
<td>Musculocutaneous, median</td>
</tr>
<tr>
<td>Triceps</td>
<td>Radial, ulnar</td>
</tr>
<tr>
<td>Forearm extensors</td>
<td>Radial</td>
</tr>
<tr>
<td>Forearm flexors</td>
<td>Ulnar, median</td>
</tr>
<tr>
<td>Thenar/hypothenar</td>
<td>Recurrent branch of median</td>
</tr>
<tr>
<td>Interossei/lumbricals</td>
<td>Motor branches of digital and ulnar</td>
</tr>
<tr>
<td>Carpal tunnel, Guyon canal</td>
<td>Median, ulnar</td>
</tr>
<tr>
<td>Lower extremity</td>
<td></td>
</tr>
<tr>
<td>Gluteal</td>
<td>Sciatic</td>
</tr>
<tr>
<td>Anterior thigh</td>
<td>Femoral</td>
</tr>
<tr>
<td>Posterior thigh</td>
<td>Sciatic</td>
</tr>
<tr>
<td>Medial thigh</td>
<td>Obturator</td>
</tr>
<tr>
<td>Lateral leg</td>
<td>Superficial peroneal</td>
</tr>
<tr>
<td>Anterior leg</td>
<td>Deep peroneal</td>
</tr>
<tr>
<td>Posterior leg (superficial, deep)</td>
<td>Tibial</td>
</tr>
</tbody>
</table>

N/A, not applicable.
Pain Control

- Essential for optimal outcomes
- Children assume least painful positions
  - Results in:
    - Contracture
    - ROM loss
    - Bone density loss
    - Muscle mass loss
- Poor adherence to scar-prevention/mitigation treatments
  - Untreated pain can lead to increased anxiety and distrust in therapists
Pain Control

- No guidelines for treatment in children
  - Wide variety in treatments
  - Many studies find inadequate analgesia in the pediatric burn patient
- Procedural pain common
- Some evidence to support pharmacologic and non-pharmacologic approach for maximum efficacy

<table>
<thead>
<tr>
<th>Nonpharmacologic strategies</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep breathing exercises</td>
<td>Noninvasive, no cost</td>
<td>Limited efficacy, potential respiratory alkalosis</td>
</tr>
<tr>
<td>Relaxation techniques</td>
<td>Noninvasive, no cost</td>
<td>Training needed, limited efficacy</td>
</tr>
<tr>
<td>Distractive: art, music, television, cartoons</td>
<td>Noninvasive, low cost</td>
<td>Limited efficacy</td>
</tr>
<tr>
<td>Distractive: virtual reality</td>
<td>Works well, backed by good literature support</td>
<td>Costly, does not apply in all environments</td>
</tr>
<tr>
<td>Hypnosis</td>
<td>Decreased pain and anxiety in small studies</td>
<td>Costly, needs special technique and team, does not apply for all procedures</td>
</tr>
<tr>
<td>Massage</td>
<td>Effective for postburn itching</td>
<td>Limited by pain in burn area</td>
</tr>
</tbody>
</table>

Psychological

- Children tend to have less psychological issues compared to adults
- However, parents are often affected psychologically
- Summer camps available for burn victims
- Encourage quick return to school and reintegration with normal life
Outcomes

• Poor outcomes:
  • More than 20% TBSA partial thickness or more than 10% partial thickness and less than 10 years old
  • TBSA full thickness of 2%
  • Circumferential or involving face, feet, hands, and/or genitalia
  • Children whose burns were secondary to abuse and those with inhalation injury
• The younger the child with burn injuries, the better reported quality of life.
• Better social support predicts better outcomes.
• First outpatient outcomes study published in Oct 2014 by Brown, et al
Prevention

• ABA has published guidelines for:
  • Scald
  • Electrical
  • Gasoline
  • Fire
Prevention

• **Scald:**
  - Turn down water heater temperature to 120 degrees or less
  - Use back burners when cooking
  - Turns handles toward the back
  - Cords should be placed behind appliances

• **Electrical:**
  - Use plug covers that are the same color as the outlet
    - Covers that screw in are preferable to single plugs

• **Gasoline/Fire:**
  - Keep matches and lighters in a secure place and out of reach
  - Use proper firework safety
  - Store gasoline in child-proof containers
Prevention
References

1. Kowalke K, Helm P. Visionary Leadership in Burn Rehabilitation Over 50 Years: Major Accomplishments, but Mission Unfulfilled. PM&R. 2014 September; Vol. 6, Iss. 9, 769-773.


References