Burn Rehabilitation
Peter Esselman, MD
Professor and Chair
Department of Rehabilitation Medicine
University of Washington

Epidemiology

• United States
  – 450,000 burn injuries/year in USA that receive medical care
  – 40,000 hospital admissions per year
  – 3,400 deaths per year
  – 70% Male, 30% Female
  – Survival of those admitted to burn center 96.6%

American Burn Association Fact Sheet 2013
Miller SF. J. Burn Care Res. 27:411-436, 2006

Epidemiology

• United States — Cause of injury
  ▪ 32% fire/flame
  ▪ 34% scald
  ▪ 9% contact with hot object
  ▪ 3% chemical
  ▪ 4% electrical
  ▪ 7% other causes

Miller SF. J. Burn Care Res. 27:411-436, 2006
Burn Incidence and Treatment in the US: 2013 Fact sheet.
Available at http://www.ameriburn.org/resources_factsheet.php

Epidemiology

• Incidence has declined
  – Prevention
• Mortality has declined
  – 1984 LD50 ~ 65% TBSA burn
  – Current LD50 ~ 80% TBSA burn
• Increased mortality risk
  – Inhalation injury
  – Age
Dermal appendages have an important role in healing of burn wounds due to epidermal tissue located in the dermis.
**Depth of Burn Injury**

- Superficial
- Partial Thickness
- Full Thickness

**Superficial Burns**

- All are minor except in very young (<18 months) or elderly
- Cause
  - Sunburn, ultraviolet exposure, short flash
- Healing
  - 3-7 days

**Partial-Thickness Burn**

- Superficial - involves epidermis, papillary dermis, blisters
- Deep – involves reticular dermis
- Significant burn if >15% TBSA in adults or >10% in children
- Skin red, blanch with pressure, mottled white
- Healing
  - 7-21 days if superficial, 21-35 days if deep, may need grafting if deep or on head/neck or hand
- Painful

**Full Thickness Burn**

- Significant burn unless very small area
- Extend through the dermis and into the subcutaneous fat
- All skin appendages are damaged, therefore burns can only heal from periphery
- Skin is dry, with eschar
- Healing
  - Large areas require grafting
- Less painful at site of burn
Assessment of Burn Size

- Rule of 9s (11 segments of 9%)
  - Head 9%
  - Trunk: Anterior 18%, Posterior 18%
  - Upper Extremity: Anterior 4.5%, Posterior 4.5%
  - Lower Extremity: Anterior 9%, Posterior 9%
  - Perineum 1%
- Only Partial and Full-thickness burns included
Criteria for Burn Center Transfer

- Partial-thickness burn > 10% TBSA
- Third-degree burn in any age group
- Burns to areas at risk for complications
  - Hands, feet, face, genitalia, buttocks, major joints
- Inhalation injury
- Electrical burns, including lightning injury
- Chemical burns

Acute Burn Complications

- Inhalation injury
  - Carbon monoxide exposure
  - Upper airway obstruction
  - Chemical pneumonitis
- Wound Infection
  - Topical agents – Silver sulfadiazine (Silvadene)
  - Systemic antibiotics only as needed
- Hypermetabolism, need for nutritional support

Burn Wound Care

- Debridement
  - Remove eschar and necrotic tissue
- Early excision and grafting of deep partial thickness and full thickness burn injuries
- Pain management
  - Narcotics
  - Hypnosis and Virtual Reality

Biologic Dressings

- Xenograft
  - Pig skin
  - Provide barrier, wound covering
- Allograft
  - Human cadaver skin
  - Rejection occurs after 2-3 weeks
  - Provides wound coverage when autografting not clinically indicated or inadequate autograft donor sites

Skin Substitute Products

- Epidermal equivalents
  - Cultured epidermal autografts (CEAs)
  - Limited applications
- Allogenic Skin Equivalents
  - Cultured cells, cellular skin substitutes
  - Limited commercial availability

Skin Substitute Products

- Dermal Templates
  - Integra™
    - Collagen dermal matrix (bovine, shark)
    - Synthetic dermis vascularized from wound bed
    - Thin split thickness autograft placed on top of vascularized Integra after 10-14 days

Autografts

- Split-Thickness Skin Graft
  - Mesh graft
  - Sheet graft - face, neck, hands, joints
- Full-thickness skin graft
- Donor site

Split thickness skin graft - meshed

Split thickness skin graft- sheet
<table>
<thead>
<tr>
<th><strong>Full Thickness Skin Graft</strong></th>
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<tr>
<td>- Graft includes entire dermis</td>
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<td>- Used only for small areas such as eyelid, lip and tip of nose</td>
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<td>- Provides for good cosmetic result</td>
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<td>- Donor site heals from edges</td>
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<tr>
<th><strong>Donor Sites</strong></th>
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<tr>
<td>- Donor sites are partial thickness injuries</td>
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<td>- Typically they heal on their own with little to no scarring</td>
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<td>- They are painful</td>
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<tr>
<th><strong>Healing Donor site</strong></th>
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<tr>
<td><img src="image.jpg" alt="Image of healing donor site" /></td>
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<th><strong>Complications of Burn Injuries</strong></th>
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<tr>
<td>- Hypertrophic Scar</td>
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<tr>
<td>- Contractures, joint deformities</td>
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<td>- Heterotopic Ossification</td>
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<td>- Amputations</td>
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<td>- Neurologic injury</td>
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Hypertrophic Scarring

• Clinical picture
  – Red, raised and rigid
  – Contracts and distorts surrounding tissue

• Progression
  – Peak scarring usually occurs at 4-6 months post-injury
  – Maturation varies from 6 months to 2 years
Hypertrophic Scarring

• Who is at risk?
  – Patients with wounds that take longer than 3 weeks to heal
  – Children have higher likelihood of scarring compared to adults
  – Patients with more skin pigment tend to scar more

Hypertrophic Scarring

• Treatment
  – Identify persons at risk
  – Contractile forces - treated with stretching
  – Raising forces - treated with pressure
    • Pressure garments
    • Pressure wraps
    • Splints

Hypertrophic Scarring

• Pressure garments and wraps
  – Used to flatten hypertrophic areas and provide vascular support
  – Worn at all times except while bathing
  – Expensive
  – Many companies make ready-made and custom fit garments
Pressure garment effectiveness

- Scar measurement
  - Vancouver Scar Scale
  - Thickness, hardness, color
- Anzarut, 2007
  - Meta-analysis
  - “Pressure garment therapy does not appear to alter global scar scores.”
  - “there is insufficient evidence to support the widespread use of pressure garment therapy”
Pressure garment effectiveness

- Engrav, 2010
  - Wounds treated with compression “were significantly softer, thinner, and had improved clinical appearance.”
  - “Benefit restricted to patients with moderate to severe scarring.”

Contractures and Joint Deformities

- The most significant problem in burn rehabilitation
- Treatment
  - Positioning
  - Splinting
  - Range of Motion, Stretching

Positioning

- Prevent contractures
- The position of comfort is the position of contracture
- Prevent edema
- Prevent complications
  - Further skin breakdown
  - Neurologic injuries

Splinting

- Immobilize a joint after grafting and/or apply pressure to a new graft
- Prevent deformity
  - Place joint in functional position or position opposite the expected deformity
- Stretch soft tissue
  - Static splint
  - Dynamic splint
Exercise & Stretching

- Short frequent sessions better than long sessions
- Pain medications or non-pharmacologic pain management necessary before therapy sessions
- Paraffin may be useful
**Neck Burns**

- Flexion contractures
- Place neck in extension or hyperextension
- Avoid use of pillows
- Neck splint

**Face Burns**

- Eyes
  - Ectropian (eversion of lower lid)
- Lips
  - Lower lip eversion
- Mouth
  - Microstomia (decreased opening of mouth)

**Axilla Burns**

- Full motion difficult to obtain in deep burns
- Frequent exercise is very important
- Axillary or airplane splint
  - Position in 90 deg abduction with 15-20 deg horizontal adduction
- Risk of brachial plexus injury
- May need surgical release
**Elbow Burns**

- Flexion contractures with forearm pronation common
- Risk of heterotopic ossification

**Heterotopic Ossification**

- Elbow joint commonly involved
  - Severe upper extremity burns
  - Prolonged immobilization
  - Potential cause of ulnar neuropathy
  - May cause significant disability
  - May need surgical resection

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Image of radiograph showing the elbow joint.

Image of radiograph showing the elbow joint with heterotopic ossification.
Hand Burns

- Elevation to prevent edema
- Position in
  - Wrist extension
  - MCP flexion
  - PIP and DIP extension
  - Thumb palmar abduction
- Static and dynamic splinting
- Consider pinning to preserve function
Hand Burn Complications

- Claw Hand Deformity

- Mallet deformity
  - Injury to terminal slip of extensor tendon with loss of DIP extension
Hand Burn Complications

• Boutonniere Deformity
  – Injury to the extensor tendon at the level of the PIP joint
  – DIP hyperextension with PIP flexion

• Swan-neck deformity
  – PIP hyperextension and DIP flexion due to scarring/contraction of dorsal hand burns
Hand Burn Complications

- Syndactyly - loss of dorsal web spaces
Lower Extremity Burns

- Contractures
  - Knee flexion
  - Ankle Plantarflexion
Management of Amputations

- Complicated problem due to
  - Fragile skin
  - Contractures
  - Decreased sensation
  - Pain
Neurologic injuries

- Peripheral nerve injury in up to 30% of patients with burn injuries
- Focal Peripheral Nerve Injuries
  - Mononeuropathy
    - Direct thermal injury
    - Compartment syndrome
    - Dressings
    - Stretch/positioning
  - Brachial Plexus stretch injury
  - Mononeuritis multiplex
    - Reported in up to 56% of patients diagnosed with neuropathy

Peripheral Neuropathy

- Potential causes
  - Metabolic
  - Nutritional
  - Uremia
  - Drug induced
  - Sepsis with multi-organ failure
  - Neuotoxin

Electrical injuries

- 4% of all admissions to burn units
- Low voltage – less than 1,000 volts
- High voltage – greater than 1,000 volts
- Over 50% of electrical injuries occur at work
# Electrical Injuries

## Risk of
- Cardiac arrest
- Amputations
  - Major limb amputation in 35% of high voltage injuries
  - Peripheral nerve injury
  - Brain and spinal cord injury

## Peripheral Neurologic Injury caused by
- Direct electrical injury to nerve
- Vascular arterial thrombosis or vasospasm
- Heat generated by current
- Deep tissue injury and compartment syndrome
- Muscular contractions

## Neuropsychological Impairments
- Cognitive deficits documented even when current flow did not pass through head and without loss of consciousness or cardiac arrest
- High rate of psychiatric diagnosis