Essentials of Burn Care

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INTRODUCTION

- Over 2 million significant thermal injuries per year in US
- 7000 hospitalizations per year
- More than 5000 deaths per year
  - $\frac{1}{2}$ are children
- > 1,000,000 work days lost
- Direct costs > $1 billion
- Indirect costs > $3 billion
Mechanism of Injury

- Heat-scald, flame, flash, contact
- Electrical-low voltage/high voltage, lightening
- Chemical-acid, alkali, toxin
- Cold-frostnip/chilblains, trench foot, frostbit
ANATOMY OF SKIN

- Epidermis
- Dermis
- Subcutaneous tissue
- Dermal Appendages-hair follicles, glandular tissue
- Vascular and nervous structures
FIRST DEGREE BURNS

- Partial thickness burn/epidermis only
- Pain
- Erythema
- Peels in 2-3 days
- No scarring but damage to DNA (risk of malignancy and premature aging)
- Sunburn
SECOND DEGREE/PARTIAL THICKNESS BURNS

- Epidermis lost and variable amount of dermis
- Epidermal cells regenerate from dermal appendages, *dermis does not regenerate*
- Blisters usually present but may be very fragile, weeping wound and painful
- Healing time varies depending on depth of burn—superficial 2° burns don’t scar but may see significant pigmentary changes
- Give up to 3 weeks to heal without surgical intervention
FIRST AND SECOND DEGREE BURNS
THIRD DEGREE/FULL THICKNESS BURNS

- Full thickness burns result in complete loss of epidermis, dermis and appendages
- Pale /leathery appearance/char
- No spontaneous regeneration of skin
- Heals by contraction, epithelialization from the margins, scar formation
THIRD DEGREE BURNS
FOURTH DEGREE BURNS

- Involvement of muscle, tendon, bone and fascia or exposure of deeper structures
- Will often require local or distant tissue flaps for reconstruction—skin grafts must have a good bed for survival
Fourth Degree Burns
BURN DEPTH

- Temperature
- Duration of exposure
- Children have thinner skin
- Time to full thickness burn in scald injury
  - Adult $130^\circ \times 30$ sec.
  - Child $130^\circ \times 10$ sec.
  - Child $140^\circ \times 5$ sec.
BURN ZONES - Coagulation/Stasis/Hyperemia

Superficial 2° burn

Deep 2° burn
EXTENT OF BURNS

- Only count $2^0$ and $3^0$ burns, not $1^0$
- Rule of nines
- Lund and Browder method
- Palm (including fingers) of patient = 1-1.5% TBSA (approximately)
RULE OF NINES

Adult body    % of total
Part          BSA
Arm           9%
Head          9%
Neck          1%
Leg           18%
Anterior trunk 18%
Posterior trunk 18%

Child body    % of total
Part          BSA
Arm           9%
Head and neck 18%
Leg           14%
Anterior trunk 18%
Posterior trunk 18%
LUND AND BROWDER METHOD
ESSENTIAL HISTORY

- Cause of burn, closed space vs. open
  - Inhalation risk
- Electrical/chemical involvement
- Age, health, medications
- Related trauma
- Obtain prehospital or simultaneously with initial treatment
ABA REFERRAL CRITERIA

- Second degree burns > 10% TBSA
- Burns involving face, hands, feet, genitalia, perineum, and major joints
- Third degree burns in any age group
- Electrical Burns (including lightening)
ABA REFERRAL CRITERIA

- Chemical burns
- Inhalation injury
- Preexisting medical conditions affecting outcome
- Concomitant trauma where burn is greatest risk of morbidity/mortality
INITIAL MANAGEMENT PRINCIPLES

- Airway management
- Circulatory management
- Stop the burning process
  - remove clothing/flush chemically exposed areas-protect yourself
  - remove rings/watches etc.
- NG tube
- Foley catheter
INITIAL MANAGEMENT PRINCIPLES

- Pain relief (IV only)
- tetanus immunization status/consider need for immune globulin
- Assess extremity pulses
  - escharotomy of extremities
- Assess chest/abdomen constriction
  - escharotomy of chest and abdomen
INITIAL MANAGEMENT
PRINCIPLES

- Watch for abdominal compartment syndrome - measure bladder pressure; if >30 mmHg need to decompress abdomen
- Universal precautions
- Emotional Support/suicide concerns
INITIAL MANAGEMENT
TRANSFER

- Thermal burns
  - cover burns with a clean dry sheet
    - prevents air currents from causing pain
    - prevents hypothermia
  - no ice (frostbite)
  - cold applications should be brief if at all
    - hypothermia must be avoided
Inhalation Injury

- Present in 20% to 50% of admissions
- Present in 60% to 70% of deaths
- $2^0$ to products of incomplete combustion or other toxic agents
- Generally evident within first 5 days but may have few early signs
TYPES OF INHALATION INJURY

- CO poisoning
- Inhalation injury above the glottis
- Inhalation injury below the glottis
CARBON MONOXIDE: Pathophysiology

- CO binds to Hg with greater affinity than oxygen
- Results in hypoxia
- Most common cause of fatality at the scene
  - CO levels often 50%-70%
INHALATION INJURY
CO Levels

- >40% = altered consciousness, unconscious, seizures, coma, cardiac and respiratory compromise, death or neurological death

- 15% to 40% = vomiting, confusion, heart palpitations, extreme muscle weakness, throbbing headache, tachycardia

- 10% to 15% = asymptomatic or headache, fatigue, flu-like symptoms, weakness, SOB, dizziness, nausea, blurred vision, fatigue, ringing in ears, may appear intoxicated
INHALATION INJURY
ABOVE THE GLOTTIS

- Chemical or thermal
- Pure thermal injury almost always results in supra glottic injury
  - Efficient heat exchange of upper airway
- Airway obstruction early
- Airway obstruction late
  - After resuscitation
INHALATION INJURY BELOW THE GLOTTIS

- Usually chemical/particulate/steam injury
- Tracheobronchitis
  - severe spasm/wheezing
- Tissue response unpredictable
- Impaired ciliary activity/hypersecretion
- Erythema/edema/ulceration
Anhydrous Ammonia Inhalation

Day 1
Edema and mucous

Admit

Day 3
Raw surface
Mucous plug
AA Inhalation

Day 4
- Striations
- Loss of mucous membrane

Day 4
- Swollen glottis
- False vocal cords

Day 5
- Extensive damage and debris
INHALATION INJURY ASSESSMENT

- LOC
- Closed Space
- Noxious Chemicals
- Carbonaceous sputum
- Facial burns/singed nasal hairs
INHALATION INJURY ASSESSMENT

- Signs of hypoxemia
  - tachypnea/cyanosis/agitation/stupor
- Rapid RR/Flaring nostrils/Extra-respiratory muscle use
- Hoarse voice
- Rales/Rhonchi
- Erythema/edema of oro-nasopharynx
INHALATION INJURY
Initial Management

- 100% O₂ by face mask immediately
- With 100% oxygen ½ life of carbon monoxide decreased from 2.5-4 hrs to 45 min
- Bronchospasm, bronchorrhea, dyspnea, impaired oxygenation/hypercarbia indications for intubation
- **Stridor** = *Immediate Intubation*
  - secure with umbilical tape
  - post intubation CXR
- Cricothyroidotomony should not be necessary
Inhalation Injury

- Serial ABG and carboxyhemoglobin levels
- Nebulized heparin 5,000-10,000 U heparin alternating with 5 cc of 20% mucomyst Q4H
- Surfactant/nitric oxide experimental
- Hyperbaric oxygen may be of benefit with high levels of carbon monoxide but never delay transport or treatment to institute
SYSTEMIC RESPONSE - > 20% TBSA

- Increased vascular permeability leading to edema
- Decreased intravascular volume
- Hemoconcentration/increased hematocrit
- Decreased peripheral vascular resistance
- Decreased cardiac output
The aim of fluid resuscitation is to maintain vital organ perfusion while avoiding the complications of inadequate or excessive fluid administration.
FLUID NEEDS

PARKLAND FORMULA
First 24\textsuperscript{0}

Use Lactated Ringers
Adults: 2-4 ml x Kg Body Weight x % Burn
$\geq 20\%$ TBSA Burns

– Kids: 3-4 ml x Kg Body Weight x % Burn
$\geq 10\%$ TBSA Burns

plus their maintenance requirements-limited glycogen reserves (D5W 1/2NS)
FLUID INFUSION

- $0^\circ \text{ TO } 8^\circ$ post burn = 1/2 est. fluid vol.

- $8^\circ \text{ - } 24^\circ$ post burn = 1/2 est. fluid vol.

- Adjust according to urine output

- Time is calculated from time of burn injury, not when resuscitation started
INADEQUATE RESUSCITATION

- Shock
- Renal failure
- Death
SPECIAL CONSIDERATIONS
PATIENTS REQUIRING MORE FLUID THAN PREDICTED

- Electrical injury
- Inhalation injury
- Delayed resuscitation
- Prior dehydration
- Pregnancy
- Alcoholics
SPECIAL CONSIDERATIONS
VOLUME SENSITIVE PATIENTS

- > 60 YEARS OLD
- < 10 YEARS OLD
- Pre-existing cardiopulmonary or renal disease
- Anyone can be pushed in CHF
URINE OUTPUT

- Adults: 30 - 50 ml/hr
- Kids (<30Kg): 1.0ml/Kg/hr
- ↑ rate by 1/3 if UOP falls by 1/3
- ↓ rate by 1/3 if UOP increases by 1/3
ESCHAROTOMIES FOR PRESSURE RELEASE
WOUND MANAGEMENT
1^0 AND SUPERFICIAL 2^0 BURNS

- 1^0 burns only require moisturizing lotions/creams for comfort
- Superficial 2^0 burns require light dressings e.g., antibiotic ointments, non-stick gauze, hydrogels, silver dressings etc. and will heal within a week or two
- Don’t require use of SSD
WOUND MANAGEMENT

LARGE SUPERFICIAL 2° BURNS

- Large BSA-e.g. Steven-Johnson or TEN
- Autoimmune condition with separation at the dermal/epidermal junction
- Often benefit from xenograft/allograft or temporary artificial skin products
- Should heal within 7-21 days once disease process has stopped progressing/necrotic tissue debrided
WOUND MANAGEMENT DEEP 2° AND 3° BURNS

- Initial treatment with debridement of loose, necrotic tissue
- Topical antimicrobials-SSD, silver nitrate, mafenide
- Require surgical debridement and skin grafting in most cases-occasional flap reconstruction
NUTRITION/OTHER FACTORS

- Nutrition if essential to the healing of burn injuries
- Prefer enteral feeding but TPN required in some cases
- Dietician assistance in determining caloric and protein requirements
- Stop all factors with negative influence on wound healing-smoking/excessive alcohol etc.
WOUND MANAGEMENT DEEP 2° AND 3° BURNS
WOUND MANAGEMENT DEEP 2\(^0\) AND 3\(^0\) BURNS
Deep Flame Burn-Integra Dermal Template
Integra Dermal Template
3 weeks post application of Integra-ready for thin STSG
Healed-3 months post STSG with full ROM
Cultured Epidermal Autografts

- Biopsy taken/epidermal cells separated and grown in tissue culture
- Sheets of confluent epidermal cells but no dermal component
- Need dermal bed or equivalent for best results
- Problems with long term durability but can be life saving
WOUND MANAGEMENT
FACIAL BURNS

- Edema may be dramatic early on
  - elevate HOB
- Gentle debridement-consider enzymatic agent
- Antibiotic ointment/fine mesh gauze
- If require grafting use thicker sheet grafts in aesthetic units/FTSG for eyelids
WOUND MANAGEMENT
EYE BURNS

- Examine the eye early
  - Rapid edema formation may make it difficult later
- Fluorescein to identify corneal injury
- Chemical burn - irrigate with NS until normal Ph
- Ophthalmic antibiotics if corneal injury
- Ophthalmology consult
WOUND MANAGEMENT
HAND AND FOOT BURNS

- Vascular status
  - Cap refill/doppler/neurologic symptoms
  - May need escharotomy of hand/fingers
- Elevate above level of heart
- Light dressing with individualization of digits- avoid constrictive dressings
- Range of motion (active and passive) and splints to maintain position of function and prevent nerve compression
- Early debridement and grafting
SCAR CONTRACTURES
HAND AND FOOT BURNS
ELECTRICAL BURNS

- Low Voltage < 1000 volts
- High Voltage > 1000 volts
- High tension accidents 7200v - 19,000v
- Household current 100-220v (AC)
- DC accidents uncommon
  - car battery
  - lightening
Electrical Burns - Pathophysiology

- Injury dependant on current, pathway of flow of electrons, tissue resistance and duration of contact
- Tissue Resistance: least to most
  - Nerve, blood vessels, muscles, skin (varies depending on moisture), tendon, fat, bone
  
  Heat production in joules = current squared x tissue resistance x time of contact

- Tissue acts as volume conductor and all heated equally but dissipation of heat varies
INITIAL PROCEDURES

- Electrical injuries
  - look for entrance/exit wounds
  - 12 lead EKG
  - continuous cardiac monitoring
    - arrhythmia
  - Rhabdomyolysis - results in precipitation of myoglobin in kidneys leading to renal failure
ELECTRICAL BURNS Management

- Hx of injury - heat may ignite/melt clothing
- ABC's
- Neuro exam/hourly neurovascular checks
- Spinal injury or other associated injuries/fractures in >20% in high voltage injuries
- Titrate fluids based on response - cutaneous burn may underestimate true injury
ELECTRICAL BURNS
Management

- **Myoglobinuria**
  - UOP 100cc/hr
  - Bicarb 1 amp/L to alkalinize urine
  - Mannitol 12.5 g - acts as osmotic diuretic
  - Serial urine myoglobin

- **Arrhythmia**
  - 12 lead EKG/ 240 monitoring
  - Cardiac isoenzymes

- **Compartment syndrome**
  - Fasciotomies and if cutaneous involvement then escharotomies
ELECTRICAL BURNS: ORAL COMMISURE

- Occur when child sucks on poorly insulated electrical cord
- Deep burns of oral commisure and lips
- Initial conservative treatment and let eschar separate
- Make parents aware of possible labial artery bleeding at 7-10 days
ELECTRICAL BURNS: ORAL COMMISURE

- Once scar develops, may see microstomia: often need to treat with oral appliances to stretch tissues.
- Late reconstruction with flaps and FTSG as required.
Electrical lineman suffered high voltage contact burn >7200 v

Full thickness defect referred after 2 failed free tissue transfer attempts

To OR for debridement and local flap reconstruction
Scalping Flap for Calvarial Coverage
STSG to Cover Scalping Flap Defect
ELECTRICAL BURN

- Working underneath trailer home on plumbing
- Came in contact with electrical wiring that fell across his left face
- No other associated injuries
ELECTRICAL BURNS
Complex Defect

- After debridement, enucleation and placement of ocular spacer
- Exposed nasal bones and complete loss of eyelids
ELECTRICAL BURNS
Radial Forearm Free Flap

- Based on radial artery and venae commitantes
- Provides thin, pliable tissue for reconstruction of complex tissues
ELECTRICAL BURNS
Radial Forearm Free Flap

- Radial artery and venae commitantes anastamosed to the facial artery and vein
- Later stages reconstruction of eyelids and placement of ocular prosthesis
LIGHTENING INJURIES

- Not uncommon
- DC of $1.0 \times 10^9$v and $2.0 \times 10^5$amps
- 65% survival rate
- 150 - 300 deaths per year in US
  - Direct strike
  - Side flash
  - Arrhythmia
Lightning

- Direct Strike
  - Instant cardiac and respiratory arrest
  - Deep internal burns
  - Vascular damage
    - Boils sap in trees

- Side Strike
  - More common
  - Fern or leaf like pattern
  - Superficial injuries
  - Multiple patients
CHEMICAL BURNS

- **Alkalis**
  - oven cleaners/drain cleaners/fertilizers
  - Lye/lime

- **Acids**
  - battery acid/swimming pools chemicals

- **Organic compounds**
  - creosote/gasoline/kerosene
CHEMICAL BURNS
SEVERITY

- Agent
- Concentration
- Volume
- Duration of exposure
CHEMICAL BURNS
Treatment

- Do not delay/start at the scene
- Universal precautions
- Management
  - remove contaminated clothing
  - brush chemical powder from skin if any
  - copious water irrigation/watch runoff
- Do not neutralize! - will generate heat
WOUND MANAGEMENT
TAR BURNS

- Contact burn
- Bitumen non-toxic
- Cool molten material with cold water
- Dress with bacitracin = emulsification
- Assess depth when tar removed
  - not an emergency
Frostbite Injury

- Frostbite progresses from frostnip/trench foot
- Blistering - serous or hemorrhagic
- Tissues have pale, waxy appearance in end stage
- May be associated with systemic hypothermia
Frostbite Treatment

- Do not rewarm if risk of refreezing, minimize trauma to tissue
- Rapid rewarming in whirlpool bath, do not massage tissue, debride blister (high level of thromboxane)
- NSAID, aloe vera, topical antimicrobials
- Te99 scan/MRI to assess level, late surgery
THE FUTURE

- Noninvasive cardiac monitoring/burn depth determination
- Growth factors/cytokines
- True bilayer skin grown in culture
- Control over scar formation