Thermal injuries. Burns.

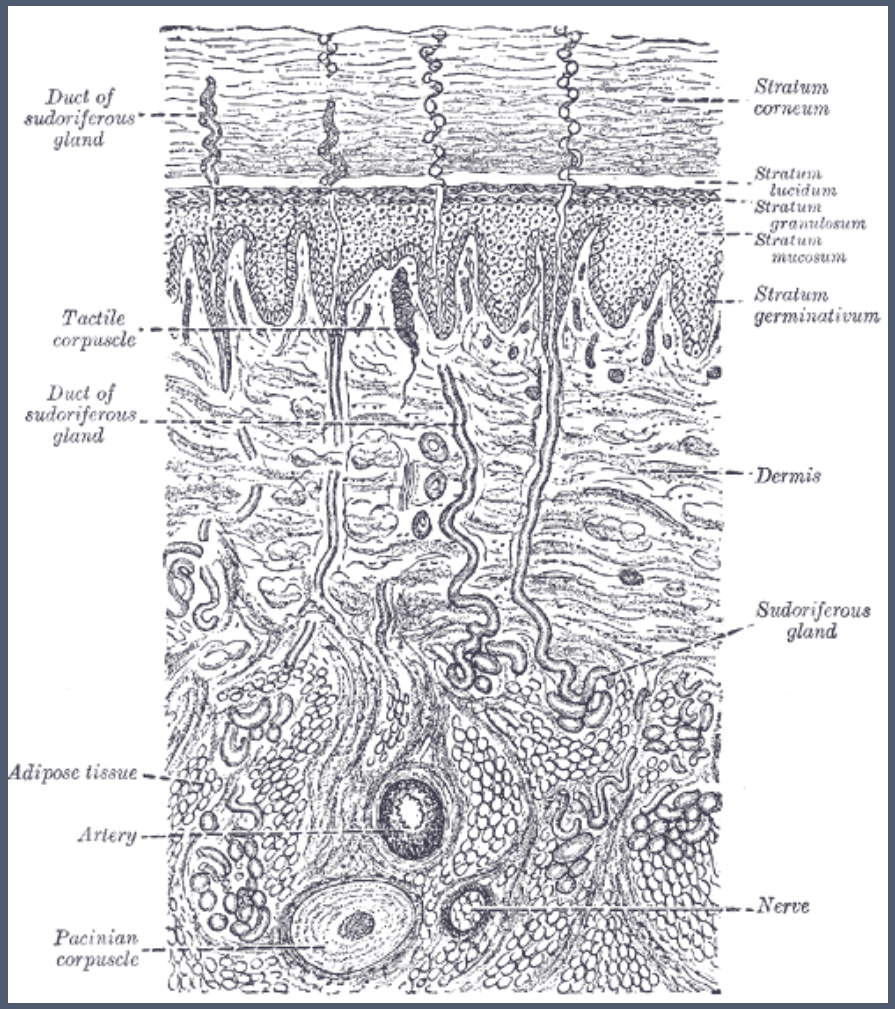
Jakub Szmytkowski, MD PhD
Dept. of General Surgery and Transplantology
Division of Hepatobiliary and General Surgery
Ludwik Rydygier Collegium Medicum in Bydgoszcz
Nicolaus Copernicus University, Poland

Skin: roles

- Protection: an anatomical barrier from pathogens
- Sensastion: contains a variety of nerve endings (heat, cold, touch, pressure, vibration and injury)
- Thermoregulation: sweat glands and dilated blood vessels (increased superficial perfusion) aid heat loss, constricted vessels greatly reduce cutaneous blood flow and conserve heat.
- Control of evaporation: the skin provides a relatively dry and semi-impermeable barrier to fluid loss.
- Storage and synthesis: acts as a storage center for lipids and water
- Absorption: O_2, N_2 and CO_2 can diffuse into the epidermis in small amounts; (in humans, the cells comprising the outermost 0.25–0.40 mm of the skin are almost exclusively supplied by external oxygen)
- Water resistance: acts as a water resistant barrier so essential nutrients aren't washed out of the body.

Skin: structure

- Epidermis → provides waterproofing and serves as a barrier to infection
- Dermis → serves as a location for the appendages of the skin



Burn Injury

- 10,000 deaths/year
- More common in men
- Death rates high in kids and older adults
- Most deaths happen in home
- High incidence in low-income households

Pathophysiology of Thermal Burn Injury

- Tissue destruction depends on:
  - Temperature and duration of exposure
- Ability to resist burn injury depends on:
  - Water content of skin tissue
  - Thickness and pigmentation of skin
  - Insulating substances (e.g., skin oils, hair)
  - Peripheral circulation of skin
    - Affects dissipation of heat

Severity factors

- area → percentage of total body surface area (TBSA)

> 40%

- thickness → split – thickness vs full – thickness
- respiratory tract injury (inhalational trauma, IHT)
- age > 60
- comorbidities

Determining depth

- Clinical assessment
- Biopsy
- Laser Doppler Imaging (LDI) ; Laser Doppler Perfusion Imaging (LDPI)
- Photooptical techniques

1st degree

- Limited to epidermis
- Redness
- Dry
- Painful
- Heals in 1wk or less

2nd degree (2a)

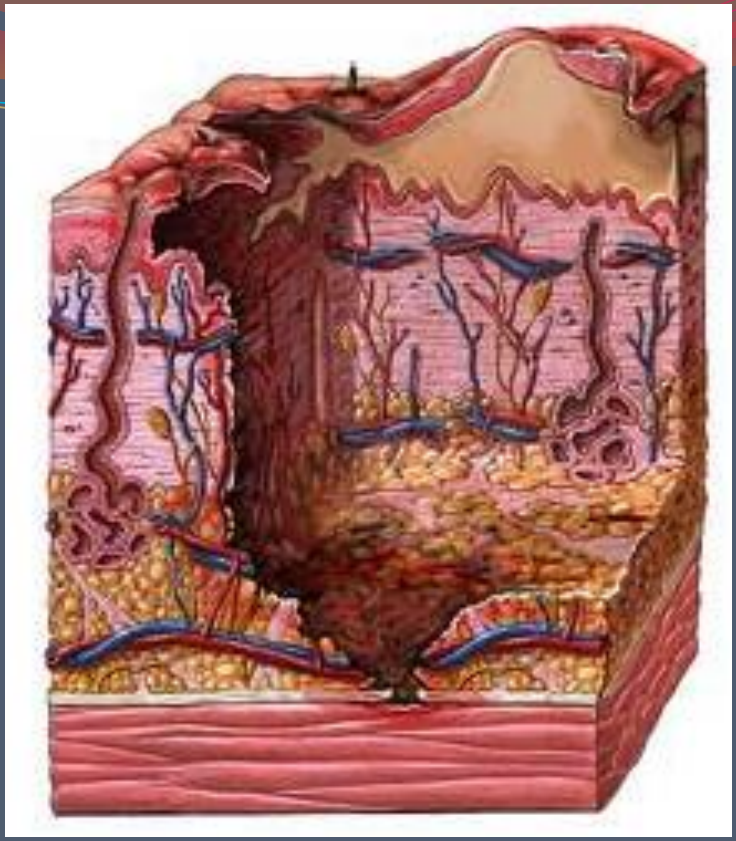
- superficial partial thickness - extends into superficial (papillary)dermis
- Red with clear blister Blanches with pressure
- Moist
- Painful
- Heals in 2-3wks
- Local infection

2nd degree (2b)

- deep partial thickness- extends into deep (reticular) dermis
- Red-and-white with bloody blisters. Less blanching.
- Moist
- Painful
- Weeks - may progress to third degree
- Scarring, contractures (may require excision and skin grafting)

3rd degree

- Extends through entire dermis
- Stiff and white/brown
- Dry, leathery
- Painless
- Requires excision
- Scarring, contractures, amputation



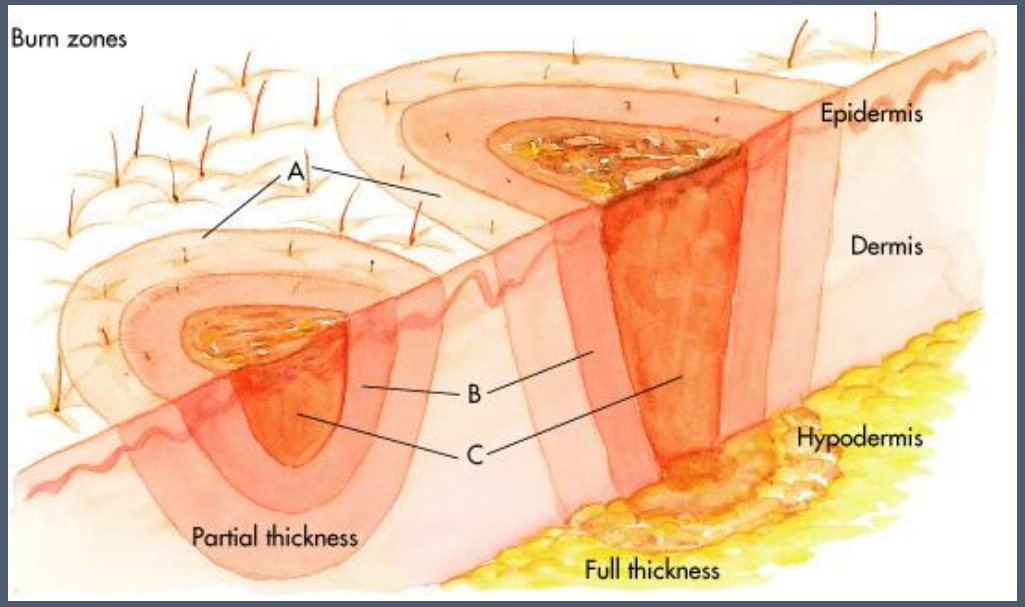
Fourth-Degree Burn

- Included in some burn classifications

- Full-thickness injury that penetrates
  - Subcutaneous tissue
  - Muscle
  - Fascia
  - Periosteum
  - Bone

Local Response to Burn Injury

- Major burns have three zones of injury
- Appear in bulls-eye pattern:
  - Zone of hyperemia (A)
  - Zone of stasis (B)
  - Zone of coagulation (C)



Classifications of Burn Injury

- Assess and classify as accurately as possible in the prehospital setting
  - Difficult because of progressive nature of injury
  - Amount of tissue damage may not be evident for hours/days after injury

Severity

- Major burns (typically require referral to a specialized burn treatment center):
  - Age 10-50 yrs: partial thickness burns >25% of total body surface area
  - Age <10 or >50: partial thickness burns >20% of total body surface area
  - Full thickness burns >10%
  - Burns involving the hands, face, feet or perineum
  - Burns that cross major joints
  - Circumferential burns to any extremity
  - Any burn associated with inhalational injury
  - Electrical burns

Severity

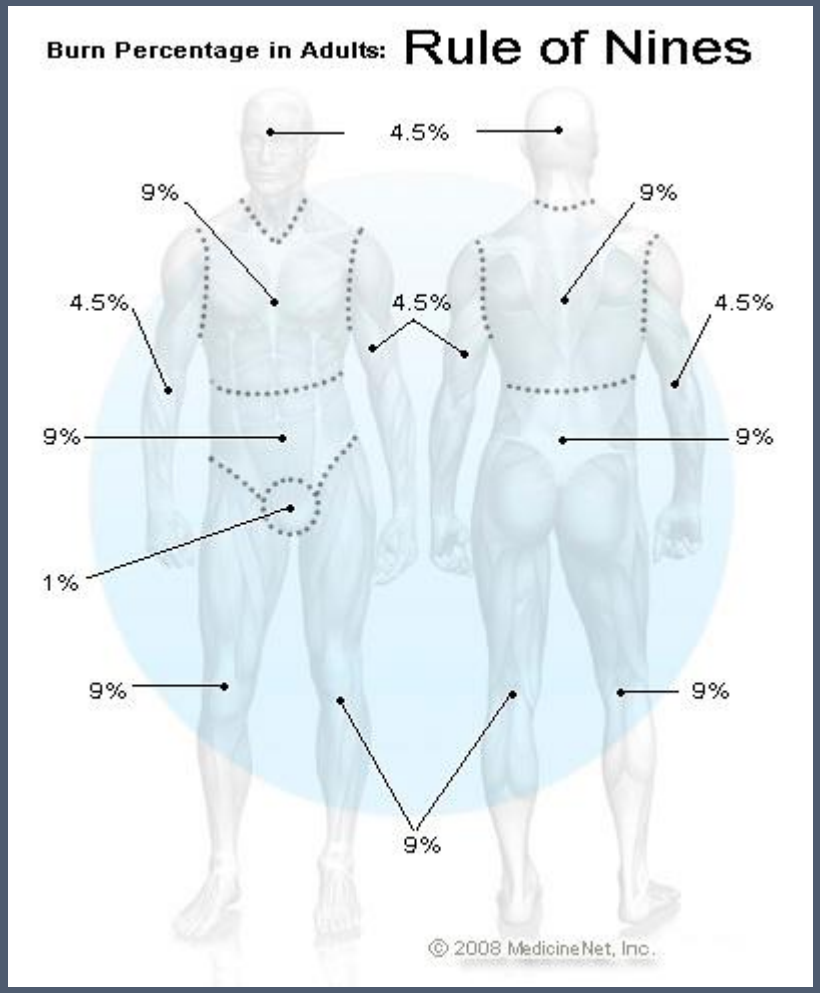
- Moderate burns (Persons suffering these burns often need to be hospitalised for burn care):
  - Age 10-50 yrs: partial thickness burns involving 15-25% of total body surface area
  - Age <10 or >50: partial thickness burns involving 10-20% of total body surface area
  - Full thickness burns involving 2-10% of total body surface area

Severity

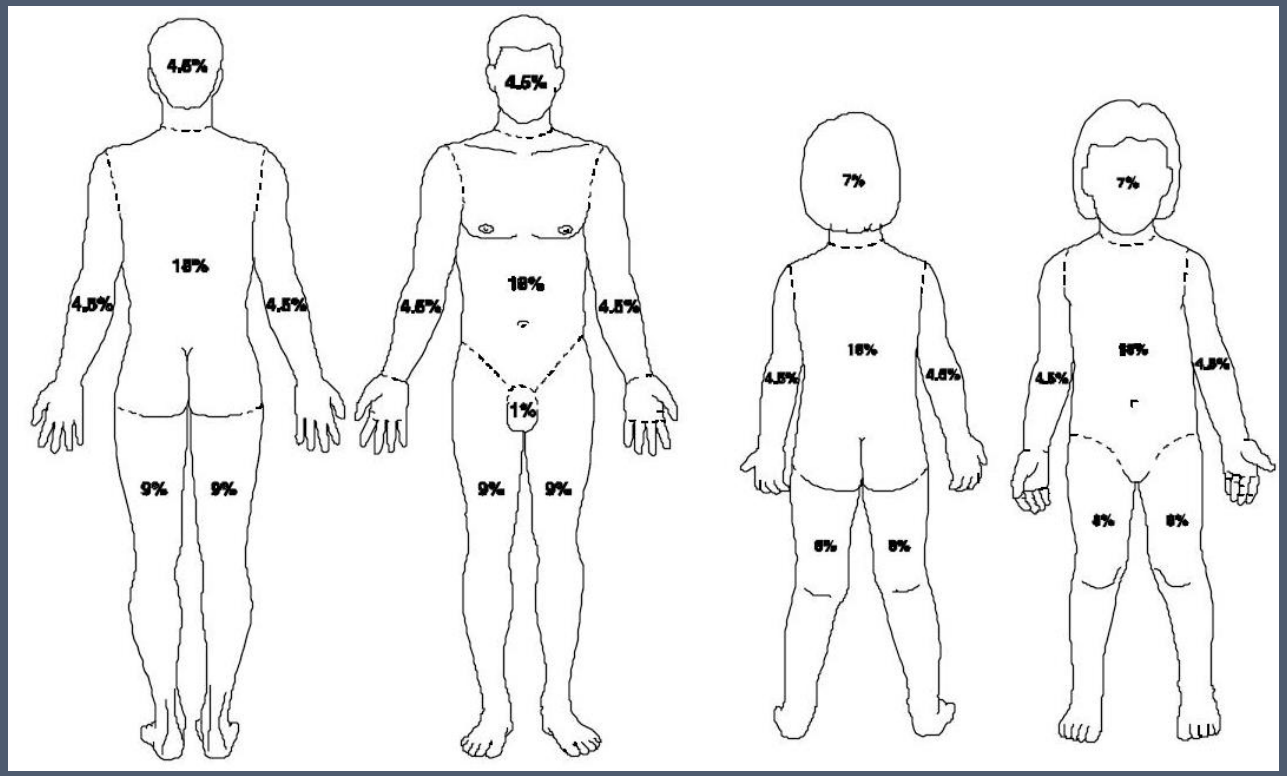
- Minor burns (usually no hospitalization required):
  - Age 10-50 yrs: partial thickness burns <15% of total body surface area
  - Age <10 or >50: partial thickness burns involving <10% of total body surface area
  - Full thickness burns <2% of total body surface area, without associated injuries

Area: rule of nines

- head = 9%
- chest(front) = 9%
- abdomen (front) = 9%
- upper/mid/low back and buttocks = 18%
- each arm = 9% (front = 4.5%, back = 4.5%)
- groin = 1%
- each leg = 18% total (front = 9%, back = 9%)



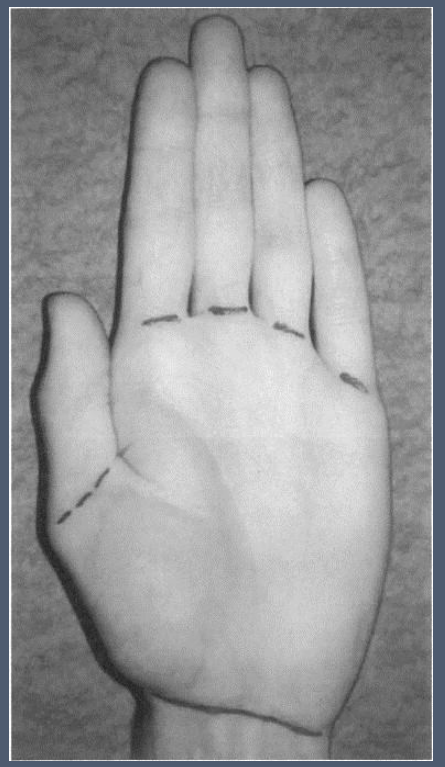
Area: Lund – Browder chart



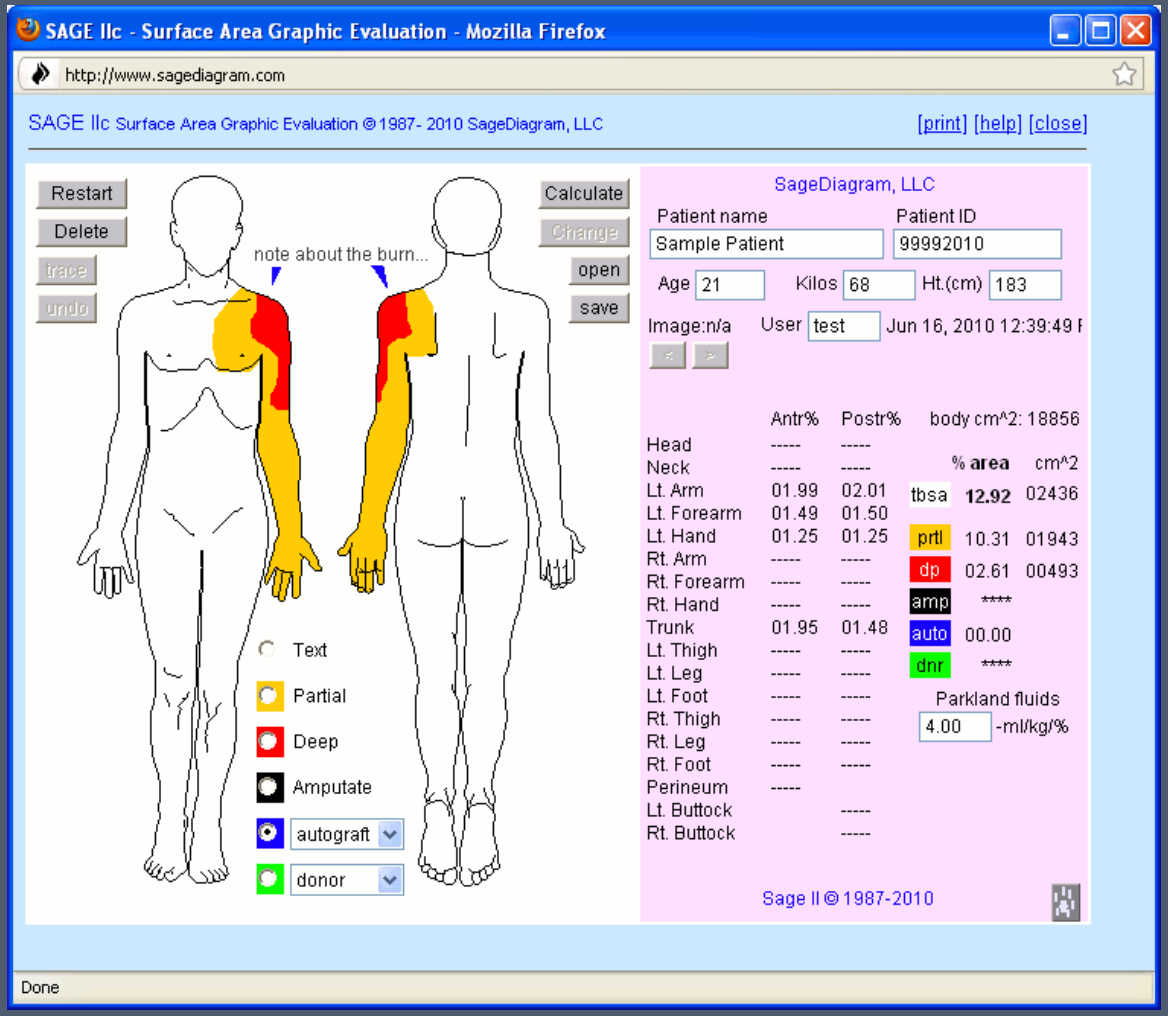
- Age – adjusted area chart

Area: hand surface area (HSA)

- Palmar surface of the PATIENT'S hand represents 1% of TBSA
- Not adjusted for BMI
  (if BMI > 31 , then HSA = 0.64% TBSA)
- Not adjusted for sex
  (in females HSA < 1% TBSA)
- High risk of overestimation



Area: Surface Area Graphic Evaluation (SAGE)

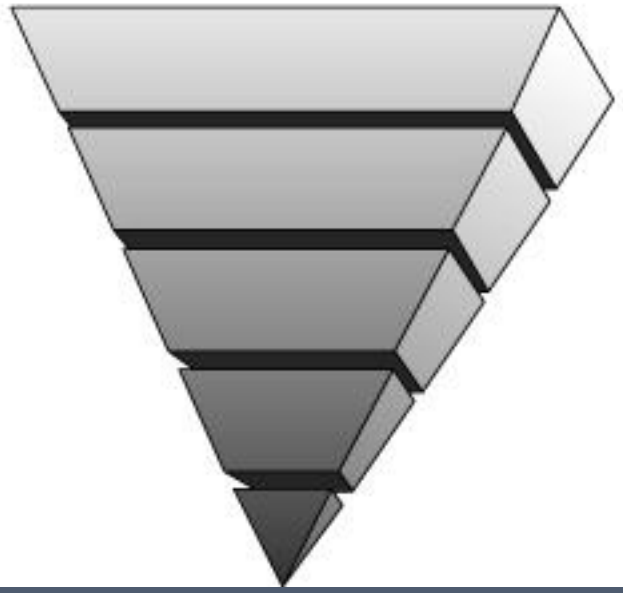


Assessment of the Burn Patient

- Initial assessment
  - Airway
    - Especially patients with inhalation injury
  - Breathing
  - Circulation
  - Neurological status

Probability of Upper Airway Obstruction

- Burns around nose or mouth
- Soot in mouth or nose: singed nasal hairs
- Intraoral burns: burned tongue
- Intraoral swelling (no stridor)
- Hoarseness of voice
- Visible pharyngeal edema
- Inspiratory stridor



Carbon Monoxide Poisoning

- Colorless, odorless, tasteless gas
- Produced by incomplete combustion of carbon fuels
  - Does not physically harm lung tissue
- Affinity for hemoglobin 250x oxygen
  - Small concentrations of CO can cause severe physiological impairments
  - Effects of carbon monoxide poisoning related to blood CO Hgb level

History

- Chief complaint (pain, dyspnea)
- Circumstances of injury
  - Enclosed space?
  - Explosive forces involved?
  - Hazardous chemicals involved?
  - Related trauma?
- Source of burning agent (e.g. flame, metal, liquid, chemical)

History

- Significant medical history
- Patient medications (and drugs/alcohol)
- Loss of consciousness at any time
  - Suspect inhalation injury
- Last tetanus immunization

Goals of Prehospital Burn Management

- Preventing further tissue injury
- Maintaining patent airway
- Administering oxygen and ventilatory support
- Fluid resuscitation (per protocol)
- Rapid transport to appropriate medical facility
- Clean technique to minimize patient's exposure to infectious agents
- Psychological and emotional support

Stopping the Burning Process

- Provide scene safety for rescue crew
- Minor first-degree burns
  - Cool the local area with cool water

Stopping the Burning Process

- Severe burns
  - Move patient to area of safety
  - If clothing is in flames or smoldering:
    - Place patient on floor or ground
    - Roll in blanket to smother flames and/or douse with large quantities of cleanest available water
  - Remove clothing while cooling burn so heat is not trapped under smoldering cloth
  - After burn is cooled, cover patient with clean sheet

Airway, Oxygen, and Ventilation

- Administer high-concentration humidified (if available) oxygen
- Assist ventilation as needed
- If inhalation injury is suspected, closely observe for signs of impending airway obstruction:
  - Laryngeal edema may be progressive and may make tracheal intubation difficult or impossible
  - Do not delay intubation in these patients

Circulation

- Fluid resuscitation is based on:
  - Severity of injury
  - Vital signs
  - Transport time to hospital
- IV therapy
- If transport is to be delayed or interfacility transport is possible, consider:
  - Analgesics - aggressive pain control
  - NG tube placement
  - Bladder catheterization

Special Considerations

- Facial burns swell rapidly
  - Associated with airway compromise
  - Elevate stretcher at least 30 degrees (if not contraindicated by spinal trauma) to minimize edema
- Avoid pillow if ears are burned

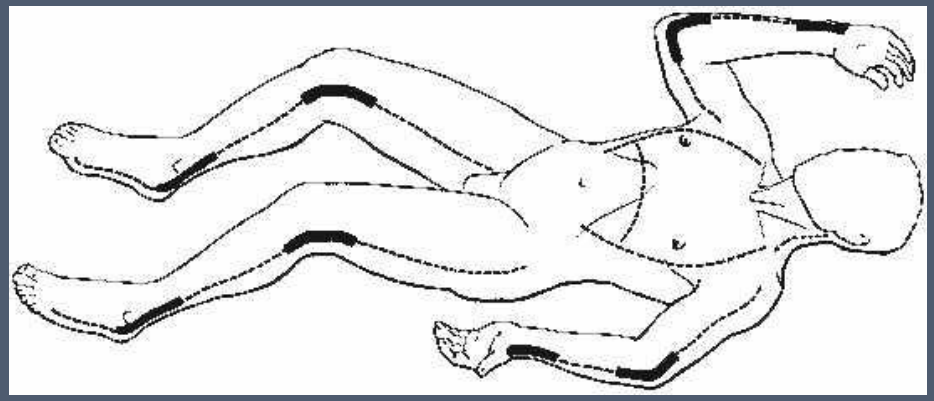
Special Considerations

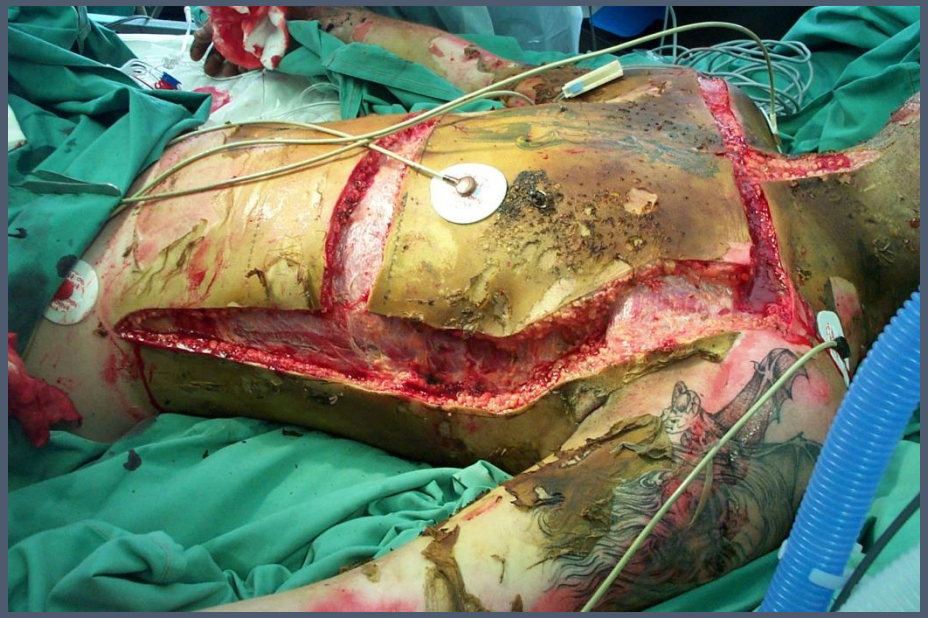
- Extremity burns
  - Remove jewelry to prevent vascular compromise from edema
  - Assess peripheral pulses frequently
  - Elevate burned limb above patient's heart

- Circumferential burns
  - Threat to patient's life or limb
  - Tourniquet-like effect on extremity or chest

Escharotomy

- In full – thickness burns, a rigid layer of necrotic tissue impairs breathing / blood supply to limbs (compartment syndrome upon rehydration)
- Incision through eschar to subcutaneous fat
- Avoid joints





Systemic Response to Burn Injury

- Hypovolemic shock associated with:
  - Decrease in venous return
    - Decreased cardiac output
    - Increased vascular resistance (except in zone of hyperemia)
  - Renal failure may occur due to:
    - Hemolysis (destruction of RBCs)
    - Rhabdomyolysis (muscle necrosis)

Treatment: fluid resuscitation

- Fluid loss starts immediately after the burn occurs
  - increased capillary permeability
  - loss of watertightness
  - edema
  - evaporative loss at the burn surface
- Greatest loss of plasma occurs in the first 12 hours after burn
- Extensive leakage can continue for up to three days
- Fluid replacement during this period is essential to ensure cardiac output and renal and tissue perfusion

Fluid resuscitation

- The primary function of fluid resuscitation is to:
  - Prevent burn shock by giving adequate fluid without overloading the vascular system or causing excessive oedema;
  - Maintain circulatory volume in the face of losses due to the burn – this is essential for cardiac output, renal perfusion and tissue perfusion;
  - Provide metabolic water;
  - Maintain tissue perfusion to the zone of stasis and prevent the burn from deepening.

Fluid resuscitation

- Burns of more than 15% of surface body area in adults and of over 10% in children warrant formal resuscitation
- Parkland formula:
  - First 24 h postburn:
    - Ringer's lactate 4 ml/kg/% TBSA
    - First 8 hours: 50% of fluids
    - The remaining 50% over the next 16 hours
  - Second 24 h postburn:
    - First 8 hours: FFP 0.5 ml/kg/% TBSA
    - Remaining 16 hours: 5% glucose to maintain diuresis (1 ml/kg/h)

Wound management

- Preserve the tissues that may survive.
- Remove the tissues that are devitalized as soon as possible.
- Provide durable skin coverage as soon as possible.
- Prevent infection and if it is established, treat it vigorously.
- Protect recently healed tissues.

Wound treatment: conservative

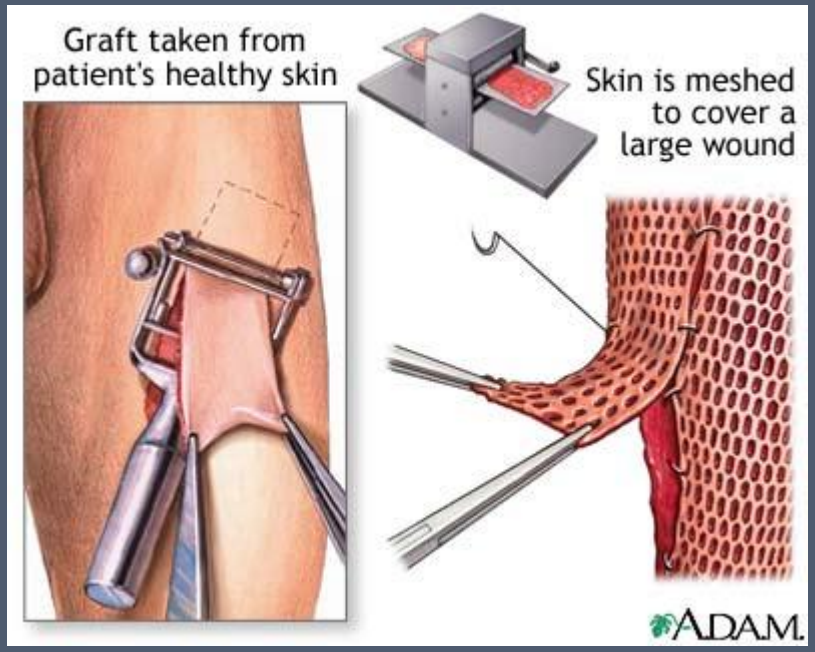
- First hours: pain control → Aquagel dressing
- topical antimicrobials:
  - Silver sulfadiazine
  - Mefenide acetate
  - Silver nitrate

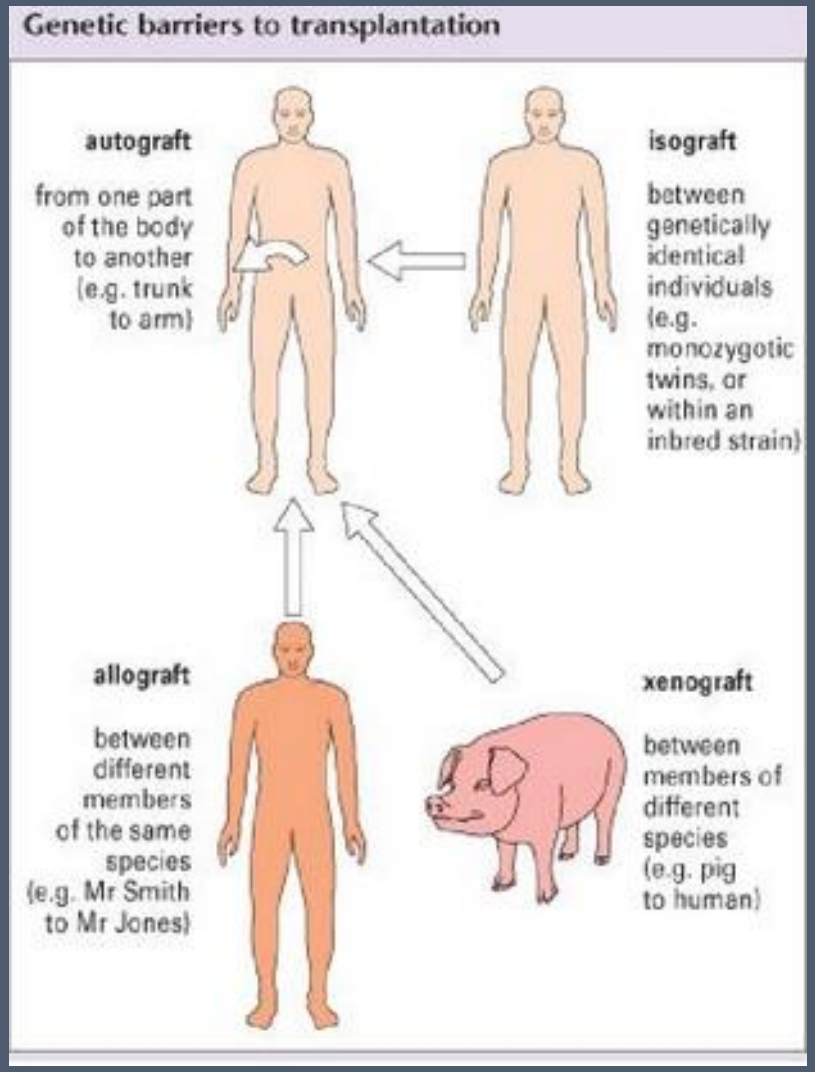
Surgical treatment - Timing of Surgery

- Early excision and grafting
- Tangential excision
- Fascial excision
- Late surgery: after three weeks
- Skin grafting
- Split thickness skin grafting, sheet vs. meshed
- Full thickness skin grafting

Skin grafting

- Full – thickness vs split thickness
- Mesh vs solid



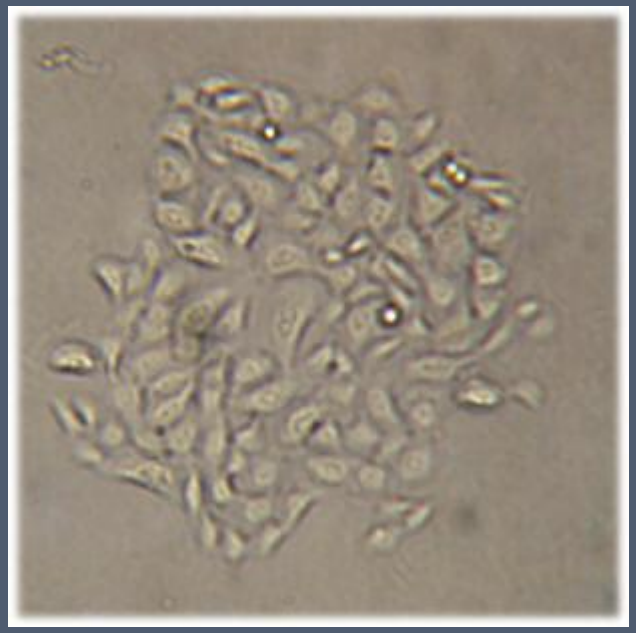


Other modes of cover

- Amnion cover
- Cadaveric skin cover
- Xeno graft
- Keratinocyte culture

Keratinocyte culturing

- keratinocyte grafts take best (50 to 90%) on remaining dermal structures after deep dermal (II b) burns.



Scar prevention and management

- In deep dermal burns, spontaneous healing may be delayed for 3-4weeks and is frequently followed by the development of hypertrophic scars
- Scars may affect mobility
- Plastic surgery to increase joint mobility

Frostbite – localized freezing of body fluids

- Prevention is best
- Get out of cold
- Remove constricting clothing or jewelry
- Protect blisters
- Immersion in hot water
- *NEVER RUB FROSTBITTEN AREA!*
- Medical care

Frostbite – reperfusion and necrosis

Chemical Burn Injury

- Three common types of caustic agents
  - Alkalis (strong bases with a high pH)
    - Hydroxides and carbonates of:
      - Sodium, potassium, ammonium, lithium, barium, calcium
      - Oven cleaners, drain cleaners, fertilizers, heavy industrial cleaners, cement and concrete
  - Strong acids
    - Rust removers
    - Bathroom cleaners
    - Swimming pool acidifiers
  - Organic compounds (chemicals that contain carbon)
    - Wood
    - Coal

Chemical Burn Injury

- Substances that produce chemical changes in skin with or without heat production

- Intraoral chemical burns sustained by a boy who ingested bleach

Chemical Burn Injury

- Severity of chemical injury related to:
  - Chemical agent
  - Concentration and volume of chemical
  - Duration of contact

Assessment—Chemical Injury

- Determine:
  - Type of chemical
  - Concentration of chemical
  - Volume of chemical
  - Mechanism of injury
    - Local immersion of body part, injection, splash
  - Time of contamination
  - First aid before EMS arrival
  - Appearance (chemical burns vary in color)
  - Pain

Management

- Scene safety
- Consider protective gear
- Remove all clothing, including shoes
- Brush off powdered chemicals
- Irrigate affected area with copious amounts of water

- No agent superior to water for treating most chemical injuries

Electrical burns

- Lightning injuries
- Direct contact with electrical current
- Arcing of electricity between two contact points near skin
- Flash burns if fuel source is ignited

Types of Electrical Injury

- Tissue damage produced by electrical current depends on
  - Amperage (current flow)
  - Voltage (force)
  - Resistance
  - Type of current
    - Alternating
    - Direct
  - Current pathway
  - Duration of current flow

Direct Contact Burn

- Direct contact burn—entry wound (hand)

- Exit wound

Effects of Electrical Injury

- Musculoskeletal
  - Similar to crush injury
  - Myoglobin released from muscle damage
- Cardiovascular
  - Significant dysrhythmias
  - Tachycardia
  - Hypertension
  - Hemolysis releases hemoglobin
  - Blood vessel necrosis

Effects of Electrical Injury

- External burns
- Respiratory injury
  - Ventilation impaired
- Neurological injuries
  - Respiratory center depression
  - Brain tissue injury
- Myoglobin release and renal involvement

Assessment and Management

- Scene safety for rescuers or bystanders
- If patient is in contact with electrical source, consult appropriate personnel before touching patient
  - Once scene is safe, patient care can begin

Initial Assessment

- Proceed as for all other trauma patients
- Immobilize cervical spine
- If apnea, provide assisted ventilation:
  - Intubation because apnea may persist for lengthy periods
- For breathing patient, maintain a patent airway and support with supplemental high-concentration oxygen

Initial Assessment

- If patient is in cardiac arrest, resuscitation efforts should be implemented according to protocol

Physical Examination

- Search for:
  - Entrance and exit wounds
  - Trauma caused by tetany or a fall
- Remove all clothing and jewelry
- Assess and document distal pulses, motor function and sensation in all extremities
- Cover wounds with sterile dressings
- Manage associated trauma appropriately
- Monitor ECG

Radiation burns

- Ionizing and nonionizing radiation
- Burns may result from high level of radiation exposure to a specific area
- Rare

Lightning Injury

- 70 deaths/year
- DC of 200,000 amps
- Potential of 100 million volts
- Injury by direct strike or side flash
- Cardiac arrest possible

Lightning Injury

- Pathway of damage often over rather than through skin
  - Lightning burns are linear, feathery, and punctate (pinpoint)
  - Classified as minor, moderate, or severe

Radioactive Particles

- Alpha particles
  - Skin will stop
  - Dangerous if ingested or inhaled
- Beta particles
  - Penetrate subcutaneous tissue
  - Full PPE, including SCBA, needed
- Gamma rays and x-rays
  - Most dangerous
  - Lead shields needed