Burn Injuries
Topics To Be Discussed:

- Anatomy and physiology of the skin.
- Different types of burns including thermal, chemical, electrical, radiation, and inhalation injury.
- Burn classification.
- Burn criteria.
- Assessment and treatment of the burn injury.
- Transport considerations for specific injuries.
Epidemiology

- Tissue injury caused by thermal, electrical, or chemical agents.
- Can be fatal, disfiguring, or incapacitating.
- ~1.25 million burn injuries per year.
  - 45,000 hospitalized per year.
  - 4500 die per year (3750 from housefires).
- 3rd leading cause of accidental death.
Risk Factors

- Fire/Combustion
  - Firefighter
  - Industrial Worker
  - Occupants of multiple family dwellings, burning structures

- Chemical Exposure
  - Industrial Worker
  - Agriculture

- Electrical Exposure
  - Electrician
  - Electrical Power Distribution Worker
Anatomy and Physiology of the Skin
Skin

- Largest organ of the body, but is much more than a passive organ.
  - Protects underlying tissues from injury.
  - Responsible for temperature regulation.
  - Acts as water tight seal, keeping body fluids in.
  - Sensory organ.
Skin

- Injuries which result in damage to the skin have problems with:
  - Infection
  - Inability to maintain normal water balance
  - Inability to maintain body temperature
Skin

- Two layers
  - Epidermis
  - Dermis
- Epidermis
  - Outer cells are dead
  - Act as protection and form water tight seal
Skin Layers

The layers of the epidermis

- Stratum corneum
- Stratum lucidum
- Granular layer
- Spiny layer
- Basal layer
Skin

- **Epidermis**
  - The deepest layer of cells divide and push already formed cells to higher layers where they flatten and die.
  - The layers from the deepest to the most superficial are:
    - stratum basale
    - stratum spinosum
    - stratum granulosum
    - stratum lucidum
    - stratum corneum
Skin

Dermis

- Consists of tough, elastic connective tissue which contains specialized structures
  - Nerve endings
  - Blood vessels
  - Sweat glands
  - Oil glands - keep skin waterproof, usually discharges around hair shafts
  - Hair follicles - produce hair from hair root or papilla
    - Each follicle has a small muscle (arrectus pilorum) which can pull the hair upright and cause goose flesh
Burn Injuries
Burn Injuries

Potential complications:
- Fluid and electrolyte loss that leads to hypovolemia.
- Hypothermia, infection, acidosis.
- Increased catecholamine release with vasoconstriction.
- Renal or hepatic failure.
- Formation of eschar.
- Complications of circumferential burn.
An important step in management of the burn injury is to determine:

- The cause of the injury.
- The depth of the burn.
- The extent of damage or surface area to determine where and how the patient should be treated.
Types of Burn Injuries

- **Thermal burn**
  - Skin injury
  - Inhalation injury
- **Chemical burn**
  - Skin injury
  - Inhalation injury
  - Mucous membrane injury
- **Electrical burn**
  - Lightning
- **Radiation burn**
Depth Classification

- Superficial
- Partial thickness
- Full thickness
Superficial burn (1st degree)
- Involves the epidermis.
- Characterized by reddening.
- Tenderness and pain.
- Increased warmth.
- Edema may occur, but no blistering.
- Burn blanches under pressure.
- Example – sunburn.
- Usually heal in ~ 7 days.
- Is not counted when calculating surface area burned.
Burn Classifications

- **Partial Thickness (2nd degree)**
  - Damage extends through the epidermis and involves the dermis.
  - Not enough to interfere with regeneration of the epithelium.
  - Moist, shiny appearance.
  - Salmon pink to red color.
  - Painful.
  - Does not have to blister to be 2nd degree.
  - Usually heals in ~7-21 days.
Burn Classifications

- Partial Thickness Burn
Burn Classifications

- **Full Thickness Burn (3rd degree)**
  - Both epidermis and dermis are destroyed with burning into subcutaneous fat.
  - Thick, dry appearance.
  - Pearly gray or charred black color.
  - Painless - nerve endings are destroyed.
  - Pain is due to intermixing of 2nd degree.
  - May be minor bleeding.
  - Will not heal, requires grafting.
Burn Classifications

- Full Thickness Burn
Burn Injuries

- Often it is not possible to predict the exact depth of a burn in the acute phase. Some 2nd degree burns will convert to 3rd when infection sets in. When in doubt call it 3rd degree.
Body Surface Area Estimation

Rule of Nines

- Adult

- Palm Rule
Body Surface Area Estimation

**Rule of Nines**

- **Peds**
  - For each year over 1, subtract 1% from head and add equally to the legs

- **Palm Rule**
Burn Severity

Factors to Consider

- Depth or classification
- Body surface area burned
- Age: adult vs pediatric
- Pre-existing medical conditions
- Associated trauma
  - blast injury
  - fall injury
  - airway compromise
  - child abuse
Burn Severity

- **Patient age**
  - Less than 2 years or greater than 55 have increased incidence of complications

- **Burn configuration**
  - Circumferential burns can cause total occlusion of circulation to an area due to edema
  - Restrict ventilation if the burns encircle the chest
  - Burns on a joint area can cause disability due to eschar formation
Critical Burn Criteria

- 3° > 10% BSA
- 2° > 30% BSA
  - >20% pediatric
- Burns with respiratory injury
- Hands, face, feet, or genitalia
- Burns complicated by other trauma
- Underlying health problems
- Electrical and deep chemical burns
Moderate Burn Criteria

- 3° 2-10% BSA
- 2° 15-30% BSA
  - 10-20% pediatric
- Excluding hands, face, feet, or genitalia
- Without complicating factors
Minor Burn Criteria

- $3^\circ < 2\% \text{ BSA}$
- $2^\circ < 15\% \text{ BSA}$
  - $<10\% \text{ pediatric}$
- $1^\circ < 20\% \text{ BSA}$
Thermal Burn Injury Pathophysiology

- **Emergent phase**
  - Response to pain causes catecholamine release

- **Fluid shift phase**
  - Massive shift of fluid from the intravascular space to the interstitial and extra vascular space

- **Hypermetabolic phase**
  - Increased demand for nutrients needed by the body to begin the healing process and repair tissue damage

- **Resolution phase**
  - Scar tissue formation and the remodeling of tissue
Thermal Burn Injury Pathophysiology

- **Jackson’s Thermal Wound Theory**
  - **Zone of Coagulation**
    - Area nearest burn
    - Cell membranes rupture, clotted blood and thrombosed vessels
  - **Zone of Stasis**
    - Area surrounding zone of coagulation
    - Inflammation, decreased blood flow
  - **Zone of Hyperemia**
    - Peripheral area of burn
    - Limited inflammation, increased blood flow
Eschar formation

- Skin denaturing
  - Hard and leathery
- Skin constricts over wound
  - Increased pressure underneath
  - Restricts blood flow
- Respiratory compromise
  - Secondary to circumferential eschar around the thorax
- Circulatory compromise
  - Secondary to circumferential eschar around extremity
Assessment & Management - Thermal Injury

- Remove to safe area, if possible
- Stop the burning process
  - Extinguish fire, put out any smoldering areas
  - Remove clothing and jewelry
  - Cut around areas where clothing is stuck to skin
  - Cool adherent substances (tar, plastic)
Assessment & Management - Thermal Injury

- **Determine History**
  - How long ago?
  - What care has been provided?
  - What was the source of the burn?
  - Burned in closed space?
    - Products of combustion present?
    - How long exposed?
    - Loss of consciousness?
  - Past medical history?
Assessment & Management - Thermal Injury

Airway and Breathing

- **Assess for potential airway involvement**
  - Soot or singing of mouth, nose, hair, face, facial hair
  - Coughing, black sputum
  - Enclosed environment

- **Assist ventilations as needed**

- **100% oxygen via NRB if:**
  - Moderate or critical burn
  - Patient unconscious
  - Signs of possible airway inhalation injury
  - History of exposure to carbon monoxide or smoke
Assessment & Management - Thermal Injury

Airway and Breathing (continued)

- Respiratory rates are unreliable as toxic byproducts may have a depressant effect on respirations.
- Be prepared to intubate early if patient has inhalation injuries
  - Prepare for RSI
Circulatory Status

- Burns do not cause rapid onset of hypovolemic shock
- If shock is present, look for other injuries
- Circumferential burns may cause decreased perfusion to extremity
Assessment & Management - Thermal Injury

Other

- Assess burn surface area and associated injuries
- Provide analgesia
- Avoid topical agents unless directed by Burn Center
  - Silvadene
  - Water Gel
- Fluid therapy
Consider Fluid Therapy for:

- >10% BSA 3°
- >15% BSA 2°
- >30 - 50% BSA
- 1° with any accompanying 2° burns
Initial Fluid Therapy

- Use warmed LR or 0.9% NS.
- Start the IV through burned skin if necessary.
- For adults, start infusion at 500 ml/hr.
- For adolescents, start infusion at 250 ml/hr.
- For infants and small children, start infusion at 150 ml/hr.
- Calculate the Parkland Burn Formula as time permits.
Parkland Burn Formula

- Patient’s weight in kilograms x % of total body surface area burned (TBSA) x 4 ml.
  - 1/2 in first 8 hours.
  - 1/2 over next 16 hours.
  - Titrated to urine output.
Assessment & Management - Thermal Injury

Fluid therapy

- **Objective**
  - HR < 110/minute
  - Normal sensorium (awake, alert, oriented)
  - Urine output – 30 - 50 ml/hour (adult)
  - Urine output - 0.5-1 cc/kg/hr (pediatric)
  - If myoglobinuria is present, fluids are increased to maintain urine output to 70 ml/hr in adults.
  - Resuscitation formula’s provide estimates, adjust to individual patient responses

- Monitor for CHF and pulmonary edema
Assessment & Management - Thermal Injury

Analgesia

- Morphine Sulfate
  - 2-4 mg IV repeated every 5-10 minutes to a maximum dose of 20 mg. 0.1 mg/kg IV to a maximum dose of 10 mg for the pediatric patient.
  - Titrate to control of pain with adequate ventilations and blood pressure.
  - Contact Medical Control for additional MS. May require large total doses.
  - Avoid IM administration with burns.
Assessment & Management - Thermal Injury

Analgesia

- Fentanyl
  - 1 - 2 mcg/kg IV slow push to a maximum single dose of 100 mcg in patients over 6 months of age.
  - Contact Medical Control for additional Fentanyl.
  - Avoid IM administration.

Contact Medical Control for additional Fentanyl.
Assessment & Management - Thermal Injury

- Treating the Burn Wound
  - Low priority - After ABC’s and initiation of IV’s
  - Do not rupture blisters
  - Cover with sterile dressings
    - Moist: controversial, limit to small areas (<10%) or limit time of application to only the first minutes following the burn.
    - Dry: use for larger areas due to concern for hypothermia.
    - Plastic wrap. Keeps the area from drying out and helps with pain by inhibiting contact with the air and air movement.
  - Cover with burn sheet
- No “goo” on a burn unless directed by Burn Center
Assessment & Management - Thermal Injury

- Transport Considerations
  - Appropriate facility
    - Burn Center
    - Trauma Center
  - Factor to consider
    - Burn Severity Criteria
    - Critical, Moderate, Minor Burn Criteria
    - Co-morbidities
    - Contributing factors
    - Transport resources
Inhalation Injury

- Anticipate respiratory problems:
  - With burns to the head, face, neck or chest
  - Nasal or eyebrow hairs are singed
  - Hoarseness, tachypnea, drooling present
  - Loss of consciousness in burned area
  - Nasal/oral mucosa red or dry
  - Soot in mouth or nose
  - Coughing up black sputum
  - Occurred in an enclosed area (e.g. small apartment, confined space)
Inhalation Injury

- Burned or exposed to products of combustion in closed space
- Cough present, especially if productive for carbonaceous sputum
- Any patient in fire that has the potential for hypoxia and/or carbon monoxide poisoning
Inhalation Injury

- **Supraglottic Injury (above the glottis)**
  - Susceptible to injury from high temperatures
  - May result in immediate edema of pharynx and larynx
    - Brassy cough
    - Stridor
    - Hoarseness
    - Carbonaceous sputum
    - Facial burns
Inhalation Injury

- Subglottic Injury (below the glottis)
  - Rare injury
  - Injury to lung parenchyma
  - Usually due to superheated steam, aspiration of scalding liquid, or inhalation of toxic chemicals
  - Signs and symptoms may be immediate but systemic signs are usually delayed
    - Wheezing or crackles
    - Productive cough
    - Bronchospasm
Inhalation injury

- Other Considerations
  - Toxic gas inhalation
  - Smoke inhalation
  - Carbon monoxide poisoning
  - Thiocyanate poisoning
  - Thermal burns
  - Chemical burns
Inhalation Injury Management

Airway, Oxygenation and Ventilation
- Assess for airway edema early and often
- Consider early intubation, RSI
- When in doubt oxygenate and ventilate
- High flow oxygen
- Bronchodilators may be considered if bronchospasm present
- Diuretics are not appropriate for pulmonary edema
Inhalation Injury Management

Circulation

- Treat for shock (rare)
- IV Access
  - LR/NS large bore, multiple IVs
  - Titrate fluids to maintain systolic BP and perfusion
Inhalation Injury Management

Other Considerations

- Assess for other burns and injuries
- Treat burn soft tissue injury
- Treat associated inhalation injury/poisoning
  - Cyanokit® for cyanide, hydrogen sulfide
  - Positive pressure ventilation
  - Hyperbaric chamber (carbon monoxide poisoning)
Cyanokit®
Cyanide poisoning is commonly due to smoke inhalation during closed-space structure fires secondary to the combustion of plastics and synthetics. Hydrogen cyanide is a colorless gas with a faint odor of bitter almonds.

- Signs and symptoms commonly include headache, confusion, dyspnea, chest tightness, and nausea. Signs of cyanide toxicity include an altered level of consciousness, seizure, dilated pupils, tachypnea and hypertension (early), bradypnea and hypotension (late), vomiting, and shock. Soot may be present in the mouth, nose, or oropharynx. Be alert to any of these signs or symptoms during responses to structure fires or industrial settings.
Administer Cyanokit® IV 5 grams over 15 minutes. For adults, prepare the full 5 gram dose in two equal portions: each portion is 2.5 grams of hydroxycobalamin in 100 ml of 0.9% NS. Administer each portion over 7.5 minutes and monitor for clinical response. Depending on severity of the poisoning, a second dose of 5 grams may be administered by IV infusion for a total dose of 10 grams.

For pediatrics, administer 70 mg/kg of the 25 mg/ml solution over 15 minutes. Monitor for clinical response. Depending on severity of the poisoning, a second dose of 70 mg/kg may be administered by IV infusion for a total dose of 140 mg/kg.
Inhalation Injury

- **Transport considerations**
  - Burn Center
  - Trauma Center
  - Hyperbaric chamber
Chemical Burns

- Usually associated with industrial exposure.
- First Consideration:
  - Your safety.
  - Does the patient need decontamination before treatment?
- Burning will continue as long as the chemical is on the skin.
Chemical Burns

- **Acids**
  - Immediate coagulation-type necrosis creating an eschar though self-limiting injury.
  - Decontamination of the area is essential.
  - HF acid has specific protocol.
    - HF seeks calcium.
    - Administer topical Calcium Gluconate and IV Calcium Chloride.
HF Acid Exposure

- Assess and manage acute life threatening conditions in the usual manner. Use gloves, masks, and gowns, if necessary.
- Remove soiled clothing. Initially decontaminate by irrigation with copious amounts of water.
- Ice packs on the affected area may alleviate symptoms by retarding diffusion of the ion.
- Mix 10 ml of calcium gluconate with a 30 ml tube of K-Y jelly and apply liberally to the affected area.
- For digital burns, if calcium gluconate gel is not available, the fingers may be soaked in magnesium hydroxide-containing antacid preparations (i.e. Mylanta) en route to a medical facility.
- Treat inhalation injuries with oxygen and 2.5% calcium gluconate via nebulizer by mixing 1 ml of the 10% calcium gluconate solution with 3 ml of 0.9% NS. Provide CPAP if pulmonary edema develops.
- For eye exposure, instill Tetracaine and insert Morgan Lens and irrigate with a calcium gluconate solution by mixing 10 ml in a 250 ml bag of warmed NS and irrigate for 5 minutes. Continue irrigation with warmed LR and repeat calcium gluconate solution every 20 minutes.
- Monitor the ECG. If the QTc widens, administer 500 mg – 1 gram of Calcium Chloride IV slow push.
- Transport the patient to the nearest appropriate medical facility.
Chemical Burns

- **Bases (Alkali)**
  - Liquefactive necrosis with continued penetration into deeper tissue resulting in extensive injury
    - characterized by dull, opaque, partly or completely fluid remains of tissue

- **Dry Chemicals**
  - Exothermic reaction with water
Chemical Burn Management

- Definitive treatment is to get the chemical off!
- Begin washing immediately - remove the patient’s clothing as you wash
  - Watch for the socks and shoes, they trap chemicals
Chemical Burn Management

- **Liquid Chemicals**
  - wash off with copious amounts of fluid

- **Dry Chemicals**
  - brush away as much of the chemicals as possible
  - then wash off with large quantities of water

- **Flush for 20 - 30 minutes** to remove all chemicals
Chemical Burn Management

- Do not attempt neutralization
  - can cause additional chemical or thermal burns from the heat of neutralization
- Assess and deliver secondary care as with other thermal and inhalation burns
Chemical Burn to Eye Management

- Flood the eye with copious amounts of water only
  - Never place chemical antidote in eyes
- Remove contact lenses
  - May trap irritants
- Flush using warmed LR / 0.9%NS from medial to lateral for at least 15 minutes.
  - Morgan Lens (see Morgan Lens procedure)
  - Nasal cannula
Chemical Burn to the Eye
Specific Chemical Considerations

- **Dry lime**
  - Brush off
  - Dry lime is water activated
  - Then flush with copious amounts of water

- **Phenol**
  - Not water soluble
  - If available, use alcohol before flushing except in eyes
  - If unavailable, use copious amounts of water
Specific Chemical Considerations

- **Sodium/Potassium metals**
  - Reacts violently on contact with H₂O
  - Requires large amounts of water

- **Sulfuric Acid**
  - Generates heat on exposure to H₂O (exothermic)
  - Wash with soap to neutralize or use copious amounts H₂O

- **Tar Burns**
  - Use cold packs
  - Do not pull off, can be dissolved later
Specific Chemical Considerations

- **Chemical Mace**
  - CN or CS
    - First chemical agents used by police/military
  - Mucous membrane and respiratory tract irritant
  - Skin sensitizer

- **Management**
  - Treat respiratory distress
  - Continued irrigation and shower decontamination
  - Protect yourself first
  - Decontaminate everything afterward
Specific Chemical Considerations

- **Chemical Mace**
  - **OC**
    - Commonly referred to as “pepper spray”
  - Not as toxic as CN or CS
  - Mucous membrane irritant and skin sensitizer
  - May cause respiratory irritation

- **Management**
  - Treat respiratory distress
  - Continued irrigation and shower decontamination
  - Protect yourself first
  - Decontaminate everything afterward
Electrical Burns

- Usually follows accidental contact with exposed object conducting electricity
  - Electrically powered devices
  - Electrical wiring
  - Power transmission lines
- Can also result from lightning
- Damage depends on intensity of current
Electrical Burns

- **Current kills, voltage simply determines whether current can enter the body**
  - Ohm’s law: \( I = \frac{V}{R} \)
- **Electricity follows shortest path to ground**
- **Low Voltage**
  - usually cannot enter body unless:
    - Skin is broken or moist
    - Low resistance (follows blood vessels/nerves)
- **High Voltage**
  - easily overcomes resistance
Electrical Burns
Electrical Burns

- Severity depends upon:
  - what tissue current passes through
  - width or extent of the current pathway
  - AC or DC
  - duration of current contact
Electrical Burns

- Most damage done is due to heat produced as current flows through tissues
- Skin burns where current enters and leaves can be almost trivial looking
  - Burn path follows nerves, vessels, muscles, tissues, etc. Follows shortest path to a grounding source.
  - Everything in-between can be cooked due to heat produced
- Higher voltage may result in more obvious external burns
Electrical Burns

- **Alternating Current (AC)**
  - Tetanic muscle contraction may occur, resulting in:
    - Muscle injury
    - Tendon Rupture
    - Joint Dislocation
    - Fractures
  - Muscle spasms may prevent the patient from being able to let go or free themselves from the current.
Electrical Burns

- Contact with Alternating Current can also result in:
  - Cardiac arrhythmias
  - Apnea
  - Seizures
In addition to contact burns, patients can also develop flash burns when the current arcs near them.

- Flame burns may occur when clothing ignites after exposure to electrical current.
Electrical Burns

- **Lightning**
  - HIGH VOLTAGE!!!
  - Injury may result from
    - Direct Strike
    - Side Flash
  - Severe injuries often result

- Provides additional risk to EMS provider
  - Weather capable of producing lightning may still be in the area.
Electrical Burns

- Pathophysiology of Injuries
  - External Burn
  - Internal Burn
  - Musculoskeletal injury
  - Cardiovascular injury
  - Respiratory injury
  - Neurologic injury
  - Rhabdomyolysis and Renal injury
Lichtenberg figure due to lightning strike
Electrical Burn Management

- Make sure current is off
  - Lightning hazards
  - Do not go near patient until current is off

- ABC’s
  - Ventilate and perform CPR as needed
  - Oxygen
  - ECG monitoring
    - Treat dysrhythmias
    - Ventricular fibrillation is more common with low voltage alternating current.
    - Asystole is more common with electric shock from direct current or high-voltage alternating current.
Rhabdomyolysis and Myoglobinuria

- When muscle is damaged, a protein pigment called myoglobin is released into the bloodstream and filtered out of the body by the kidneys. Myoglobin breaks down into potentially harmful compounds that blocks the structures of the kidney causing acute tubular necrosis or kidney failure.
Electrical Burn Management

- **Rhabdomyolysis Considerations**
  - Fluids? Maintain urine output of 70 ml/hr.
  - Dopamine? Maintain systolic pressure of 90 mmHg systolic.
- Assess for additional injuries
- Consider transport to a burn or trauma center
Electrical Burn Management

Any patient with an electrical burn, regardless of how trivial it looks, needs to be evaluated at a hospital. There is no way to determine how bad the burn is on the inside by the way it looks on the outside.
Radiation Exposure

- Waves or particles of energy that are emitted from radioactive sources
  - Alpha radiation
    - large, travel a short distance, minimal penetrating ability
    - can harm internal organs if inhaled, ingested or absorbed
  - Beta radiation
    - small, more energy, more penetrating ability
    - usually enter thru damaged skin, ingestion or inhalation
  - Gamma radiation and X-rays
    - most dangerous penetrating radiation
    - may produce localized skin burns and extensive internal damage
Radiation Exposure

- Radiation exposure may result in:
  - external injury
  - contamination
  - incorporation injury
  - combined injuries
Radiation Exposure

- Effect of injury is dependent upon:
  - duration of exposure
  - distance from the source
  - shielding
- The patient is at risk for delayed complications
Radiation Exposure Management

- Think safety!!!
  - Time, distance, and shielding are the most useful tools for the management of a Radiation Incident.
  - Protective equipment
- Consider the need for decontamination
- Likelihood of survival
- ABCs and supportive care
Pediatric Burns

- Thin skin
  - increases severity of burning relative to adults
- Large surface/volume ratio
  - rapid fluid loss
  - increased heat loss → hypothermia
- Delicate balance between dehydration and overhydration
- Immature immunological response → sepsis
- Always consider possibility of child abuse
Geriatric Burns

- Decreased myocardial reserve
  - fluid resuscitation difficulty
- Peripheral vascular disease, diabetes
  - slow healing
- COPD
  - increases complications of airway injury
- Poor immunological response ➔ sepsis
- % mortality ~= age + % BSA burned