Burn injury

Types of burn

Pathophysiology:

1. Local effects
2. Systemic effects:

Burn shock

Inhalation injury

Burn assessment:

Degree

Percentage

Indication of admission

Initial management and prophylaxis

Possible complications and their management.

Surgical management and management of specific areas

Mortality estimation

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Late reconstruction.

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Burn: is a term used to describe integument damage caused by thermal, electrical or chemical injuries.

Thermal burn: refer to injury by heat or by cold.

Types of heat: the extent and depth of burn injury varies according to the type of thermal damage as follow:

1. Scald burn: variable depth according to viscosity of the liquid and duration of exposure (the greater viscosity the greater contact time the more severe injury is).

2. Flame burn: usually deep

3. Contact burn: usually deep but is limited in extent.

4. Flash burn: occurs during ignition, usually superficial.

Pathophysiology:

Local effects: Local burn injury has been subdivided into three zones:

1. The central zone of coagulation: Tissue in this area has no blood flow and is nonviable.
2. The middle zone of stasis: viable area but Microvascular sludging and thrombosis soon results in progressive

tissue necrosis.
3. The outer zone of hyperemia, which is entirely viable.

Systemic effects: systemic effect can be summarized as the following:

1. **Cardiovascular compromise (burn shock):**
   Following sever burn injury (more than 20 % of TBSA) the patient develop sever shock due to combination of external fluid loss through the wound and internal fluid loss due to **local and systemic edema** (3rd space loss).

   *Injury Impairment of vascular endothelial integrity
   *Increased osmotic pressure in burned tissue } **Local edema**

   Release of vasoactive substances e.g. (leukotriene,
   Prostaglandins, histamine, and free radicals) } **Systemic edema**

In >40% TBSA **myocardial depression** can result which may exacerbate shock.

The above effects reach peak at 8-12 post injury hours and start to decline after 12-18 hours when capillary leakage start to seal.

2. **Respiratory impairment**: Mainly due to:
   - Systemic edema.
   - Inhalational injury (inhalation of product of combustion, CO poisoning and rarely by direct thermal injury e.g. steam inhalation.

3. **Immunological impairment**: due to loss of mechanical barrier, endocrine response to trauma, impaired cellular and humeral response and invasive procedures e.g. CV line, folly's cath. etc.

Acute burn management

Evaluation: every burn patient should be initially assessed to determine the following:

1. Depth

2. Extent of burn to TBSA (total of total body surface area involved).

3. Presence of inhalational injury.

4. Presence of circumferential 3rd. degree burn.

Depth assessment

BURN DEPTH CATEGORIES

BURN DEGREE	CAUSE	SURFACE APPEARANCE	COLOR	PAIN LEVEL
First (superficial)	Flash flame, ultraviolet (sunburn)	Dry, no blisters, no or minimal edema	Erythematous	Painful
Second (partial thickness)	Contact with hot liquids or solids, flash flame to clothing, direct flame, chemical, ultraviolet	Moist blebs, blisters	Mottled white to pink, cherry red	Very painful
Third (full thickness)	Contact with hot liquids or solids, flame, chemical, electrical	Dry with leathery eschar until debridement; charred vessels visible under eschar	Mixed white, waxy, pearly; dark, khaki, mahogany; charred	Little or no pain; hair pulls out easily
Fourth (involves underlying structure)	Prolonged contact with flame, electrical	Same as third degree, possibly with exposed bone, muscle, or tendon	Same as third degree	Same as third degree

Determination of Burn Extent: when total body surface area (TBSA) burned is calculated one should include those areas of partial and full thickness bums while 1st degree burns **are not** included in the calculation.

1. The **rule of nines:** it is important to note that the proportions of infants and children are different than those of adults. The head of children tends to be proportionately greater than 9% TBSA, and the lower extremities are less than 18%
2. The **patient's hand**: The patient's hand represents about 1% TBSA.
3. **Lund and Browder charts**: are a more accurate method of assessing burn extent. They provide an age based diagram to assist in more precisely calculating the bum size.

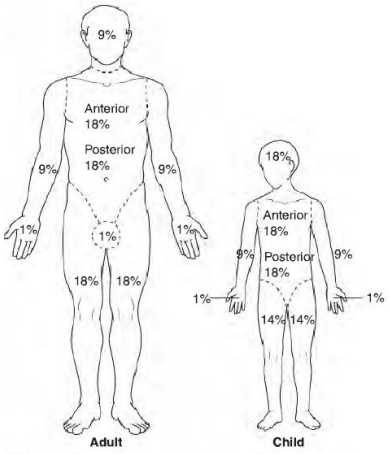
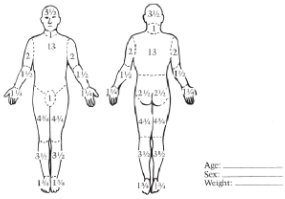


FIGURE 15.1. The Rule of 9's provides a facile method of estimat-



Area	Birth–1 y	1–4 y	5–9 y	10–14 y	15 y	Adult	Partial thickness 2°	Full thickness 3°	Total
Head	19	17	13	11	9	7			
Neck	2	2	2	2	2	2			
Anterior trunk	13	13	13	13	13	13			
Posterior trunk	13	13	13	13	13	13			
Right buttock	2½	2½	2½	2½	2½	2½			
Left buttock	2½	2½	2½	2½	2½	2½			
Genitalia	1	1	1	1	1	1			
Right upper arm	4	4	4	4	4	4			
Left upper arm	4	4	4	4	4	4			
Right lower arm	3	3	3	3	3	3			
Left lower arm	3	3	3	3	3	3			
Right hand	2½	2½	2½	2½	2½	2½			
Left hand	2½	2½	2½	2½	2½	2½			
Right thigh	5½	6½	8	8½	9	9½			
Left thigh	5½	6½	8	8½	9	9½			
Right leg	5	5	5½	6	6½	7			
Left leg	5	5	5½	6	6½	8			
Right foot	3½	3½	3½	3½	3½	3½			
Left foot	3½	3½	3½	3½	3½	3½			
						Total			

FIGURE 15.2. The Lund and Browder chart provides a more precise estimate of burn TBSA for each body part based on

Indication of referral to burn center:

BURN CENTER REFERRAL CRITERIA
The American Burn Association has identified the following injuries as those usually requiring a referral to a burn center. Patients with these burns should be treated in a specialized burn facility after initial assessment and treatment at an emergency department.
Questions about specific patients can be resolved by confirmation with the burn center.
Second- and third-degree burns >10% body surface area (BSA) in patients <10 or >50 years old.
Second- and third-degree burns >20% BSA in other groups.
Second- and third-degree burns with serious threat of functional or cosmetic impairment that involve the face, hands, feet, genitalia, perineum, and major joints.
Third-degree burns >5% BSA in any age group.
Electrical burns, including lightening injury.
Chemical burns with serious threat of functional or cosmetic impairment.
Inhalation injury with burn injury.
Circumferential burns with burn injury.
Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality.
Any burn patient with concomitant trauma (for example, fractures) in which the burn injury poses the greatest risk of morbidity or mortality. However, if the trauma poses the greater immediate risk, the patient may be treated in a trauma center initially until stable, before being transferred to a burn center. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
Hospitals without qualified personnel or equipment for the care of children should transfer burned children to a burn center with these capabilities.

Initial management

Intravenous access:

- Two peripheral IV lines are usually sufficient for patients with Less than 30% burns.
- Patients with larger burns or significant inhalation injury may require central line placement.

Lines should be sutured in place, particularly over burned areas where the use of tape dressings is Difficult.

Escharotomy: The leathery eschar of a full thickness burn can form a constricting band that compromises limb perfusion. Indicated for full thickness circumferential bums of the extremity or for full thickness burns of the chest wall when the eschar compromises thoracic cage excursion and, thus, ventilation. The incision should go through only eschar, not fascia.

Fluid Resuscitation: The purpose of fluid resuscitation is to provide adequate replacement for fluid Lost through the skin and fluid lost into the interstitium from the systemic capillary leak that occurs as part of the body's inflammatory response. Therefore, significant volumes of intravenous fluid may be required to maintain adequate organ perfusion. Fluid resuscitation is reserved for patients with bums involving more than *15%* to 20%. Awake and alert patients with burns less than 20% should be allowed to resuscitate themselves orally as best as possible.

Day 1 :(hours 0-24)

THE PARKLAND FORMULA FOR FLUID RESUSCITATION
Formula: **4 cc/kg/%TBSA = total fluid to be administered in the first 24 h**
½ of fluid should be given in the first 8 h
½ of fluid should be given in the next 16 h
Fluid should be Ringer's lactate
Sample calculation: 70 kg person with a 50% TBSA burn
4 × 70 × 50 = 14 L of fluid
7 L in the first 8 hours (875 cc/h)
7 L in the next 16 hours (437 cc/h)
• The formula is only a guideline. Fluid administration should be titrated to urine output of 30 cc/h for adults and 1 cc/kg/h for children.
Pediatric patients less than 15 kg should also receive maintenance fluid based on their weight.

Day 2(hours 25-48):

Change ringer's lactate to 5% dextrose water and adjust according to O.U.P as above.

Begin colloid infusion: 5% albumin at 0.3-1.0 cc/kg/% burn /16 = cc 5% albumin/hr. (do not vary according to U.O.P)

Day 3 (hours 49):

Change to maintenance intravenous fluid or begin oral and/or enteral feeding.

Topical Wound Agents: Burn injury destroys the body's protective layer from the environment and dressings are needed to protect the body from infection and minimize evaporative heat loss from the body. The choice of topical burn wound treatment depends on the depth of bum injury and the goals of management:
Superficial burn wounds (such as sunburns) require soothing lotions that will expedite epithelial repair such as aloe Vera.
Partial thickness burn wounds need coverage with agents that will keep the wound moist and provide antimicrobial protection that optimizes epithelialization.
Deeper partial thickness and full thickness burn wounds should be covered with agents that will protect the eschar from microbial colonization.
Commonly used agents:

Name of agent	Antimicrobial spectrum	Depth of penetration	Side effects
Silver sulfadiazine 1% cream	Broad spectrum but weak against enterobacteriaceae and pseudomonas aeroginosa	Incapable of eschar penetration, so it is less useful in management of infected wound.	• Leukopenia • sulfa allergy
Mafenide (Sulfamylon) 5% solution	broad spectrum	Readily penetrates burn eschar, making it an excellent agent for infected wound	• Metabolic acidosis.(potent carbonic anhydrase Inhibitor) • Painful
Silver nitrate O.5% solution	Broad spectrum	No penetration	• Stains everything it touches black. • osmolar dilution (hyponatremia and hypochloremia) • methemoglobinemia
Other agents: Bacitracin, neomycin, and polymyxin B ointments			

Nutrition:

following burn injury nutritional requirements is increased due to:

- Hypermetabolism and hypercatabolism that persists until complete wound coverage is achieved.
- The nutritional requirements to heal burn wounds, skin grafts, and donor sites.

Feeds, whether oral or enteral, should be initiated as soon following admission as possible, Ileus following burn injury commonly occurs, and it may take days for the return of gastrointestinal function. However, ileus can be prevented by starting feeds in the immediate post injury period.

- Patients with burns of under 20% TBSA can obtain enough calories by oral feeding.
- Patients with larger burns and patients who will be intubated for several days should have an enteral feeding tube placed on **admission.**
- Because of the high levels of narcotics patients receive, routine use of stool Softeners should also begin on admission to prevent constipation.

Estimation of **caloric requirements**. The two most commonly used formulas for calculating caloric requirements are the Curreri formula and the Harris-Benedict formula.

The Curreri formula:

Adult: 25 kcal × weight (kg) + 40 kcal × %TBSA

Children: 60 kcal × weight (kg) + 35 kcal × %TBSA

The Harris-Benedict formula: provides an estimate of basal energy expenditure (BEE):

Men: 66.5 + 13.8 × weight (kg) + 5 × height (cm)−6.76 × age (years)

Women: 65.5 + 9.6 × weight (kg) + 1.85 × height (cm)−4.68 × age (years)

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Protein requirement: 2 g of protein per kilogram per day.

Gastrointestinal Prophylaxis:

Stress ulcers (Curling ulcers) are a common complication following severe burn injury. Best protection against stress ulcers is feeding the patient.

Drug prophylaxis indication:

1. Patients who are not taking oral diet or enteral feeds.
2. Patients with previous history of peptic ulcer disease.

Prophylactic agents:

Histamine receptor blockers, sucralfate, and proton pump inhibitor.

Pain control:

Burn patients typically have two types of pain: background and procedural. Narcotics are the most commonly used analgesics, Nonsteroidal medications are not used in patients who are going to undergo surgery because of the increased risk of bleeding.

Background pain presents on a daily basis with little variation. Best treated with longer-acting agents (Methadone).

Procedural pain occurs during daily wound care and therapy, shorter-acting agents are probably best (fentanyl).

Deep Venous Thrombosis Prophylaxis:

Indication:

- Injuries to the extremity.
- The intubated patient.
- Indwelling catheters (femoral vein).

INHALATION INJURY:

Diagnosis:

- History (the circumstances surrounding the burn injury) and findings on physical examination.
- Bronchoscopy.
- Arterial blood gas and carboxyhemoglobin level.

Treatment:

- 100% oxygen to correct carboxyhemoglobin level (CO poisoning)
- Secure a patient's airway early in the post burn period, particularly if the patient is going to require large volumes of fluid.

Decision Not to Resuscitate DNR:

Despite the significant advances in bum care, some injuries are not survivable. In cases of extensive burn injury, a decision is made regarding the potential futility of resuscitation and subsequent surgical management based on several factors:

- location of bums,
- depth of burns
- Presence of inhalation injury increase mortality by 30-40% alone.
- patient's age
- comorbidities

Mortality rate = age+ burn % of TBSA (Baux formula)

Patients who are awake and alert who are not candidates for resuscitation should be informed of the decision not to resuscitate and given the opportunity to say good-bye to family members.

Infection:

Risk factors:

- Loss of mechanical barrier.
- Impaired cellular and humeral response.
- Invasive procedures e.g. CV line, folly's cath. etc.

Common sites:

- blood stream
- burn wound eschar
- urinary tract
- respiratory tract

Causative organisms:

- pseudomonas aeroginosa and staphylococcus aureus are the most common
- candida
- CMV

Prevention:

- Early wound excision and closure.
- Adequate nutrition.
- Immunization with tetanus toxoid.
- Regular infection surveillance by periodic cultures of urine, sputum, blood, and central lines.
- Subeschar tissue quantitative culture and histologic examination

The Use Of Prophylactic Antibiotics Should Be Avoided.

Clinical Presentation:

- Spiking fever
- Unexplained hypotension
- Tachypnea

- New onset ileus
- Altered mental status
- Decreased UOP
- Hypothermia

Investigation: hypoxia, leukopenia, leukocytosis with left shift, hypo or hyper glycaemia.
Treatment:

- Support of cardiopulmonary and GIT systems.
- Eschar debridement.
- Empiric antibiotic therapy followed by culture derived use.
- Change topical agent to more penetrating one.

Surgical management of burns:
Early staged excision should begin on post burn day 3 for major burns that are clearly full thickness.
Operations can be spaced 2 to 3 days apart until all eschar is removed and the burn wound covered. The interval days are to allow for stabilization and resuscitation of the patient.

CHEMICAL INJURIES:

Classified as: acid or alkali (base) burns.
Alkali burns cause more severe injury than acid burns since alkaline agents cause a liquefaction necrosis and penetrate deeper. The severity of chemical injuries depends on the composition, concentration and duration of contact with the agent.

Principle of treating chemical burns:

- Removal of the inciting agent and all contaminated Clothes.
- Copious irrigation of all Areas of affected skin with water. Adequate irrigation can be verified by checking the skin pH.

Avoid:

- Irrigation of chemical **powders** since the water can activate the chemical. The powder should first be dusted off, and then irrigation can take place.
- **Neutralization** of the inciting agent since this will produce an exothermic reaction that will superimpose a thermal injury on top of the chemical injury.

Specific chemicals management:

- **Hydrofluoric acid (HF)** : used in the glass and cleaning solutions, readily penetrates skin and continues to injure tissue until it contacts a calcium source, likely bone causing hypocalcaemia, HF burns in excess of 10% can be fatal. Treated by Calcium gluconate gel topically with or without intra-arterial infusion of calcium gluconate, Diminished pain is the hallmark of effective treatment.
- **Elemental Sodium, potassium and lithium:** ignite on water exposure so should be covered with oil before surgical debridement.
- **Phosphorus:** garlic smell, ignite on air exposure, should be treated by underwater debridement.

ELECTRICAL INJURIES

Mechanism:
It could be caused by direct or alternating current each of them can be of low or high voltage.

Low voltage (<1000 v) alternating current is more dangerous than that of direct current because of low resistant of skin to passage of alternating current and also due to tetanizing effect on muscle (The point at which the muscle contractions are so severe that individuals grasping on the electrical conductor cannot let go) is called the "let-go" threshold. Muscle contractions are most pronounced between the frequencies of 15 and 150 Hz. Household current at 60 Hz, can therefore be dangerous. The let-go threshold is 15 mAmp. Above 20mamp, there is a sustained contraction of the muscles of respiration,

leading in lime to respiratory asphyxiation, above 40 mAmp, ventricular fibrillation may be induced. The let-go effect is the main cause of prolonged heat buildup and tissue damage in low-tension accidents.

high-voltage (>1000 v) alternating current causes Two types of injuries:

First, injuries associated with an arc, or flash of light, formed between the high-voltage power source and the body The temperature of this arc may be as high as 4000° C, and the flash may ignite the victim's clothing and even melt bone, the victim may be thrown away from it and may sustain traumatic injuries .

Second type of injury is caused by the passage of an electrical current between the power source and the patient's exit wound (i.e., within the patient's body), tissue resistance to the passage of current causes the buildup of intense heat. Current can produce temperatures greater than 1000° C along bone, causing bone destruction and deep tissue necrosis. Muscle necrosis causes compartment syndrome and myoglobinuria.

High-tension electrical entrance wounds are usually charred and centrally depressed with severe eschar; exit wounds are more likely to be exploded.

Guidelines for management:

- Follow the ATLS protocol and determine from history if the injury was high or low voltage.
- Specific evaluation :
  - % TBSA is calculated (if there was a flame burn).
  - The neurovascular status of injured extremities.
  - All patients who sustain electrical injuries should have an ECG in the emergency room.

Patients with a **low-voltage** injury who had no loss of consciousness and no dysrhythmia present can be discharged home.

Patients with **high-voltage** injuries should be monitored for the followings:

- Compartment syndrome and myoglobin urea .
- Cardiac arrhythmia and possible infarction.
- Possible neurological injury or cataract.

COLD INJURY

Cell death and tissue necrosis occur from the formation of ice crystals within the cells and extracellular space as well as from microvascular thrombosis. Cellular injury from ice crystal formation occurs during the Period of cold exposure, whereas microvascular thrombosis is thought to occur during reperfusion when the affected limb is rewarmed.

Frost-bitten extremities should be rapidly rewarmed in water that is 40°c. Typically, rewarming can be completed in 20 to 30 minutes. Adjunctive use of nonsteroidal anti-inflammatory medications and calcium channel blockers.

Patience is required in determining which areas require debridement since it is difficult in the immediate post-injury period. Early debridement and amputation are necessary if soft tissue infection occurs during the waiting period.

LATE EFFECTS OF BURN INJURY:

- Hypertrophic Scarring (deep 2^{nd}. and 3^{rd}. Degree)
- Hyper or hypopigmentation. (superficial 2^{nd}. degree)
- Marjolin's ulcer malignant degeneration of a healed burn wounds, occur decades following injury, typically in areas that were not skin grafted.
- Heterotopic Ossification deposition of calcium in the soft tissue around joints blocking normal joint functioning. Most commonly affects elbow and shoulder joints and occurs 1 to 3 months following injury.