Burns

- ✓ Types of burns (etiology): thermal, electrical, and chemical.

1. Thermal burns:

Heat causes coagulative necrosis; which preserves the shape of tissue involved. The temperature that causes coagulative necrosis is usually >45^{o}C.

- ✓ Thermal burns are classified into:
- ✓ Dry heat; direct exposure to fire. May be associated with inhalation injury.
- ✓ Moist heat (scald burn); exposure to hot liquids.
- ✓ Contact burn; contact with hot metals.
- ✓ Friction burns.

- ✓ The burn wound and surrounding tissues are described as circumferential zones radiating from the burned tissue, as follows:

1. **Zone of coagulation:** The area of dead necrotic tissue.
2. **Zone of injury** (zone of ischemia/ stasis): tissues surrounding the zone of coagulation; injured but not dead, may progress irreversibly to necrosis if not resuscitated properly; The primary aim of burn management.
3. **Zone of hyperemia**: Peripheral tissues that undergo vasodilatory changes due to neighboring inflammatory mediator release, they're not injured thermally and remain viable.

> The depth (degree of burn) depends on the quantity of heat (temperature and duration of exposure); exposure to a lower temperature for long period causes more damage than exposure to high temperature for a short period.

General management:

1. Adequate oxygenation.
2. Fluid resuscitation (maintain adequate perfusion), and management of electrolytes and acid-base derangements.
3. Treatment of anemia, and nutritional support.
4. Minimizing tissue edema, by fluid resuscitation (avoid over-resuscitation) and by elevation of injured limbs. (Edema has a negative effect on micro-circulation and decreases tissue perfusion).

> ! If these measures are not performed properly, more necrosis will follow, and the degree of burn would increase.

Local management: Proper burn wound management; wound care.

2. Chemical burns: caused by acids or alkalis

- ✓ Deep penetration and tissue damage due to longer action of the chemicals (continues until inactivated by reaction with the tissues).
- ✓ Acids produce less damage and penetration than alkalis because acids produce coagulative necrosis, this forms a barrier limiting the destructive effect of acids on tissues, while alkalis produce liquefaction necrosis, allowing deeper penetration and destruction.

The primary management of chemical burns is by irrigation by water to dilute the chemical agent; 2-4 hours for alkaline burn, 30 minutes for acids. DO NOT apply acids to neutralize alkalis and vice versa, this can result in harmful heat production.

3. Electrical burn:

- ✓ The severity of burn depends on voltage and resistance, it is more serious with high voltage current (>1000 volts), and with low resistance:
  - ➢ Nerves, muscles, blood, and blood vessels → low resistance → affected most.
  - ➢ Skin (especially if dry) and tendons → high resistance → less damaged.

Electrical burn is deceiving!!

> Although nervous tissue is the most sensitive to electric injury, the major effect of electric burn involves the muscles due to their bulk. A patient with massive electric burn may be deceiving due to minimal skin burn, despite hidden muscle burn.

Management:

1. Patients should be assessed for head injury and peripheral nerves damage.
2. Manage cardiac arrythmias in case of cardiac muscle involvement.
3. Good hydration, and alkalization of urine in case of acute kidney injury. (Myoglobinemia and myoglobinuria due to myoglobin release from skeletal muscles).
4. Management of compartment syndrome, if present.
5. Asses for bone fractures. (Severe muscle contractions lead to fractures).

Compartment syndrome: Increased pressure inside a skeletal muscle compartment above the capillary pressure (32 mmHg), leading to decreased capillary perfusion and muscle ischemia.

- ✓ Causes severe undue pain along with paresthesia and numbness. The affected limb is tense, but pulses may still be palpable in the beginning (because the pressure is not enough to close an artery).
- ✓ Pressure should be relieved by fasciotomy within 6 hours to avoid permanent ischemic necrosis.

- ✓ The severity of the electrical burn can't be estimated based on percentage of burned skin, so fluid management is based on clinical observation of urine output, serial hematocrit values, and CVP readings.

Assessment of the severity of burn: (Depth and Percentage)

1. **The depth of burn damage (degree):** determines the <u>local management</u> and <u>outcome</u> of the wound.
2. **The surface area involved in burn**

Degree of burn:

- ✓ In **partial thickness** burn, part of the dermis that contains skin appendages is preserved, these epithelial elements would heal the wound by <u>**regeneration**</u> within weeks, hence the local treatment of the burn is conservative.
- ✓ In **full thickness** burn, all the dermis is lost, so the burn would heal by <u>**fibrosis**</u>, to avoid this, it should be treated by skin grafting.
- ✓ The deeper the burn is, the more the scarring would be, and the more time is taken to heal.

Classification of the depth of burn injury:

	First degree	Second degree (partial thickness)	Third degree (full thickness)
necrosis	Limited to the epidermis	Epidermis and varying depth of the dermis	Necrosis of the whole skin
Clinically	Pain and erythema	Pain, erythema, blisters, weeping (wet area with exudate), blanching (intact dermal vascularity), and preservation of skin elasticity.	Eschar; insensitive, leathery, hard, inelastic, and may show thrombosed dermal vessels.
Healing	1-6 days, leaves no scars	1-4 weeks, leaves minimal scarring	Months, leaves significant scarring and joint contractures. Should be skin grafted after removal of the eschar.

- ✓ Note that the deeper the burn the more dermis is necrotic so:

Less pain due to damage of dermal nerves[1], healing is by fibrosis rather than regeneration, leaving more post burn contractutes[2], and more loss of skin elasticity, so it compresses the limbs that needs escharotomy[3].

Estimation of the percentage of the burn: %burned area/ %total body surface area.

We add areas with 2nd degree to those with 3rd degree burn. 1st degree burn is not calculated.

- ✓ The percentage of burn determines:
  a. The prognosis (mortality rate), and systemic complications (sepsis, ↓immunity) as organ failure increases with the increase in burn percentage.
  b. Degree of hypovolemic shock and hence the systemic management.
  c. Malnutrition, and catabolism.
- ✓ Estimation of total body surface area (TBSA):
  1. **Rule of nines:** 11 nines; Head &neck (9%), Upper limbs (9% each), Anterior & posterior trunk (18% each), Lower limbs (18% each) and 1% genitals.
  2. **Special accurate charts**: used for accurate estimation of the burn percentage, because:
     a. The rule of nines is rough and not very accurate.
     b. Children have different body proportions compared with adults: head and neck of the newborn is around (20%) and decreases with age, while the percentage of the lower limbs is (14%) and increases with age.
  3. **Palm of the hand** equals 1% of the body surface area (for small burns).

When the percentage of burn is significant, we should look at the burn injury as a systemic disease:
Respiratory system: first 24 hours: may develop upper respiratory tract obstruction.
2-3 days: Smoke inhalation syndrome and later may develop respiratory infections, or ARDS.

The cardiovascular, renal, GI, endocrine, immune systems may be affected, which increases the metabolic rate, and results in negative nitrogen balance and malnutrition.

Management of burns: divided into:

1. Acute/ emergency stage.
2. Local management of burn wounds.
3. Treatment of complications.

Acute/ emergency management:

Follow the ATLS (Advanced Trauma Life Support) rules, which dictates treatment of life-threatening conditions in the first minutes before full screening and diagnosis of the injuries, so we follow the ABC rules:

A: AIRWAY, patients involved in flame burns may suffer from upper airway obstruction, due to soft tissue edema of the oropharynx and vocal cords, resulting from direct thermal injury to the upper respiratory tract, by inhalation of flame and hot gases. This obstruction may not be evident initially but appears in the first 24 hours. Direct inspection of the oropharynx and the vocal cords, by either direct laryngoscopy, or better by bronchoscopy is indicated. Endotracheal intubation, to secure a patent airway, should be performed before obstruction is complete.

Signs of impending obstruction: tachycardia, progressive hoarseness, and difficulty to clear bronchial secretions.

CARBON MONOXIDE POISONING: due to occupation of oxygen carrying sites of hemoglobin by CO, which has 210 times higher affinity to hemoglobin. The condition is diagnosed by estimation of carboxyhemoglobin level in the blood, the PO2 level may be normal. The treatment is by administration of 100% oxygen to displace the CO.

Total body water (TBW):

Water constitutes 50- 60% of total body weight, in males 60% of total body weight is TBW, whereas in females it is 50% (higher percentage of adipose tissue and lower percentage of muscle mass). The highest percentage of TBW is found in newborns, with 80% of their weight comprised of water. This decreases to 65% by 1 year of age.

In a male adult of 70 kg weight, 42 kg is water, divided into three functional fluid compartments: 2/3 is intracellular (28 L), 1/3 is extracellular (14 L) divided into: ¼ intravascular (plasma 3.5 L), and ¾ extravascular (interstitial 10.5 L).

✓ Composition of Fluid Compartments:

	ECF (plasma & interstitial fluid differ slightly in composition)	ICF
Cations	Na+	K+, Mg2+
Anions	Cl-, bicarbonate	phosphate, proteins

Movement of ions and proteins between fluid compartments is restricted, but water is freely diffusible and distributed evenly throughout all compartments, so a given volume of water increases the volume of any compartment relatively little. Sodium, however, is confined to the ECF compartment, and remains associated with water. Therefore, sodium-containing fluids are distributed throughout the ECF, although the administration of sodium-containing fluids expands the plasma volume, it also expands the interstitial space by approximately three times as much as the plasma.

Osmotic Pressure

Measured in units of osmoles (osm) or milliosmoles (mOsm) that refer to the actual number of osmotically active particles. For example, 1 mmol of NaCl contributes to 2 mOsm. The principal determinants of osmolality are the concentrations of sodium, glucose, and urea (blood urea nitrogen; BUN)

Calculated serum osmolality = 2*sodium + (glucose/18) + (BUN/2.8)

- ✓ The osmolality of the ECF and ICF is maintained between 290 and 310 mOsm in each compartment. Although the ICF gets affected by the losses in composition of the ECF, for practical clinical purposes, most significant gains and losses of body fluid are directly from the extracellular compartment. Isotonic gain or loss of salt solution results in extracellular volume changes (with little impact on intracellular fluid volume). If free water is added or lost from the ECF, water will pass between the ECF and intracellular fluid until solute concentration or osmolarity is equalized between the compartments. (Make sure you know the results of hypo/hyper/iso-tonic changes).
- ✓ Unlike with sodium, the concentration of most other ions in the ECF can be altered without significant change in the total number of osmotically active particles producing only a compositional change. For instance, doubling the serum potassium concentration will profoundly alter myocardial function without significantly altering volume or concentration of the fluid spaces because potassium level= 3.5-5 mEq/L in the extra-cellular fluid, so it has little effect on ECF osmolarity and volume.

Body fluid changes:

The healthy person consumes an average of 2000 mL of water/ day.

	Input	Output	
Sensible	Oral intake 75% Solid food 25%	Urine 800-1500 ml Sweat	Stool 0-250 ml Pathologic GIT losses
Insensible	Oxidation=25 ml	Lungs and skin 600 ml	

Classification of Body Fluid Changes

- ✓ Disorders in fluid balance are classified into: volume, concentration, and composition. Although each of these may occur simultaneously, each is a separate entity with unique mechanisms demanding individual correction.

Disturbances in Fluid Balance (volume): Volume changes may be associated with normal, high or low sodium concentration.

- ✓ Extracellular volume deficit is the most common fluid disorder in surgical patients. Divided into:
  1. Acute (Hypovolemic shock): associated with cardiovascular and central nervous system signs.
  2. Chronic (dehydration): tissue signs of dehydration; decrease in skin turgor and sunken eyes, in addition to cardiovascular and CNS signs.
- ✓ Labs: significant ECF losses may be associated with:

a. Elevated BUN level.
b. Urine osmolality higher than serum osmolality.
c. Urine sodium is low, typically <20 mEq/L.

Causes of fluid losses in surgical patient:

1. Loss of GI fluids from nasogastric suction, vomiting, diarrhea, or enterocutaneous fistula. (Most common cause of volume deficit in surgical patients).
2. Sequestration (third space losses) secondary to soft tissue injuries, inflammation burns, and intra-abdominal processes such as peritonitis, pancreatitis, intestinal obstruction, or prolonged surgery can also lead to massive volume deficits.
3. Hemorrhage.

Fluid resuscitation (systemic management):

Fluid management in major burns is critical, the following guidelines are important in planning the fluid replacement:

- ✓ Most of the fluids administered would leak into the interstitium causing more tissue edema, which increases tissue hypoxia. So we give crystalloids in the first 16-24 hours, and colloids thereafter. Also, a huge amount of fluid is needed to maintain a functional intra-vascular compartment.
- ✓ Amount of fluid given should be just adequate to perfuse tissue; over-perfusion causes edema.
- ✓ Although there are so many formulas to estimate the amount of fluid needed to resuscitate a burned patient, the amount of fluid needed vary among patients, and the only way to ensure that the optimal amount of fluid is given is by close monitoring:
    a. Clinically by observing the general condition of the patient and vital signs.
    b. Urine output (most sensitive indicator of tissue perfusion) should be **0.5-1 ml/kg/hr.** higher urine output may indicate extra fluid is given.
    c. Serial packed cell volume readings: a. high PCV → hemoconcentration → administer more fluid.
       b. low PCV → hemodilution → decrease rate of fluid administration.
    d. Swan-Gans or CVP lines may be indicated in patients with borderline cardiac reserve, like the elderly.
- ✓ All formulas are based on burn percentage and patient weight. **Parkland formula**: **Fluid in the first 24 hours = 4*Weight* % of burn.**

*An adult weighing 70 Kg, with 50% burn, should receive 14000 ml of Ringer lactate; half of this amount is administered in the first 8 hours.

> Burns → shift of fluids from intravascular to interstitial due to increased capillary permeability, or loss of integrity (direct thermal damage & inflammatory mediators) → capillary membrane becomes fully permeable → proteins leak to the interstitium, dragging along water → edema in the interstitium. The shifted fluid called **3rd space loss**. However, this is not limited to the burned areas, the non-burned tissues are affected due to generalized hypo-proteinemia and circulating vasoactive mediators.
> Depletion of the intra-vascular compartment → hypovolemic shock (severity depends on percentage of burn).
> Burn shock is seen in adults with burns ≥ 15-20% and in children with burns ≥ 10-15%.

Escharotomy: Management of eschars:

- Elevation affected limbs.
- Observation of the circulation (capillary filling, color, temperature) and signs of ischemia (pain, paresthesia, paralysis).
- If ischemia is suspected, ESCHAROTOMY is indicated; incising the eschar on the medial and lateral aspects, to release the pressure. We can do it on the limbs, neck, and chest wall.

> ✓In full thickness burns, skin is transformed into necrotic tissue, so in circumferential burns of the limbs, the eschar acts as a tourniquet. So edema → ↑ pressure → ischemia. The picture is similar to compartment syndrome.
> ✓Presence of distal pulses does NOT rule out the condition.
> ✓Note that escharotomy is different from escharectomy which means excision or debridement of the eschar.

Antibiotics: used to treat infections, but not prophylactically, **Prophylactic antibiotics are contra-indicated in burns**, for the following reasons:

a. Studies did not prove that prophylactic antibiotics decrease the incidence of sepsis.
b. Antibiotics increase the incidence of fungal infections and bacterial resistance.

Analgesia and sedation: pain & anxiety relief is needed in burn patients (even in those with full thickness burn), the following guidelines are to be applied:

1. In patients with low tissue perfusion, drugs are administered IV to avoid accumulation of the drug.
2. Given in small doses, till the required dose is reached.
3. Head injury, hypoxia, and shock all have the same symptomatology of pain, and should be ruled out before treating pain.

Indications of admission:

1. Burns that need fluid resuscitation: Adults>15%, children>10%
2. Full-thickness burns >2%
3. Burns of special areas: face, hands, perineum.
4. Electrical and chemical burns.
5. Inhalation injury.
6. Old age and co-morbidity.
7. Suspected child abuse.

Local management of burn wound:

a. Partial thickness burn: healing is by regeneration within weeks, and treatment is conservative, aiming at protecting the wound from dryness, infection, and trauma, through keeping the burn wet, covered with local antibiotics, and changing the dressing as required. **Infection** would damage the epithelial elements (which are responsible for regeneration) and change the burn to full thickness one.
b. Full thickness burn: heals by fibrosis and should be grafted. The eschar is adherent to the underlying subcutaneous tissue. As time goes by, bacteria invade the eschar and produce enzymes that separates the eschar from the deeper tissues. Within 2-3 weeks the eschar is spontaneously separated, at this time the deep tissue is covered by granulation, and split thickness skin graft can be applied to the burn wound. However, nowadays, we do **early escharectomy** and cover the burn wounds by skin graft, rather than waiting for bacterial assisted separation.

✓ Advantages of early escharectomy and grafting are:

1. Helps early mobilization of the patient, decreasing joint contractures.
2. Decreases catabolic state, protein breakdown, and malnutrition.
3. Decrease duration of hospital stay.
4. Decrease the incidence of sepsis.
5. Better cosmetic outcome.

✓ Problems of early wound excision:

1. The eschar is adherent to the underlying tissues, so surgical excision results in massive blood loss and hypo-thermia. Solved through better blood banking, better ICU care, hypotensive anesthesia, and staged excision.
2. When the burned area is large (>60 %burn), excision would leave a large exposed wound that we cannot cover by the patient's own skin. So we cover as much as we can with split thickness graft (autografts), the remaining areas are covered temporarily with biological dressing (allografts/homografts taken from cadavers or heterografts taken from animals). After around two weeks, when the donor areas heal, we take skin grafts again from the same areas (reharvesting) and apply them to new areas after taking off the biological dressing.

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