Burns

- The incidence of burn injury varies greatly between cultures.
- The majority of burns in children are scalds caused by accidents with kettles, pans, hot drinks and bath water.
- Among adolescent patients, the burns are usually caused by young males experimenting with matches and flammable liquids.
- In adults, scalds are not uncommon, but are less frequent than flame burns. Most electrical and chemical injuries occur in adults.
- Cold and radiation are very rare causes of burns.

- Associated conditions in adults, such as mental disease (attempted suicide or assault), epilepsy and alcohol or drug abuse, are underlying factors in as many as 80% of patients with burns admitted to hospital in some populations.
- A large burn injury will have a significant effect on the patient’s family and friends and the patient’s future.
- The importance of multidisciplinary care needs to be stressed for the adequate and effective care of the burn patient.

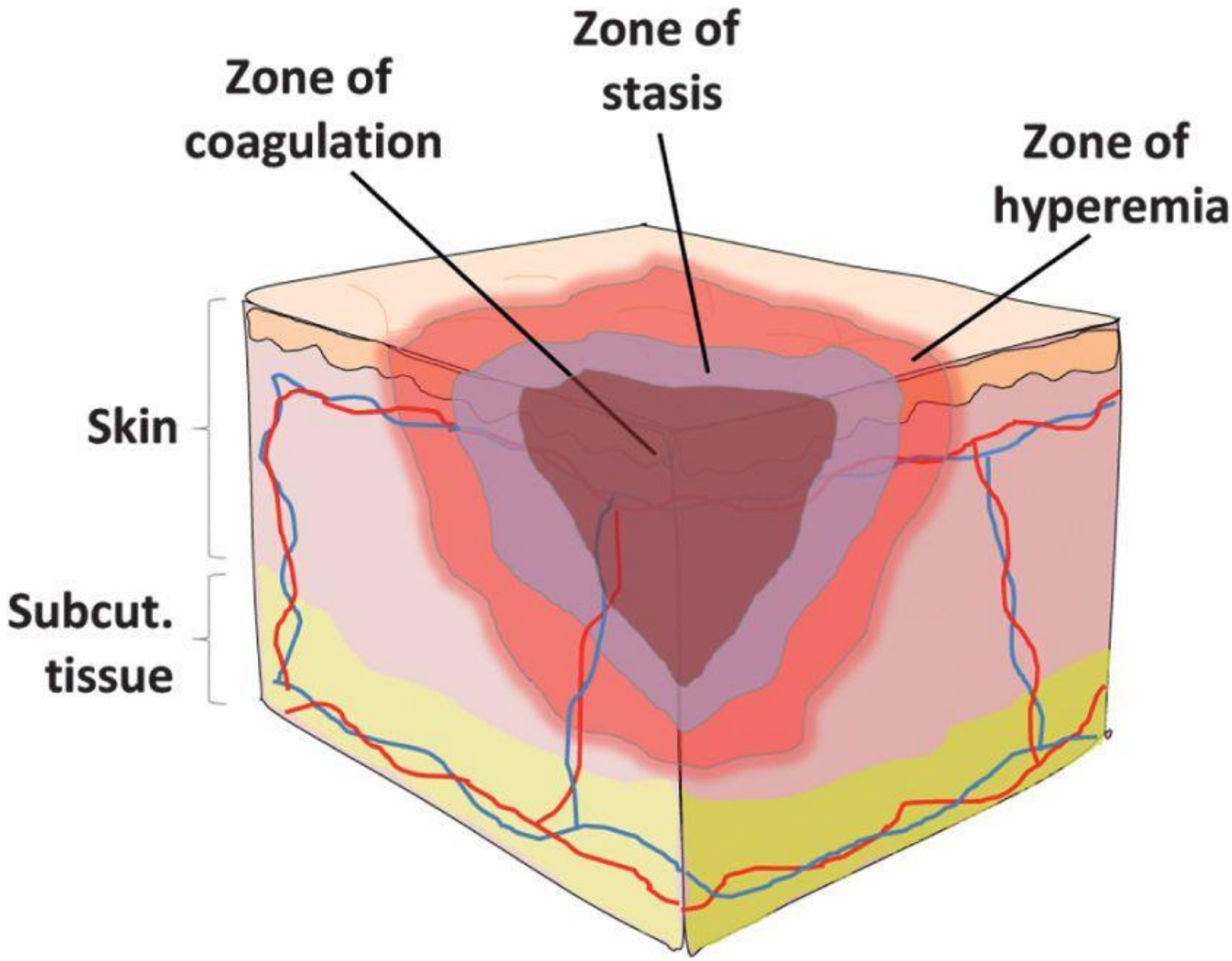
Causes of Burns

1. Scald
2. Fat burns
3. Flame burns
4. Alkali burns including cement
5. Acid burns
6. Electrical contact burn

Zones of Burn

There are 3 zones in a burn according to Jackson's Burn Model.

1. Zone of coagulation
   - Irreversible
2. Zone of stasis
   - Inflammation
   - Impaired vascularity
   - Potential to recover
3. Zone of hyperaemia
   - Vasodilation
   - Increased blood flow
   - Reversible


Zone of coagulation
Zone of stasis
Zone of hyperemia
Skin
Subcut. tissue

Pathophysiology of Burn Injury

- Burns cause damage in a number of different ways, but by far the most common organ affected is the skin.
- However, burns can cause,
  1. **Injury to the airway and lungs**
  2. **Inflammation and circulatory changes**
  3. **Many other life threatening events associated with major burns**

1. Injury to the airway and lungs

- Airway injuries occur when the face and neck are burned.
- Respiratory system injuries usually occur if a person is trapped in a burning vehicle, house, car or airplane and is forced to inhale the hot and poisonous gases.

Warning signs of burns to the respiratory system

- Burns around the face and neck
- A history of being trapped in a burning room
- Change in voice
- Stridor

- Burns can damage the airway an lungs in several ways, such as,
    a) Physical burn injury to the airway above the larynx
    b) Physical burn injury to the airway below the larynx
    c) Metabolic poisoning
    d) Inhalational injury
    e) Mechanical block on rib movement

a) Physical burn injury to the airway above the larynx

- The hot gases can physically burn the nose, mouth, tongue, palate and larynx.
- Once burned, the linings of these structures will start to swell.
- After a few hours, they may start to interfere with the larynx and may completely block the airway if action is not taken to secure an airway.

Dangers of smoke, hot gas or steam inhalation

- Inhaled hot gases can cause supraglottic airway burns and laryngeal edema
- Inhaled steam can cause subglottic burns and loss of respiratory epithelium
- Inhaled smoke particles can cause chemical alveolitis and respiratory failure
- Inhaled poisons, such as carbon monoxide, can cause metabolic poisoning
- Full-thickness burns to the chest can cause mechanical blockage to rib movement

b) Physical burn injury to the airway below the larynx

- This is a rare injury as the heat exchange mechanisms in the supraglottic airway are usually able safely to absorb the heat from hot air.
- However, steam has a large latent heat of evaporation and can cause thermal damage to the lower airway.
- In such injuries, the respiratory epithelium rapidly swells and detaches from the bronchial tree.
- This creates casts, which can block the main upper airway.

c) Metabolic poisoning

- The most common poisonous gas that can be given off in a fire is carbon monoxide.
- It is a product of incomplete combustion that is often produced by fires in enclosed spaces.
- This is the usual cause of a person being found with altered consciousness at the scene of a fire.
- Carbon monoxide binds to haemoglobin with an affinity 240 times greater than that of oxygen and therefore blocks the transport of oxygen.
- Blood levels of carboxyhaemoglobin above 10% are dangerous and need treatment with pure oxygen for more than 24 hours.
- Death occurs with concentrations around 60%.
- Another metabolic toxin produced in house fires is hydrogen cyanide, which causes a metabolic acidosis by interfering with mitochondrial respiration.

d) Inhalational injury

- Caused by the minute particles within thick smoke, which, because of their small size, are not filtered by the upper airway, but are carried down to the lung parenchyma.
- They stick to the moist lining, causing an intense reaction in the alveoli.
- This chemical pneumonitis causes oedema within the alveolar sacs and decreasing gaseous exchange over the ensuing 24 hours and often gives rise to a bacterial pneumonia.
- Its presence or absence has a very significant effect on the mortality of any burn patient.

e) Mechanical block on rib movement

- Burned skin is very thick and stiff, and this can physically stop the ribs moving if there is a large full-thickness burn across the chest.

2. Inflammation and circulatory changes

- The cause of circulatory changes following a burn are more complex.
- The changes occur because burned skin activates a web of inflammatory cascades.
- The release of neuropeptides and the activation of complement are initiated by the stimulation of pain fibres and the alteration of proteins by heat.

Stimulation of pain fibers and the alteration of proteins by heat

Release of neuropeptides and the activation of complement

Complement causes the degranulation of mast cells and coats the proteins altered by the burn

This attracts neutrophils, which also degranulate, with the release of large quantities of free radicals and proteases

Mast cells also release primary cytokines such as Tumour necrosis factor alpha (TNF-α).

These act as chemotactic agents to inflammatory cells and cause the subsequent release of many secondary cytokines

Alteration of the permeability of blood vessels

- The overall effect of these changes is to produce a net flow of water, solutes and proteins from the intravascular to the extravascular space.
- This flow occurs over the first 36 hours after the injury, but does not include red blood cells.
- In a small burn, this reaction is small and localized but, **as the burn size approaches 10–15% of total body surface area (TBSA), the loss of intravascular fluid can cause a level of circulatory shock.**
- Once the area increases to 25% of TBSA, the inflammatory reaction causes fluid loss in vessels **remote** from the burn injury.
- This is why such importance is attached to measuring the TBSA involved in any burn.
- It dictates the size of inflammatory reaction and therefore the amount of fluid needed to control shock.

3. Other life threatening events with major burns

The immune system and infection

- Cell-mediated immunity is significantly reduced in large burns, leaving them more susceptible to bacterial and fungal infections.
- There are many potential sources of infection, especially from the burn wound and from the lung if this is injured, but also from any central venous lines, tracheostomies or urinary catheters present.

Changes to the intestine

- The inflammatory stimulus and shock can cause microvascular damage and ischaemia to the gut mucosa.
- This reduces gut motility and can prevent the absorption of food.
- Failure of enteral feeding in a patient with a large burn is a life-threatening complication.
- This process also increases the translocation of gut bacteria, which can become an important source of infection in large burns.
- Gut mucosal swelling, gastric stasis and peritoneal oedema can also cause abdominal compartment syndrome, which splints the diaphragm and increases the airway pressures needed for respiration.

Danger to peripheral circulation

- In full-thickness burns, the collagen fibres are coagulated.
- The normal elasticity of the skin is lost. A circumferential full-thickness burn to a limb acts as a tourniquet as the limb swells.
- If untreated, this will progress to limb-threatening ischaemia.

Immediate Care of the Burn Patient

Immediate care of the burn patient

- Pre hospital care
- Hospital care

Pre Hospital Care

- The principles of prehospital care are,
  1. Ensure rescuer safety
  2. Stop the burning process
  3. Check for other injuries
  4. Cool the burn wound
  5. Give oxygen
  6. Elevate

Hospital Care

- The principles of managing an acute burn injury are the same as in any acute trauma case:
  1. A, Airway control.
  2. B, Breathing and ventilation.
  3. C, Circulation.
  4. D, Disability – neurological status.
  5. E, Exposure with environmental control.
  6. F, Fluid resuscitation.

- The possibility of injury additional to the burn must be sought both clinically and from the history, and treated appropriately.
- **The major determinants of severity of any burn injury are the percentage of TBSA that is burned, the presence of an inhalation injury and the depth of the burn.**
- Not all burned patients will need to be admitted to a burns unit.

The criteria for acute admission to a burns unit

- Suspected airway or inhalational injury
- Any burn likely to require fluid resuscitation
- Any burn likely to require surgery
- Patients with burns of any significance to the hands, face, feet or
- perineum
- Patients whose psychiatric or social background makes it
- inadvisable to send them home
- Any suspicion of non-accidental injury
- Any burn in a patient at the extremes of age
- Any burn with associated potentially serious sequelae, including
- high-tension electrical burns and concentrated hydrofluoric acid
- burns

Airway Management

- The burned airway creates problems for the patient by swelling and, if not managed proactively, can completely occlude the upper airway.
- The treatment is to secure the airway with an endotracheal tube until the swelling has subsided, which is usually after about 48 hours.
- The symptoms of laryngeal oedema, such as change in voice, stridor, anxiety and respiratory difficulty, are very late symptoms.
- Intubation at this point is often difficult or impossible owing to swelling, so acute cricothyroidotomy equipment must be at hand when intubating patients with a delayed diagnosis of airway burn.
- Because of this, early intubation of suspected airway burn is the treatment of choice in such patients.
- The time-frame from burn to airway occlusion is usually between 4 and 24 hours.

Managing Inhalational Injury

- Time is also a factor; anyone trapped in a fire for more than a couple of minutes must be observed for signs of smoke inhalation.
- Other signs that raise suspicion are the presence of soot in the nose and the oropharynx and a chest radiograph showing patchy consolidation.
- The clinical features are a progressive increase in respiratory effort and rate, rising pulse, anxiety and confusion and decreasing oxygen saturation.
- These symptoms may not be apparent immediately and can take 24 hours to 5 days to develop.

- **Recognition of the potentially burned airway**
  - A history of being trapped in the presence of smoke or hot gases
  - Burns on the palate or nasal mucosa, or loss of all the hairs in the nose
  - Deep burns around the mouth and neck

- Treatment starts as soon as this injury is suspected and the airway is secure.
- Physiotherapy, nebulizers and warm humidified oxygen are all useful.
- The patient's progress should be monitored using respiratory rate, together with blood gas measurements.
- If the situation deteriorates, continuous or intermittent positive pressure may be used with a mask or T-piece.
- In the severest cases, intubation and management in an intensive care unit will be needed.
- The key, therefore, in the management of inhalational injury is to suspect it from the history, institute early management and observe carefully for deterioration.

- Thermal burn injuries to the lower airway can occur with steam injuries.
- Management is supportive and the same as that for an inhalational injury.

Metabolic Poisoning Management

- Any history of a fire within an enclosed space and any history of altered consciousness are important clues to metabolic poisoning.
- Blood gases must be measured immediately if poisoning is a possibility.
- Carboxyhaemoglobin levels raised above 10% must be treated with high inspired oxygen for 24 hours to speed its displacement from haemoglobin.
- Metabolic acidosis is a feature of this and other forms of poisoning.

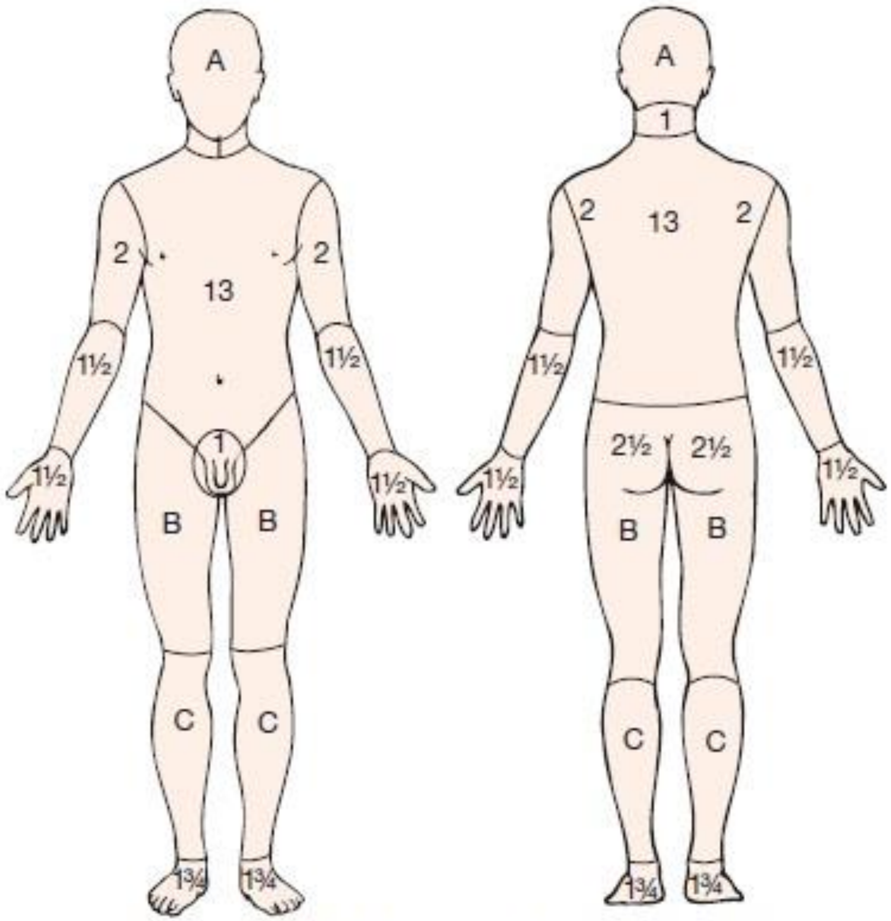
Escharotomy

- Any mechanical block to breathing from the eschar of a significant full-thickness burn on the chest wall is obvious from the examination.
- There will also be carbon dioxide retention and high inspiratory pressures if the patient is ventilated.
- The treatment is to make some scoring cuts through the burned skin to allow the chest to expand (escharotomy).
- The nerves have been destroyed in the skin, and this procedure is not painful for the patient.

Assessment of the Burn Wound

Assessing size

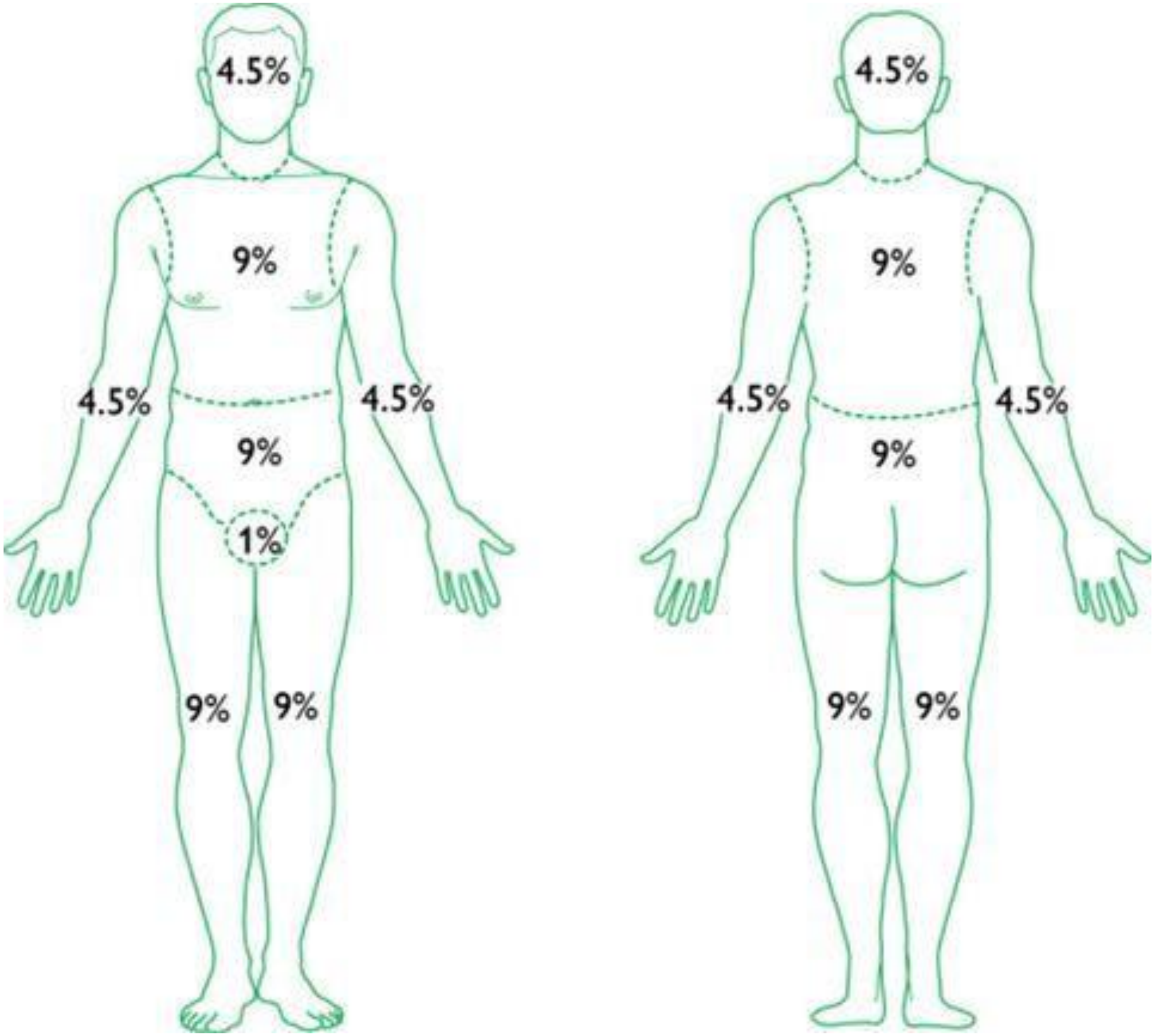
- Burn size needs to be formally assessed in a controlled environment.
- This allows the area to be exposed and any soot or debris washed off.
- Care should be taken not to cause hypothermia during this stage.
- In the case of smaller burns or patches of burn, the best measurement is to cut a piece of clean paper the size of the patient's whole hand (digits and palm), which represents 1% TBSA, and match this to the area.
- Another accurate way of measuring the size of burns is to draw the burn on a Lund and Browder chart which maps out the percentage TBSA of sections of our anatomy.



Relative percentage of area affected by growth

Age in years	0	1	5	10	15	Adult
A Head	9	8	6	5	4	3
B Thigh	2	3	4	4	4	4
C Leg	2	2	3	3	3	3

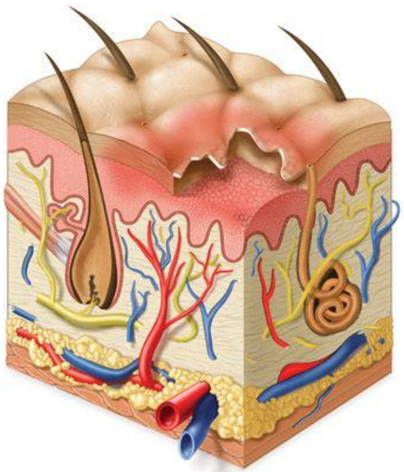
- It also takes into account different proportional body surface area in children according to age.
- The ‘rule of nines’, which states that each upper limb is 9% TBSA, each lower limb 18%, the torso 18% each side and the head and neck 9%, can be used as a rough guide to TBSA outside the hospital environment.


4.5%
9%
4.5%
4.5%
9%
1%
9%
9%
4.5%
9%
4.5%
4.5%
9%
9%
9%

Assessing depth from the history

- The history is important – temperature, time and burning material.
- The burning of human skin is temperature- and time-dependent.
- Burn wounds are categorized into 3 types according to their depth.
    1. Superficial partial-thickness burns
    2. Deep partial-thickness burn
    3. Full-thickness burns

1. Superficial partial-thickness burns

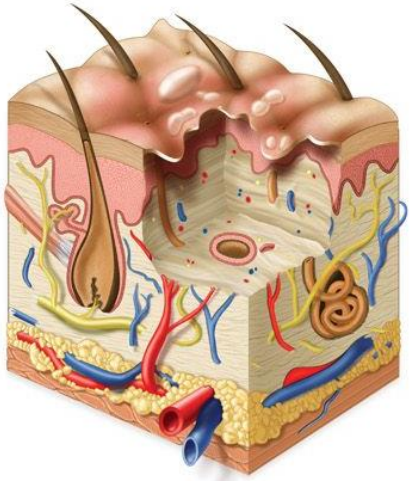


Skin reddened

(Moynahan Medical Center)

- damage goes no deeper than the papillary dermis.
- The clinical features are blistering and/or loss of the epidermis.
- The underlying dermis is pink and moist.
- The capillary return is clearly visible when blanched.
- There is little or no fixed capillary staining.
- Pinprick sensation is normal.
- Superficial partial-thickness burns heal without residual scarring in 2 weeks.
- The treatment is non-surgical.

2. Deep partial-thickness burn




(Charles Stewart MD FACEP, FAAEM)

- Involve damage to the deeper parts of the reticular dermis.
- Clinically, the epidermis is usually lost.
- The exposed dermis is not as moist as that in a superficial burn.
- There is often abundant fixed capillary staining, especially if examined after 48 hours.
- The color does not blanch with pressure under the examiner's finger.
- Sensation is reduced, and the patient is unable to distinguish sharp from blunt pressure when examined with a needle.
- Take 3 or more weeks to heal without surgery and usually lead to hypertrophic scarring.

3. Full-thickness burns

- The whole of the dermis is destroyed in these burns.
- Clinically, they have a hard, leathery feel.
- The appearance can vary from that similar to the patient's normal skin to charred black, depending upon the intensity of the heat.
- There is no capillary return, thrombosed vessels can be seen under the skin.
- These burns are completely anaesthetized: a needle can be stuck deep into the dermis without any pain or bleeding.

Fluid Resuscitation

- **The principle of fluid resuscitation is that the intravascular volume must be maintained following a burn, in order to provide sufficient circulation to perfuse not only the essential visceral organs such as the brain, kidneys and gut, but also the peripheral tissues, especially the damaged skin.**
- Intravenous resuscitation is appropriate for any child with a burn greater than 10% TBSA.
- The figure is 15% TBSA for adults.

- If oral resuscitation is to be commenced, it is important that the water given is **not salt free**.
- The resuscitation volume is relatively constant in proportion to the area of the body burned and, therefore, there are formulae that calculate the approximate volume of fluid needed for the resuscitation.
- Perhaps the simplest and most widely used formula is the Parkland formula.
- This calculates the fluid to be replaced in the first 24 hours by the following formula: **total percentage body surface area × weight (kg) × 4 = volume (mL)**.
- Half this volume is given in the first 8 hours and the second half is given in the subsequent 16 hours.

- There are three types of fluid used. The most common is Ringer's lactate or Hartmann's solution.
- Others are colloids and hypertonic saline.
- Urine output should be between 0.5 and 1.0 mL/kg body weight per hour.
- If the urine output is below this, the infusion rate should be increased by 50%.
- If the urine output is inadequate and the patient is showing signs of hypo perfusion, then a bolus of 10 mL/kg body weight should be given.
- It is important that patients are not over-resuscitated and urine output in excess of 2 mL/kg body weight per hour should signal a decrease in the rate of infusion.

Treating the Burn Wound

Escharotomy

- Circumferential full-thickness burns to the limbs require emergency surgery.
- The tourniquet effect of this injury is easily treated by incising the whole length of full-thickness burns.
- This should be done in the mid-axial line, avoiding major nerves.

Full-thickness burns and obvious deep dermal wounds

- The four most common dressings for full-thickness and contaminated wounds are,
  1. 1% silver sulphadiazine cream
  2. 0.5% silver nitrate solution
  3. Mafenide acetate cream
  4. Serum nitrate, silver sulphadiazine and cerium nitrate

Superficial partial-thickness wounds and mixed-depth wounds

- Superficial partial thickness burns will heal almost irrespective of the dressing.
- If the wound is heavily contaminated, it is prudent to clean the wound formally under a general anaesthetic.
- With more chronic contamination, silver sulphadiazine cream dressing for 2 or 3 days is very effective and can be changed to a dressing that is more efficient at promoting healing after this period.

- The simplest method of treating a superficial wound is by exposure.
- However, this method is painful and requires an intensive amount of nursing support.
- Other dressings include Vaseline-impregnated gauze and fenestrated silicone sheet.
- More interactive dressings include hydrocolloids and biological dressings.
- Early debridement and grafting is the key to effectively treating deep partial- and full-thickness burns in a majority of cases.

Other Aspects of treating a Burned Patient

1. Analgesia

- Small burns, especially superficial burns, respond well to simple oral analgesia, paracetamol and non-steroidal anti-inflammatory drugs. Topical cooling is especially soothing.
- Large burns require intravenous opiates.
- Intramuscular injections should not be given in acute burns over 10% of TBSA, as absorption is unpredictable and dangerous.
- In patients with large burns, continuous analgesia is required, beginning with infusions and continuing with oral tablets, such as slow-release morphine.
- Powerful, short-acting analgesia should be administered before dressing changes.

2. Energy balance and nutrition

- Burn injuries are catabolic in the acute episode.
- Any adult with a burn greater than 15% (10% in children) of TBSA has an increased nutritional requirement.
- All patients with burns of 20% of TBSA or greater should receive a nasogastric tube.
- The excess energy requirements must be provided and the nutritional balance monitored by measuring weight and nitrogen balance.
- Commonly used feeding formulae are, Curreri formula, Sutherland formula and Davies formula.

3. Monitoring and control of infection

- Burns patients are immunocompromised.
- They are susceptible to infection from many routes.
- Sterile precautions must be rigorous.
- Swabs should be taken regularly.
- A rise in white blood cell count, thrombocytosis and increased catabolism are warnings of infection.

4. Nursing care

- Nurses are the primary effectors of many decisions that directly affect healing.
- Bandaged hands and joints that are stiff and painful need careful coaxing.
- Personal hygiene, baths and showers are vital parts of the patient's physiotherapy.

5. Physiotherapy

- Elevation, splintage and exercise reduce swelling and improve the final outcome.
- The physiotherapy needs to be started on day 1.

6. Psychological Support

- A major burn is an overwhelming event, which can cause posttraumatic reactions.
- These are normal and usually self-limiting, receding as the patient heals.
- The features of this intensity of experience are of intrusive reactions, arousal reactions and avoidance reactions.

Surgery for the Acute Burn Wound

- Any deep partial-thickness and full-thickness burns, except those that are less than about 4 cm^2, need surgery.
- Any burn of indeterminate depth should be reassessed after 48 hours because, burns that initially appear superficial may well deepen over that time.
- Delayed microvascular injury is especially common in scalds.
- Full-thickness burns require full-thickness excision of the skin.
- After the surgery physiotherapy and splints are important in maintaining range of movement and reducing joint contracture with the elevation of the appropriate limbs.

Delayed reconstruction and scar management

- Delayed reconstruction of burn injuries is common for large full-thickness burns.
- In the early healing period, acute contractures around the eye need particular attention.
- Eyelids must be grafted at the first sign of difficulty in closing the eyelids, and this must be done before the patient has any symptoms of exposure keratitis.
- Other areas that require early intervention are any contracture causing significant loss of range of movement of a joint.
- This is particularly important in the hand and axilla.

- An established contracture can be treated in a number of ways.
- Burn alopecia is best treated with tissue expansion of the unburned hair-bearing skin.
- Tissue expansion is also a useful technique for isolated burns and other areas with adjacent normal skin.
- Z-plasty is useful where there is a single band and a transposition flap is useful in wider bands of scarring.

- In areas of circumferential or very broad areas of scarring, the only real treatment is incision and replacement with tissue.
- By far the best tissue for replacement is from either a full-thickness graft or vascularized tissue as in a free flap.
- Hypertrophy of many scars will respond to pressure garments.

Complications of Major Burns

1. Pulmonary

Respiratory failure

ARDS

Pneumonia

2. Renal

Acute tubular necrosis due to hypovolemia or myoglobinuria

3. Gastrointestinal

Ulcers- stomach / duodenum

Curling's ulcer- due to reduced mucosal defenses as a result of reduction in splanchnic blood flow

Calculous cholecystitis

Acute pancreatitis

Hepatic dysfunction

4. Cardio Vascular

DVT

Acute bacterial endocarditis

Suppurative thrombophlebitis

5. Ophthalmic

Corneal ulceration

Eye lid problems due to contractures

6. Neurological

Delirium

Altered mental status

7. Infections

Resistant bacterial infections

Nosocomial pneumonia

Sepsis (catheter or central line related)

Sinusitis

Ear infections

8. Musculoskeletal

Scarring

Contracture due to joint involvement

Minor Burns

- Whether to remove blisters or leave them intact has been the subject of much debate.
- Leaving a ruptured blister is not advised.
- Washing the burn wound with chlorhexidine solution is ideal for the initial cleaning.
- For initial management of minor burns that are superficial or partial thickness, dressings with a non-adherent material, such as Vaseline-impregnated gauze or Mepitel are often sufficient.

- Various topical creams and ointments have been used for the treatment of minor burns.
- All published comparative data show no advantage of these agents over petroleum gauze.
- Silver sulphadiazine (1%) or Flamazine® is the most commonly used topical agent.
- However, it should be avoided in pregnant women, nursing mothers and infants less than 2 months of age because of the increased possibility of kernicterus in these patients.

Dressing the minor burn wound

- The aims of dressing are to decrease wound pain and to protect and isolate the burn wound.
- The small superficial burn requires Vaseline gauze or another non-adherent dressing, such as Mepitel, as the first layer.
- Following this, gauze or Kerlix® is wrapped around with sufficient tightness to keep the dressing intact, but not to impede the circulation.
- This is further wrapped with bandage.
- It is important to realise that bulkiness of dressings in the minor burn wound depends upon the amount of wound discharge.

- Synthetic burn wound dressings are popular as they:
    - decrease pain associated with dressings;
    - improve healing times;
    - decrease outpatient appointments;
    - lower overall costs.
- Examples for such dressings are,
    - Biobrane®
    - Duoderm®

Healing of burn wounds

- Burns that are being managed conservatively should be healed within 3 weeks.
- If there are no signs of re-epithelialisation in this time, the wound requires debridement and grafting.
- Infection in the minor burn should be managed using a combination of topical and systemic agents.
- Debridement and skin grafting should also be considered.

- Most burn patients have itchy wounds. Those can be managed with cyproheptadine, loratidine and topical doxepin cream.
- The healed burn wound is prone to getting traumatic blisters because the new epithelium is very fragile.
- Non-adherent dressings and regular moisturisation is also useful in this condition.

Non Thermal Burn Injury

Electrical injuries

- Low-voltage injuries cause small, localized, deep burns.
- They can cause cardiac arrest through pacing interruption without significant direct myocardial damage.
- High-voltage injuries damage by flash (external burn) and conduction (internal burn).
- Myocardium may be directly damaged without pacing interruption.
- Limbs may need fasciotomies or amputation.
- Monitoring and treating for acidosis and myoglobinuria is important.

Chemical injuries

- There are two aspects to a chemical injury.
- The first is the physical destruction of the skin and the second is any poisoning caused by systemic absorption.
- The initial management of any chemical injury is copious lavage with water.
- Then identify the chemical and assess the risks of absorption.

Ionizing radiation injury

- Local burns causing ulceration need excision and vascularized flap cover, usually with free flaps.
- Systemic overdose needs supportive treatment

Cold injuries

- Cold injuries are principally divided into two types: acute cold injuries from industrial accidents and frostbite.
- The cold injury produces delayed microvascular damage similar to that of cardiac reperfusion injury.
- The level of damage is difficult to assess, and surgery usually does not play a role in its management, which is conservative, until there is absolute demarcation of the level of injury.