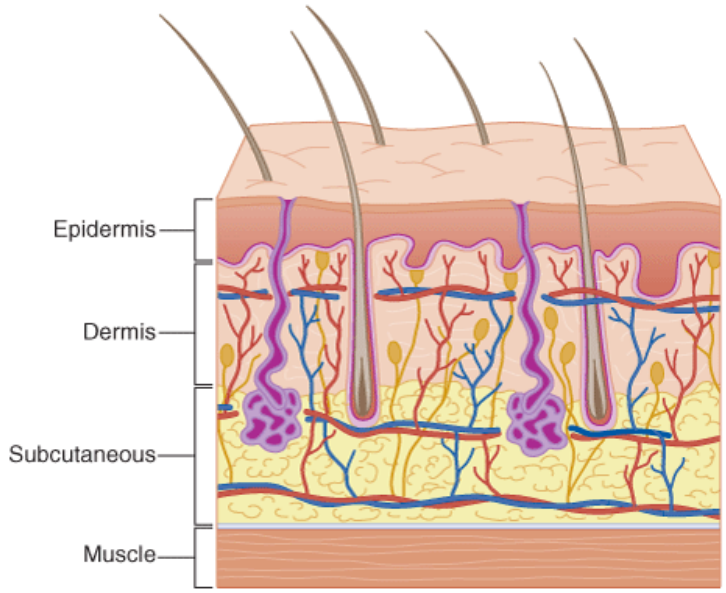
THERMAL BURNS

THE RISK OF DEATH FROM A MAJOR BURN INCREASES WITH *LARGER BURN SIZE, OLDER AGE, PRESENCE OF INHALATION INJURY AND FEMALE SEX.*

PATHOPHYSIOLOGY:

- Skin consists of two layers (epidermis and dermis) and its thickness is less in the very young and elderly.



- Thickness varies depending on the area of the body, hence an identical time frame of burning will lead to different injuries depending on the body region

Skin functions:
- Semipermeable barrier to evaporative water loss ∴ high evaporative losses in burns
- Protection from the external environment
- Control of body temperature
- Sensation and excretion

- Fluid and electrolyte abnormalities seen in BURN SHOCK are largely the result of alterations in cell membrane potentials with INTRACELLULAR INFLUX OF WATER AND SODIUM AND EXTRACELLULAR MIGRATION OF POTASSIUM DUE TO DYSFUNCTION OF THE SODIUM PUMP
- In those with BSA burns >60%, there is depression of cardiac function that does not respond to volume loading
- HAEMATOLOGIC DERANGEMENTS; increased blood viscosity, followed by anaemia from erythrocyte extravasation
- SYSTEMIC RESPONSE consists of neurohormonal axis response and profound alteration of all body systems

Table 210-1 Physiologic Effects of Thermal Injury
Disruption of sodium pump
Intracellular influx of sodium and water
Extracellular efflux of potassium
Depression of myocardial contractility (>60% of body surface area burned)
Increased systemic vascular resistance
Metabolic acidosis
Increase in hematocrit and increased blood viscosity
Secondary anemia from erythrocyte extravasation and destruction
Local tissue injury
Release of histamines, kinins, serotonins, arachidonic acids, and free oxygen radicals

Many factors influence prognosis, but foremost are:

- SEVERITY OF BURN
- PRESENCE OF INHALATION INJURY
- ASSOCIATED INJURY
- PATIENT'S AGE
- PREEXISTING DISEASE
- ACUTE ORGAN SYSTEM FAILURE

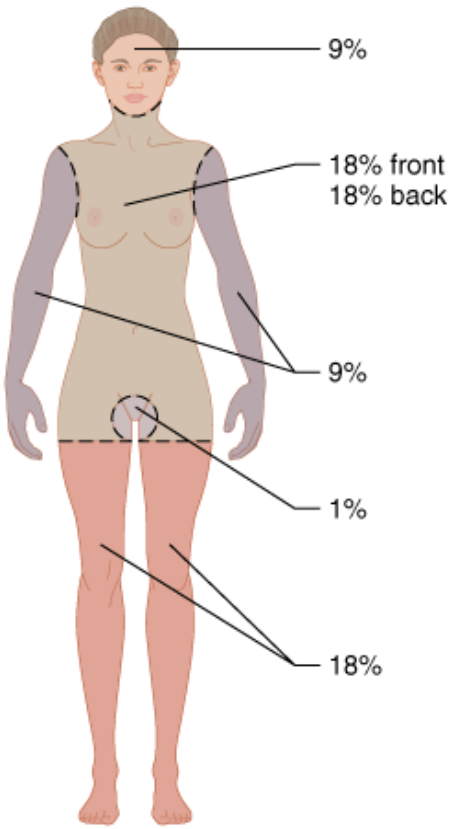
Burn wound is described as having three zones:

- ZONE OF COAGULATION: tissue is irreversibly destroyed with thrombosis of blood vessels
- ZONE OF STASIS: stagnation of microcirculation. Can become progressively more hypoxaemic and ischaemic if resuscitation is not adequate.
- ZONE OF HYPERAEMIA: increased blood flow

CLINICAL FEATURES:

BURN SIZE:

- Quantified as the percentage of BSA involved
  - Calculated by the "RULE OF NINES"
  - Must be modified in infants and children
- Alternatively, the AREA OF THE BACK OF PATIENT'S HAND IS APPROXIMATELY 1% OF THEIR BSA
  - i.e., the number of hands equates to BSA involvement
- It is common for INCORRECT ESTIMATION OF BSA INVOLVEMENT

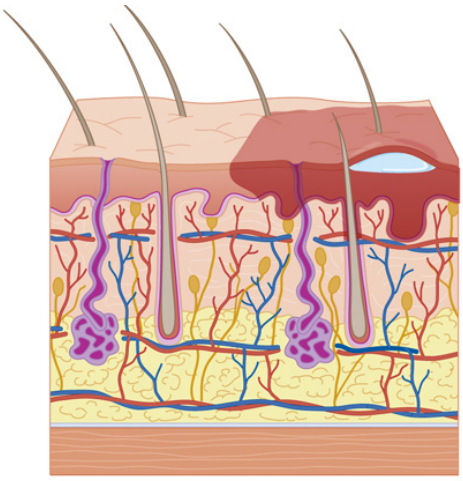


BURN DEPTH:

- Previously described by "degree" (1st, 2nd, 3rd, 4th), but current classification is based according to NEED FOR SURGICAL INTERVENTION.
    - SUPERFICIAL PARTIAL-THICKNESS
    - DEEP PARTIAL THICKNESS
    - FULL THICKNESS

Table 210-2 Burn Depth Features Classified by Degree of Burn

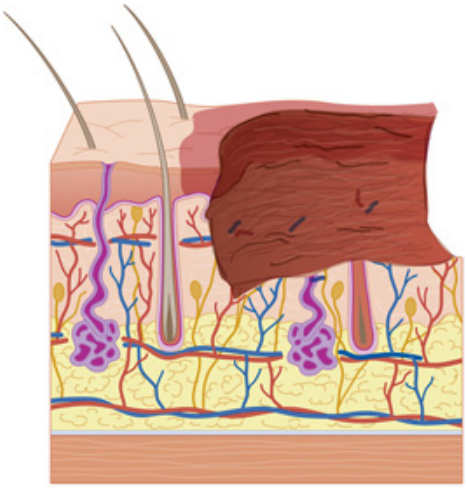
Burn Depth	Histology/Anatomy	Example	Healing
First degree	Epidermis	Sunburn	7 d
	No blisters, painful		
Superficial second degree or superficial partial thickness	Epidermis and superficial dermis	Hot water scald	14–21 d, no scar
	Blisters, very painful		
Deep second degree or deep partial thickness	Epidermis and deep dermis, sweat glands, and hair follicles	Hot liquid, steam, grease, flame	3–8 wk, permanent scar
	Blisters, very painful		
Third degree	Entire epidermis and dermis charred, pale, leathery; no pain	Flame	Months, severe scarring, skin grafts necessary
Fourth degree	Entire epidermis and dermis, as well as bone, fat, and/or muscle	Flame	Months, multiple surgeries usually required



2nd degree (superficial partial thickness)

In superficial partial thickness the epidermis and superficial dermis are injured, but deeper layers of the dermis, hair follicles and sweat/sebaceous glands are spared.

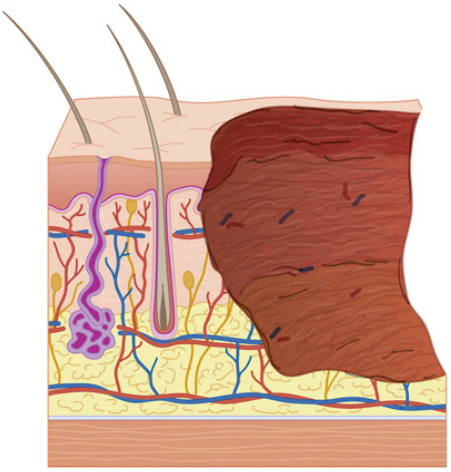
- BLISTERING OF THE SKIN, exposed dermis is red and ***moist*** at the blister's base
- VERY PAINFUL
- ***Intact capillary refill***
- Full return of function



2nd degree (deep partial thickness)

DEEP PARTIAL THICKNESS BURNS:

- Extend into the deep dermis
- Damage to hair follicles, sweat glands and sebaceous glands
- Skin may be blistered and the EXPOSED DERMIS IS PALE WHITE TO YELLOW IN COLOUR
- BURNED AREA ***DOES NOT BLANCH***
- *Absent capillary refill* and absent pain sensation
- SCARRING IS COMMON
- Surgical debridement and skin grafting may be necessary



3rd degree (full thickness)

FULL THICKNESS BURNS:

- Involve entire thickness of the skin
- *Skin is charred, pale, painless and* ***LEATHERY***
- These injuries WILL NOT HEAL SPONTANEOUSLY, because all the dermal elements are destroyed
- Surgical repair and skin grafting are mandatory

"FOURTH DEGREE BURNS":

- Those that extend through the skin to the subcutaneous fat, muscle and even bone
- Amputation or reconstructive surgery often necessary

Table 210-3 Burn Depth Features: American Burn Association Burn Classification

Burn Classification	Burn Characteristics	Disposition
Major burn	Partial thickness >25% BSA, age 10–50 y	Burn center treatment
	Partial thickness >20% BSA, age <10 y or >50 y	
	Full thickness >10% BSA in anyone	
	Burns involving hands, face, feet, or perineum	
	Burns crossing major joints	
	Circumferential burns of an extremity	
	Burns complicated by inhalation injury	
	Electrical burns	
	Burns complicated by fracture or other trauma	
	Burns in high-risk patients	
Moderate burn	Partial thickness 15%–25% BSA, age 10–50 y	Hospitalization
	Partial thickness 10%–20% BSA, age <10 y or >50 y	
	Full thickness burns ≤10% BSA in anyone	
	No major burn characteristics present	
Minor burn	Partial thickness <15% BSA, age 10–50 y	Outpatient treatment
	Partial thickness <10% BSA, age <10 y or >50 y	
	Full thickness <2% in anyone	
	No major burn characteristics present	

Table 210-4 American Burn Association Burn Unit Referral Criteria

Third-degree burns in any age group
Electrical burns, including lightning injury
Chemical burns
Inhalation injury
Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
Burn injury in any patients with concomitant trauma (such as fractures) in whom the burn injury poses the greatest risk of morbidity or mortality
Burn injury in children in hospitals without qualified personnel or equipment to care for children
Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention
Burn injury in children <10 y and adults >50 y of age

INHALATION INJURY:

As treatment of burn shock & sepsis has improved, INHALATION INJURY HAS EMERGED AS THE MAIN CAUSE OF MORTALITY IN BURNS PATIENTS

Inhalation injuries are associated with CLOSED-SPACE FIRES AND CONDITIONS THAT DECREASE MENTATION (drugs, alcohol, overdose, head injury)

- Exposure to smoke includes exposure to heat, particulate matter and toxic gases.
- Despite advances in respiratory support, smoke inhalation injury significantly increases mortality

There is general consensus that DIRECT THERMAL INJURY IS LIMITED TO THE UPPER AIRWAY --> cases below the vocal cords occur only in STEAM INHALATION

- Small particles may reach the TERMINAL BRONCHIOLES, where they initiate an inflammatory reaction that leads to BRONCHOSPASM AND OEDEMA

Toxic inhalants are divided into THREE BROAD GROUPS:

- Tissue asphyxiants
- Pulmonary irritants
- Systemic toxins

TISSUE ASPHYXIANTS:

- Two major players: CARBON MONOXIDE & HYDROGEN CYANIDE
- **CARBON MONOXIDE**
  - Well known consequence of smoke inhalation.
  - Causes brain hypoxia and coma
  - All patients should receive 100% oxygen by NRB & should be evaluated for HYPERBARIC OXYGEN THERAPY
- **HYDROGEN CYANIDE**
  - Formed when nitrogen-containing polymers (wool, silk, polyurethane, vinyl) are burned
  - Binds to and disrupts the mitochondrial oxidative phosphorylation --> profound tissue hypoxia
  - Specific treatment required with antidotes (*Hydroxycobalamin)*.

INHALATION INJURY:

- Damages endothelial cells, produces mucosal oedema of small airways, decreases alveolar surfactant activity
  - Bronchospasm, airflow obstruction & atelectasis !!
- ~ half of intubated patients due to inhalation injury end up with ARDS
  - Care with fluid resuscitation is required to avoid exacerbating pulmonary oedema and ARDS.
  - Early haemodynamic monitoring suggested

- Bronchospasm may occur early (but often delayed for 24 hours)
    - UPPER AIRWAY OEDEMA OCCURS EARLY AND RAPIDLY
    - Early intervention (i.e. intubation) if patient has FACIAL BURNS, SINGED NASAL HAIR, SOOT IN THE MOUTH OR NOSE, HOARSENESS, CARBONACEOUS SPUTUM AND EXPIRATORY WHEEZE
- Measurement of carboxyhaemoglobin is useful to document prolonged exposure within an enclosed space
- CXR may be normal initially

TREATMENT:

- Institute early prior to definitive diagnosis
- Humidified 100% oxygen
- ABG including co-oximetry (COHb, lactate)
- Control of upper airway with prompt intubation

EARLY INTUBATION IF:

- Full thickness burns of the face or perioral region
- Circumferential neck burns
- Acute respiratory distress
- Progressive hoarseness or air hunger
- Respiratory depression or altered mental status
- Supraglottic oedema and inflammation on bronchoscopy

TREATMENT OF BURNS:

PREHOSPITAL:

- *Primary survey*
- STOP THE BURNING PROCESS
    - Remove burning clothing immediately
    - All rings, watches, jewelry and belts should be removed --> beware swelling and tourniquet effect!
- ESTABLISH AND AIRWAY
    - Apply 100% oxygen
    - Diligent attention to the airway because rapid swelling may occur event when initial assessment judges the airway to be acceptable
    - PROPHYLACTIC INTUBATION
- INITIATE FLUID RESUSCITATION
- RELIEVE PAIN
- PROTECT BURN WOUND
- TRANSPORT TO APPROPRIATE FACILITY

ED MANAGEMENT:

Table 210-5 ED Care of Patients with Major Burns			
Airway	**Breathing**	**Circulation**	**Adjuncts**
Reevaluation of airway	Continuous pulse oximetry with supplemental O_2	Establishment of two large-bore peripheral IV lines in unburned skin	Placement of Foley catheter
Early intubation for any sign of airway burn, swelling, or inhalation injury			Insertion of nasogastric tube
	Determination of carboxyhemoglobin level	IV administration of lactated Ringer's solution using Parkland or other burn resuscitation formula	Administration of tetanus booster
	Bronchoscopy if inhalation injury is a concern		Assessment for other trauma using ATLS guidelines
	Mechanical ventilation as needed	Cardiac monitoring	Pain control

Need to establish:

- **What was the burning agent?**
- **Were chemicals involved? What substances were burned?**
- **What was the duration of exposure?**
- **Was the fire enclosed?**
- **Was there an explosion? Risk of blast injury?**
- **Was there any contact with electricity?**
- **Was there any trauma or LOC?**

SECONDARY SURVEY

- Head-to-toe, look for corneal burns, depth of burns, for patients with >20% BSA burns, place and NG tube as ileus frequently supervenes

BURN-SHOCK RESUSCITATION

- PARKLAND FORMULA.
- Usefulness has been questioned
- It is only a guideline and may underestimate fluid requirements when compared to early invasive monitoring being used to guide fluid administration.

Table 210-6 Parkland Formula for Fluid Resuscitation
Adults
LR 4 mL x weight (kg) x % BSA burned* over initial 24 h
Half over the first 8 h from the time of burn
Other half over the subsequent 16 h
Example: 70-kg adult with 40% second- and third-degree burns:
4 mL x 70 kg x 40 = 11,200 mL over 24 h
Children
LR 3 mL x weight (kg) x % BSA burned* over initial 24 h plus maintenance
Half over the first 8 h from the time of burn
Other half over the subsequent 16 h

- Patients who have concomitant multisystem trauma generally require fluids in excess of calculated needs
    - Frequent reassessment of the patient's vital signs, signs of cerebral and skin perfusion and urinary output as well as haemodynamic monitoring
    - Aim for urine output of 0.5-1mL/kg/hour
- No evidence of superiority of colloid vs crystalloid resuscitation
    - Israelia investigators have reported favourable results with colloid in their burn formulas
    - Use of hypertonic saline has produced an increased rate of renal failure and death
- In an effort to decrease burn oedema, protein and abdominal compartment syndrome, investigators have studied the efficacy of PERMISSIVE HYPOVOLAEMIA in reducing burn oedema and the multiple organ dysfunction that follows
    - *EXPERIMENTAL* - not able to be validated or advocated
- *Electrical injuries, incineration burns and associated crush injuries may produce* ***RHABDOMYOLYSIS AND MYOGLOBINURIA***
    - ARF occurs in ~15% of patients admitted to burn centres and is associated with severe burns
- PROVIDE TETANUS TOXOID PROPHYLAXIS
- USE OF PROPHYLACTIC ANTIBIOTICS IS INAPPROPRIATE

WOUND CARE:

- After evaluation & resuscitation of the patient, the wounds are addressed
- Soothing effect of cooling is most likely due to local vasoconstriction
    - Cooling also stabilizes mast cells and reduces histamine release, kinin formation and thromboxane.
- Patients with CIRCUMFERENTIAL DEEP BURNS OF THE LIMBS MAY DEVELOP COMPROMISE OF DISTAL CIRCULATION
    - Distal pulses need to be monitored closely.
    - Doppler can be used.
- If there is compromise to the circulation ESCHAROTOMY IS REQUIRED
    - The eschar is incised on the midlateral portion of the limb, with the fat allowed to bulge through
    - Beware, as it *may provoke substantial soft tissue bleeding*

If there are circumferential burns of the chest and neck, the ESCHAR MAY CAUSE MECHANICAL RESTRICTION TO VENTILATION

- Escharotomy should be performed to allow adequate ventilation
- Incisions are made at the anterior axillary line form the level of the second rib to the level of the twelfth rib. These two incisions should be joined transversely so the chest wall can expand

PAIN CONTROL:

- ALL BURNS ARE PAINFUL --> superficial partial-thickness burns are the most painful
- HYPERALGESIA caused in surrounding tissues
- Local cooling may be soothing, but does not provide pain control
- Morphine, fentanyl, ketamine given IV in relatively large doses are often required
- Anxiolytics should be used as adjuvants.

CARE OF MINOR BURNS:

- To qualify as a minor burn:
    - Injury should be isolated
    - Not involve the hands, face, feet or perineum
    - Not cross major joints or be circumferential
- When a minor burn is treated, the patient's social and medical situation should also be considered.
- Provide appropriate analgesia
- Burn wound is cleaned with mild soap and water or dilute antiseptic
- Blisters may be left intact or drained or the overlying epithelium may be debrided --> depends on size and location
    - Blisters should be debrided, because an intact or spontaneously collapsed blister may serve as a focus for wound infection

Table 210-7 ED Care of Minor Burns
Provide appropriate analgesics before burn care and for outpatient use
Cleanse burn with mild soap and water or dilute antiseptic solution
Debride wound as needed
Apply topical antimicrobial:
1% silver sulfadiazine cream (not on the face or in patients with a sulfa allergy)
Bacitracin ointment
Triple-antibiotic ointment (neomycin, polymyxin B, bacitracin zinc)
Consider use of synthetic occlusive dressings
Provide detailed burn care instructions with follow-up in 24–48 h

- Topical antimicrobials play an important role in reducing bacterial colonization and enhancing the rate of healing in burns
    - Use 1% silver sulfadiazine (eg. Acticoat dressing).
        - Don't use in those with a sulphur allergy or on the face, due to the potential for staining
- Dressings are ideally changed twice daily for as long as the wounds continue to weep, then they are changed daily until the burn is healed
- Burn-dressing adherence is important, as most of the pathologic bacteria produce fibrinolytic agents
- Burned extremities should be elevated for 24-48 hours to prevent oedema
- Advise return if any evidence of infection and all burn wounds should be reassessed at 24 hours for depth and extent of burn

PREGNANT PATIENTS:

- Burns to a pregnant patient are associated with significant morbidity to mother and child
    - Outcome is determined by extent of burn
- Fluid requirements may exceed those estimated using the Parkland formula !!