جامعة الملك سعود
King Saud University
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Wound Healing, Wound Infection and Injuries due to Burns

Surgery Team
MED 433

MED 433
طب ٤٣٣

Objectives :

Wounds

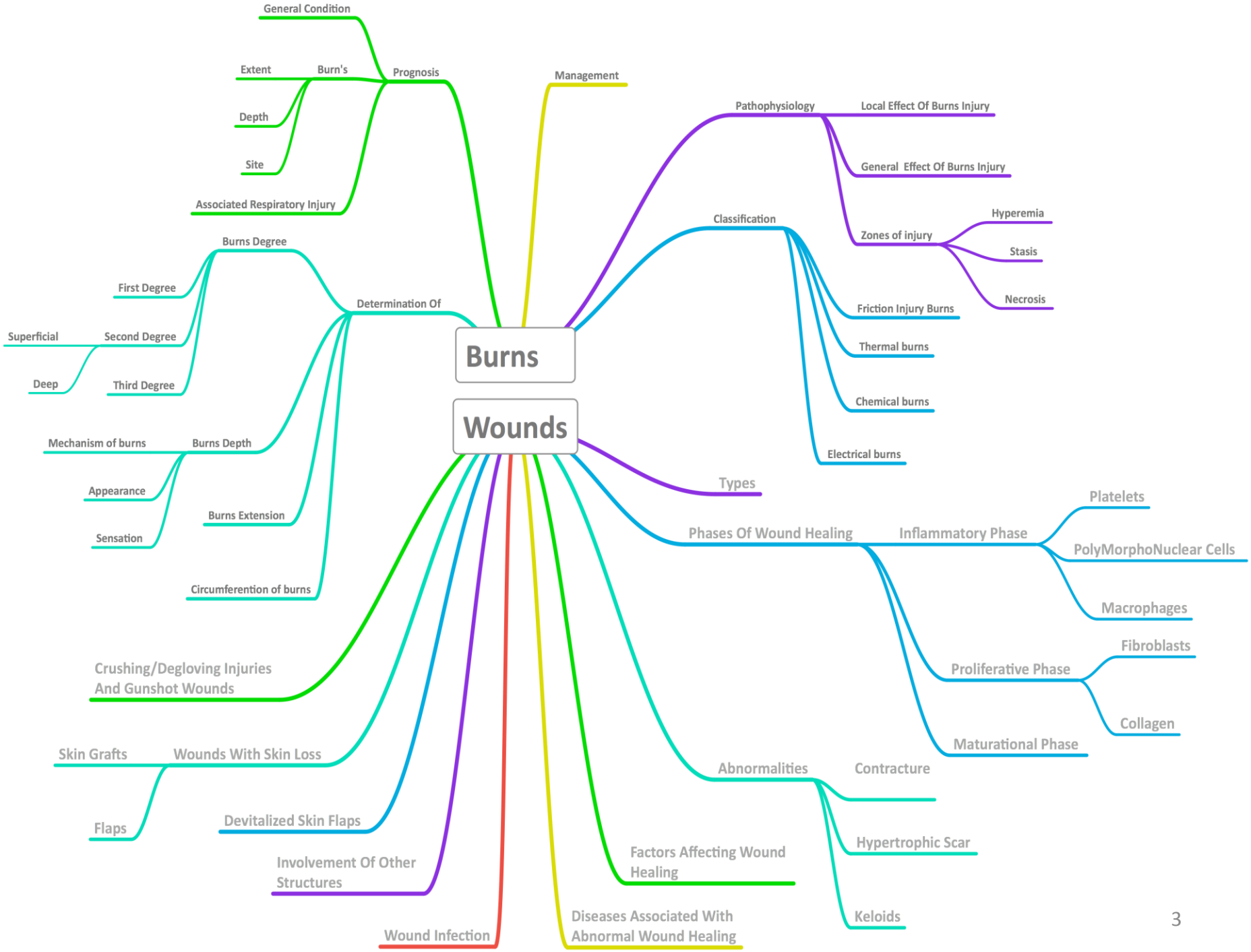
a. Types of wound
b. Principles of wound healing
c. Factors influencing wound healing
d. Wound infection
e. Involvement of other structures
f. Devitalized skin flaps
g. Wound with skin loss
h. Crushing/degloving injuries and gunshot wounds

Burns

a. Mechanisms
b. Local effects of burn injury
c. General effects of burn injury
d. Classification
e. Prognosis
f. Management

Sources : **Slides, Raslan's Notebook (P: 7-17), Principles & Practice of Surgery by: O. James Garden (P: 295-309)**

Color Index : Slides & Raslan's | Textbook | Doctor's Notes | Extra Explanation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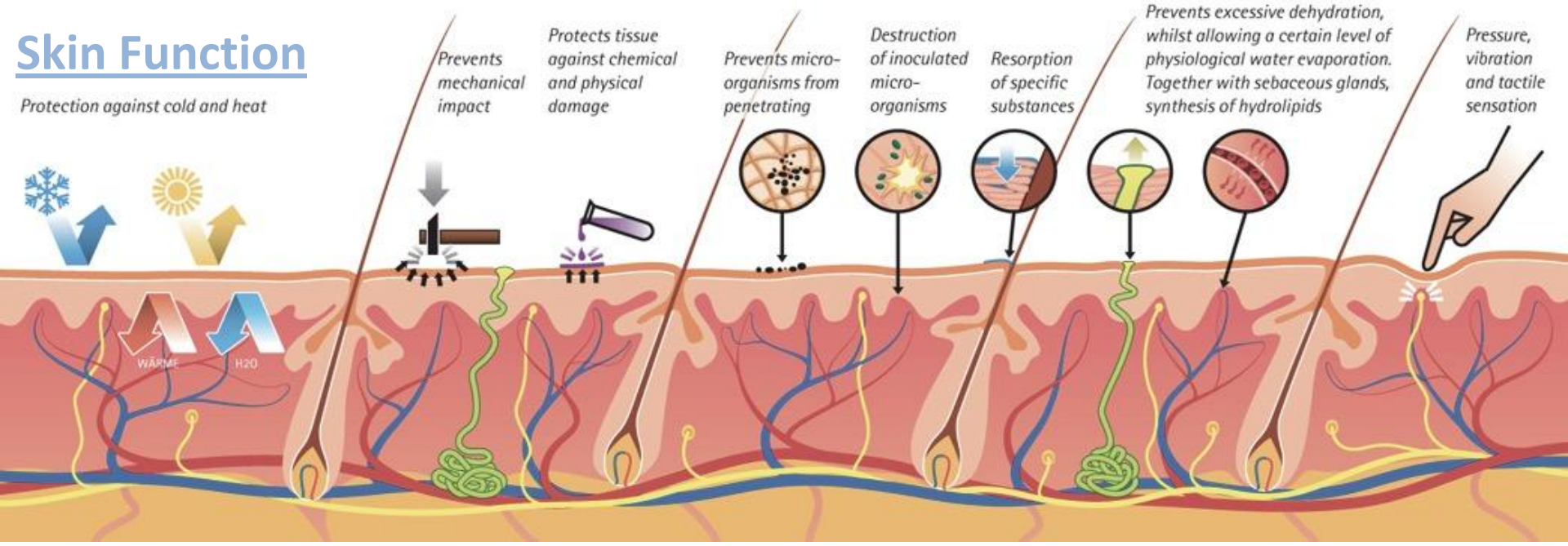
1st : Introduction

Skin Function



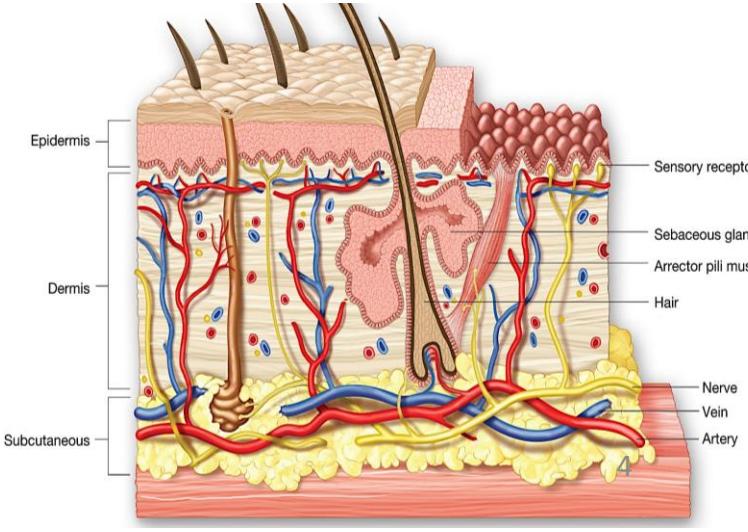
Skin Layers

- Epidermis: The rate limiting step in dermal or percutaneous absorption is diffusion through the epidermis.
- Dermis: Much thicker than epidermis True skin & is the main natural protection against trauma. Contain the **skin appendages :**

Examples of Skin appendages:

1) Sebaceous Glands (Function: Secret Sebum, which lubricate the skin and hair)
2) Sweat Glands (2 Types : Eccrine & Apocrine)
3) Hair Follicles
4) Nails

- Subcutaneous fatty layer : For cushion & insulate



2nd : Burns

Pathophysiology Of Burns

Burns are dynamic injury "progressive".

➥ Local Effect Of Burns Injury:

1- Destruction of tissues

2- Inflammation (deeper tissues) .

With deeper burns, the damaged capillaries become permeable to protein, and an exudate forms with an electrolytic and protein content only slightly less than that of plasma. Lymphatic drainage fails to keep pace with the rate of exudation and interstitial edema leads to a reduction in circulating fluid volume. Exudation is maximal in the first 12 hours. Capillary permeability returning to normal within 48 hours.

3- Infection - Burn wounds will almost always be infected by micro-organisms within 24 to 48 hours.

➥ General Effect Of Burns Injury:

Depend upon the burn's size & Depth.

Large Surface burns: lead to: water loss salt and protein loss , hypervolemia and increased catabolism.

Some red cells are destroyed immediately by a full-thickness burn. Red cell loss is small compared to plasma loss in the early period, and haemoconcentration, reflected by arising **hematocrit**. "high proportion of RBCs/Plasma"

Effects of burn injury
Destruction of tissue ★ (Depth depends on: heat of causative agent & contact time) ★ Loss of barrier to infection (caused by the destruction of the Epidermis) ★ Fluid loss from surface (↑ with the increasing of the TBSA) ★ Red cell destruction (Usually in 3^0 Burns)
Increased capillary permeability ★ Loss of circulating fluid volume ★ Edema ★ Hypovolaemic shock
Increased metabolic rate (as water losses from the burned surface cause expenditure of calories to provide the heat of evaporation)

➥ Zones of injury:

Hyperemia (Outer zone)

- Inflammatory response.
- Vasodilation

Stasis (Middle zone)

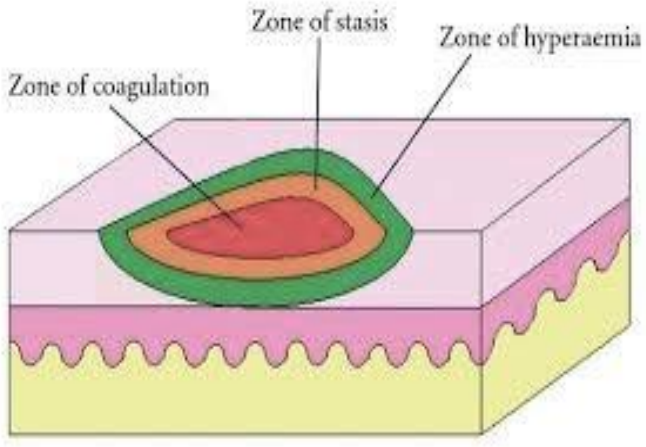
- Reversible "treatable" : treatment is important for prevention of necrosis " we focused mainly in this zone during treatment.

Necrosis (Central zone)

- Irreversible

⊙Compartment Syndrome:

Is the compression of nerves, blood vessels, and muscle inside a closed space (compartment) within the body. This leads to **tissue death** from lack of oxygenation due to the blood vessels being compressed by the raised pressure within the compartment. You must always look for circumferential burns around the chest, abdomen, limbs, etc... and **perform an Escharotomy to release the pressure**



Classification (According to the Cause) … 1- Friction Injury Burns

2- Thermal burns

- **Caused by :**

1- hot fluid :

"known as scaled burns"

2- by flame.

- It triggers intense Inflammatory response **SIRS** (will be detailed later)
- There will be an Initial release of **Histamine, Bradykinin** (Vasodilator)
- Release of prostanoids, free radicals, proteases

All of Which will Lead to:

1- Hypermetabolism.

2- Bacterial Translocation (Sepsis)

3- MOF. (Multi-organ failure)

3- Chemical burns

- 4th degree if it reaches the fat and muscle.
- Delayed and progressive injury
- Deceptively superficial at first

- **Can be causes by :**

1- Acid: more limited (coagulation necrosis)

2- Alkalis more destructive (deep liquefaction)

3- HFI "Hydrogen Fluoride": both Acid & Alkaline (significant necrosis) (it burns like an acid because it is an acid and when the fluoride "alkaline" is released it reaches the bone and causes decalcification leading to **hypocalcaemia & arrhythmias**)

- **Management :**
- Removal of causative agent
- Brush off metals and powders
- Copious irrigation with water

4- Electrical burns

- 4th degree if the current passes through the body
- Caused by passage of electric current and cause systemic effect
- Damage increased in small bony areas" Fingers, feet, lower legs, forearm"

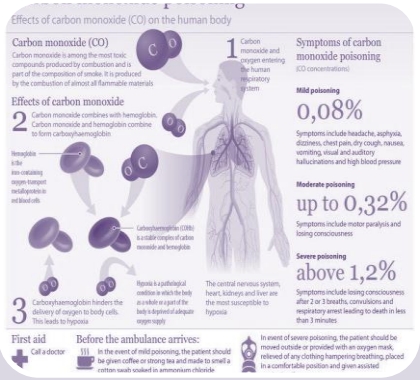
- **Two types :**

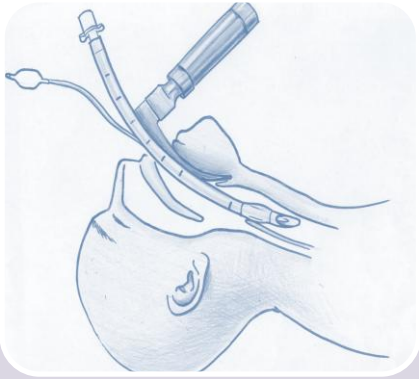
1. Low voltage (<1000): May cause **arrhythmias**
2. High voltage (>1000 V): **Massive tissue damage, respiratory and cardiac arrest.**

- **Investigations:** ECG, CPK, UA, monitor
- **Management :**

Local care often necessitates grafting and amputation

Inhalation Injures:- Smoke Inhalation "Usually with flame burns"





1.Carbon Monoxide Poisoning

- **Signs of CO poisoning:**
- Confusion & dizziness
- Dull Headache (HA)
- Nausea & Vomiting (NV)
- Flushed skin
- Weakness.
- Chest Pain.
- **Treatment:** 100% FiO2

2. Upper Airway Obstruction

- Common in **head and Neck** burns and smoke inhalation
- Edema continues at least 24 hours and decreased by day 3 post burn.
- Protect airway with tracheal intubation

3. Pulmonary Injury from Chemical Inhalation

- Develops ARDS (Acute Respiratory Distress Syndrome) within 24 hours post injury
- Pneumonia may occur as late as post burn day 10

4. Poisoning

- Caused By: flame burn in closed space.
- **Inhaling these toxins affects the lungs directly causing inflammation pneumonitis and later pneumonia.**

Determination Of:

1) **Burns Degree :** "see the table in slide #11 "

2) **Burns Depth:** depend on :

◎ **Mechanism of burns:**

Burn depth is proportional to the **temperature** of the causal agent and to the **length of contact time**. For example Scalds from liquids below boiling point usually produce partial-thickness injury, whereas scalds from boiling water and burns often produce full-thickness damage.

◎ **Appearance:**

◎ **Sensation:**

Will be mentioned in next table

3) **Burns Extension:**

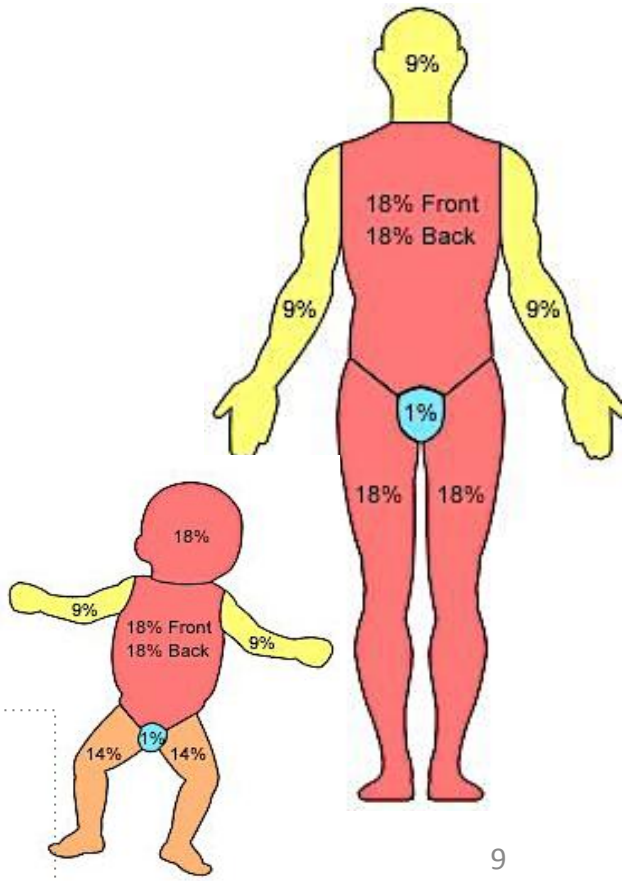
Extent of injury described using percentage of total body surface area that is burned (TBSA).

★ Determined by **Rule Of Nine** where

- Each hand is 9% "4.5% anteriorly and 4.5% posteriorly"
- Each leg is 18% "9% anteriorly and 9% posteriorly"
- Head & Neck are 9%
- Genital area is 1%

★ The 'Rule Of Nines' cannot be used in children because of the relatively large head size (about 20% of body surface at birth) and the relatively small limbs (legs are about 13%).

★ **If it is scattered burns :** use **The palm of the patient** for measurement… **Palm = 1%** TBSA.



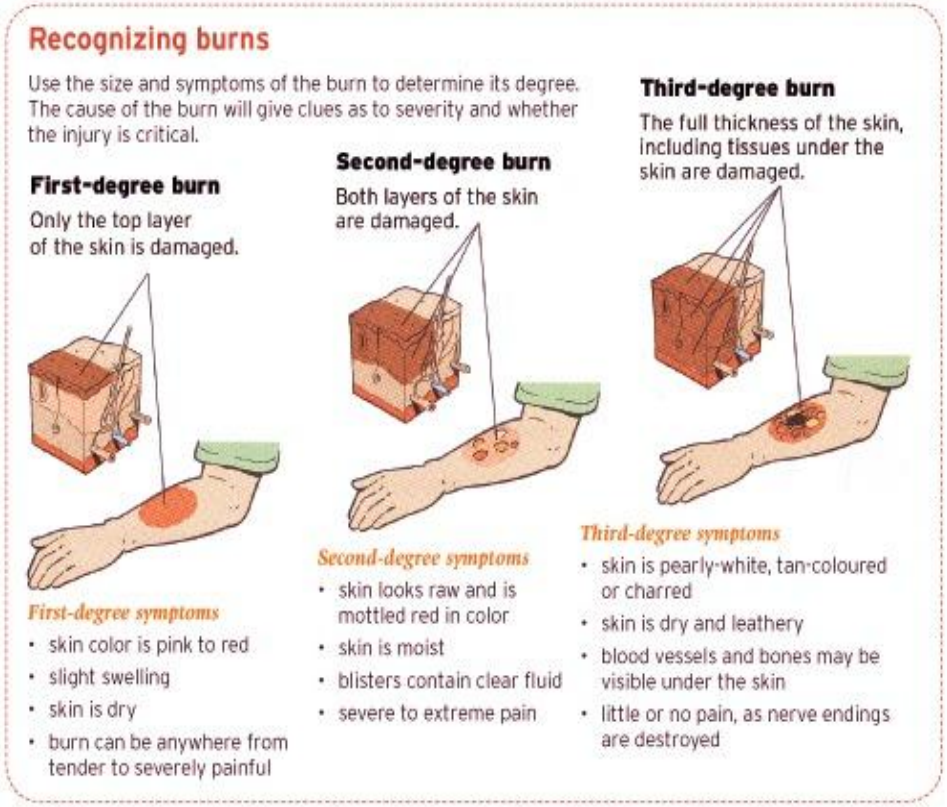
Scenario: An adult male is brought to the ED with second-degree burns on his chest and abdominal wall, anterior right leg, and perineum. What percentage TBSA does he have? *Think*: Rule of Nines says 18% for anterior torso, 9% for anterior leg, and 1% for perineum = 28%.

4) Circumferention of burns (محيط)

Circumferential burns to chest, neck and limbs that may **compromise ventilation** or circulation.

Once the burn injury is more than 30% of the body surface area the inflammatory response will be systemic (SIRS: Systemic **I**nflammatory **R**esponse **S**yndrome**)**

- ✓ There will be **systemic vasodilatation**.
- ✓ Fluid will shift from the intravascular space to the extra vascular space
- ✓ Which leads to **hypo-perfusion to vital organs** such as the kidneys; causing renal failure.
- ✓ Hypo-perfusion to the intestines may happen causing Intestinal ischemia
- ✓ Bacteria will shift into the blood stream (Bacterial Translocation) , Leading to sepsis (will lead to death, If not-managed).



Burn Degree	First Degree (Superficial)	Second Degree (Partial Thickness Burns)		Third Degree (Full Thickness)
		Superficial (Mid-dermal)	Deep (Deep-dermal)	
Affected skin layer	Epidermis only	Epidermis + superficial dermis	Epidermis +most of dermis	Epidermis and all of dermis
Involving of appendages	No	No	Most of them	All of them
Sensation	Intact	Intact	Decreased	Anesthetic
Pain	Mild to moderate	Severe pain	Less painful "more nerves are destructed"	Painless
Healing and scaring	3-6 days with no scar	1-3 weeks , scaring is unusual with perfect cosmetic result	More than 3 weeks with hypertrophic scaring	Does not heal with severe scaring
Appearance	Erythema + blanches with pressure	Blisters + blanches with pressure	Thick blisters + decreased blanching	White and tan thrombosed vessels + **Escher** "dead tissue" +leather skin + no blanching
Treatment	Analgesics & pain medications	Flamazine	Surgical	Surgery and skin grafting
Examples	Sun burns	Scaled from under boiling water	Scaled from boiling water	Flame burns

Prognosis

1) Age And General Condition

Infants, the **elderly**, **alcoholics** and those with other co-morbidity fare less well than healthy young adults .

2) Extent Of The Burn: Use the Role of nine.

3) Depth Of The Burn

Full-thickness burns inevitably become infected unless excised early, and in the case of large burns infection may prove life-threatening.

4) Site Of The Burn

Burns involving the face, neck, hands, feet or perineum are particularly liable to threaten appearance or function. **They require inpatient management.**

5) Associated Respiratory Injury

This extremely common in house fires and usually results from the inhalation of smoke from **burning plastic foam upholstery**. It is frequently fatal.

✳ Risk Factors Of Death :

- Body Surface Area (BSA) **more than 40%**
- Age (60 years or more)
- Inhalation injury

✳ Causes Of Death

Dehydration (most common cause of death in burns).

But death occur also due to smoke inhalation, **sepsis**, pneumonia and shock.

Burn Center Referral Criteria:

1. Partial thickness (2nd Degree) burns greater than **10%** total body surface area (TBSA).
2. Burns that involve the face, hands, feet, genitalia, perineum, or major joints.
3. **Third degree** burns in any age group (only if the TBSA >5%)
4. Electrical burns, including lightning injury.
5. Chemical burns.
6. Inhalation injury.
7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality. (Such as: DM patients & Patients who received chemotherapy)
8. Any patient with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
9. Burned children in hospitals without qualified personnel or equipment for the care of children.
10. Burn injury in patients who will require special social, emotional, or rehabilitative intervention.

Scenario: A 4-year-old child is brought to your emergency department (ED) with a 14% total body surface area (TBSA) burn, including both second and third degree. It looks as if he had been seated in scalding water. Where should this child be cared for? *Think:* This patient is under 10 years old, with > 10% TBSA burned, including the perineum and genitalia, and may require special social assistance (due to likelihood of child abuse). He should be transferred to a burn center.

Management

Two important Process in the treatment of burns :
- Good hydration
- Prevention of infection

1) First Aid :

- Arrest the burning process :

extinguish flames, remove clothing, cool with water

- Ensure adequacy of airway.
- Avoid wound contamination with **Clingfilm.**
- Transfer for definitive treatment as soon as possible.

2) Adequate Ventilation:

- **First Priority** on arrival at hospital.
- In case of exposed to smoke in a closed room patient should be admitted for observation (Respiratory tract injury is suggested by dyspnea, cough, hoarseness, cyanosis and the presence of soot particles around the nostrils, in the mouth or in the sputum) Endotracheal intubation is advisable.
- Tracheostomy is **never undertaken** lightly in view of the danger of infection of burned tissues around the stoma.

3) Initial Assessment And Management:

- If the burn is over 15% in extent (10% in children), establishing an intravenous infusion takes priority over a detailed history and physical examination
- When placing an I.V line, Use most peripheral vein available in the upper limb, but in shocked patients Use internal jugular or subclavian vein (Because of the vasoconstriction of the peripheral ones).
- In patients with burns of more than 20%, a **catheter is inserted** to measure hourly urine output.
- Give Tetanus Toxoid. (Tetanus can complicate burns)
- **Admit to hospital :** burns involving more than **5%** of body surface should be.

4) Prevention And Treatment Of Burn Shock

- The aim of management is to prevent hypovolemic shock by prompt and adequate fluid replacement Hypovolaemic shock is anticipated if **TBSA> 15%** in adults (**> 10% in children**) .
- The **Parkland formula** is widely used now a days. The fluid volume in **milliliter**s over the first **24** hours is: = **(4) X (Wight in kg.) X (BSA%)** Half of that volume is given in **the first 8 hours**, the remainder over the next 16 hours.
- Despite renal retention of sodium after injury, there is a tendency to **hyponatremia** in the first 2–3 days (due to the secretion of **ADH** and the sequestration of sodium in edema)
- **Hypokalemia**: Can happen if the patient is unable to eat and drink normally after few days of injury

5) Blood Transfusion

- Only in patients with large **full-thickness burns** (Because of : RBCs destruction & bone marrow suppression).
- Haemoglobin concentration and haematocrit should be monitored regularly.

6) Organ Failure And Burn Shock

✸ **Respiratory Complications:**

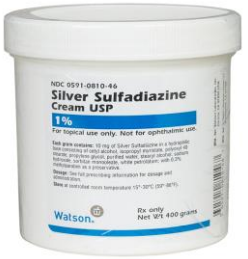
- **Patients With Ventilation Problems**: Chest X-rays & **blood gas analyses** should be repeated regularly.
- **Arterial Hypoxaemia:** require **oxygen therapy**, and may necessitate early endotracheal intubation & assisted ventilation.

✸ **Renal Failure**

- Hourly urine output should be maintained at 30–50 ml in adults (If less it indicate the development of ATN)
- **Acute Tubular Necrosis** (ATN) : in the elderly & those with pre-existing renal diseases.
- **Use Diuretics** :if oliguria persists despite adequate fluid replacement, in this case, 20% **mannitol** (1 g/kg) may be infused over 30 minutes.

7) Nutritional Management :

- In large burns oral intake can usually be supplemented at 48 hours by enteral feeding using a fine-bore **Nasogastric Tube** (NG Tube) and weight loss can be limited.
- Vitamin supplements and iron must also be provided.
- It is considered undesirable to use parenteral nutrition in burned patients.



8) Sepsis

- It is a constant threat until skin cover has been **fully** restored.
- **Prevented by: topical** antibacterial agents (Such as: **Silver Sulfadiazine** cream "Flamazine" & povidone-iodine "Betadine") and early excision and grafting.
- **Systemic antibiotics** only used in invasive infection and for patients with positive blood culture

(They are not prescribed routinely for fear of producing superinfection with resistant organisms)

9) Curling's Ulcer (Acute Duodenal Ulceration) And Gastric Erosions

- Early resumption of feeding reduces their incidence
- **H2-receptor antagonists** such as Ranitidine are prescribed prophylactically.

10) Initial Cleansing And Debridement

The wound is cleaned with a mild detergent containing **antiseptic** and **saline** in an OR or clean dressing room using aseptic technique.

- Adherent clothing and loose devitalized tissues are **removed**.
- Blisters are punctured and serum expressed. Broken blisters are completely **Deroofed** (tissue-saving technique)
- In **shocked patients**, the wound is covered with a sterile drape and **further local care is postponed** until the circulatory state has stabilized.

11) Prevention Of Contamination

- In full-thickness injury, **thrombosis of cutaneous vessels** impairs the normal response to infection.
- In large burns, **cellular and humoral** immune mechanisms are **depressed.**
- **The Most important Organisms are :**
  - ✓ **Staphylococci :** most common infecting organism.
  - ✓ **Haemolytic Streptococci :** they can convert superficial into deep burns.
    It is also a cause of graft loss. (when such infection is present, grafting must be deferred until the patient has been treated with **intravenous penicillin** and barrier nursed)

✸ Evaporative Dressings

These dressings prevent contamination, allow exudate to evaporate and provide comfortable support.

(After initial cleansing, the wound is covered by a layer of sterile non-adherent dressing, e.g. paraffin gauze or Mepotil, a layer of cotton gauze swabs, a bulky layer of cotton wool or Gamgee, and an outer retaining crepe bandage)

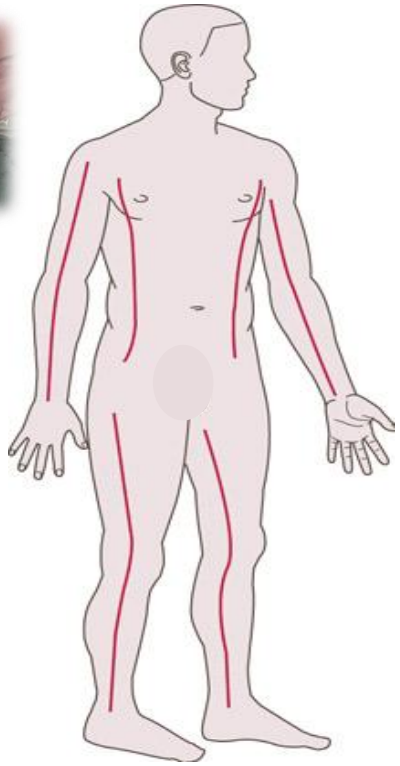
✸ Semi-Occlusive And Occlusive Dressings

- OpSite is an adhesive film that is effective for small burns; it may also leak initially, and should be covered with a well-padded dressing for 48 hours, after which time it can be patched or replaced as necessary.

✸ Biological' Dressings

- Freeze-dried **xeno-grafts** such as porcine skin (pig's skin) can be reconstituted for use as temporary biological dressings, but are expensive.
- Amnion or **stored homograft skin** is used rarely because of the danger of infection with **HIV**.
- Sheets of keratinocytes grown in tissue culture are fragile and easily destroyed by infection.

12) Relief of constriction (Escharotomy)



- The danger of progressive **respiratory embarrassment** from encircling Eschar has been mentioned.
- Increasing edema beneath encircling Eschar in the limbs may also **imperil the Circulation.**
- Escharotomy which run from the top to the bottom of circumferential deep burns, may be needed in the first few hours after injury.

13) Restoration Of Epidermal Cover

- Full-thickness and Deep second degree burns of **less than 10%** are suitable for primary excision of eschar and grafting under general anaesthesia within **48–72 hours** of injury.
- **Deep Second Degree Burns:** use **Tangential excision**.
- More extensive burns can be partially excised and grafted soon after injury, and the remaining areas of skin destruction treated by delayed grafting
- **Split-skin Grafts:** are used to cover **acute burns** (the Only one)
- **Medium-thickness Grafts:** are **most commonly** used.
- **Full-thickness Grafts:** are used for secondary reconstruction in **cosmetically important areas** where contraction has to be avoided, or in areas that subject to repeated trauma (such as the palm)

14) Functional And Cosmetic Result

- With treatment, it is usually possible to restore skin cover within 3 months.
- **Elastic Pressure Garments:** help to prevent the build-up of **hypertrophic scars.**
- **Reconstructive Procedures:** may be required for many years to correct contractures or rebuild missing or distorted features.

3rd: Wound

A disruption of normal anatomic relations as a result of injury intentional or unintentional. Regardless of causation or tissue type, wound healing presents with identical biochemical and physiologic processes, though wound healing may vary in timing and intensity.

Types Of Wound (according to the mechanism of injury)	
	**Incised Wounds** : A sharp instrument causes these; if there is associated tearing of tissues, the wound is said to be lacerated
	**Abrasions:** These result from friction damage and are characterized by superficial bruising and loss of a varying thickness of skin and underlying tissue
	**Crush Injuries:** These are due to severe pressure. Even though the skin may not be breached, there can be massive tissue destruction. Edema can make wound closure impossible. It can lea to compartment Syndrome.
	**Degloving Injuries:** These result from shearing forces that cause parallel tissue planes to move against each other. Large areas of apparently intact skin may be deprived of their blood supply by rupture of feeding vessels
	**Gunshot Wounds**: These may be low-velocity (e.g. shotguns) or high-velocity (e.g. military rifles). Bullets fired from high-velocity rifles cause massive tissue destruction after skin penetration
	**Burns:** These are caused not only by heat but also by electricity, irradiation and chemicals.

Phases Of Wound Healing

What you have to know is:
The aim, Time, Duration, important substances of each phase

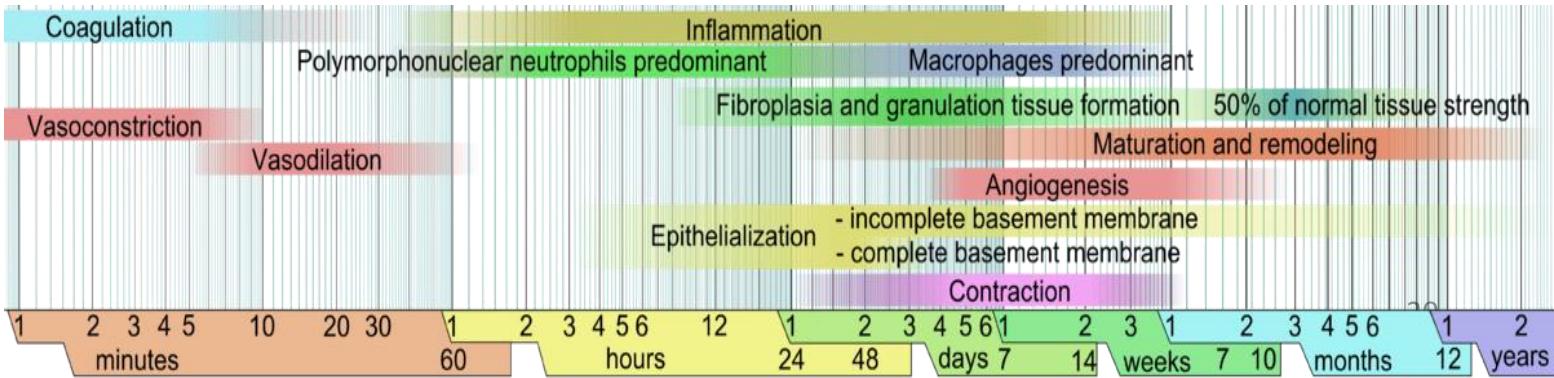
1st: Inflammatory Phase (A.K.A. Lag Phase) *Substrate or Reactive phase*

- ✦ It **Starts immediately** after wounding . Typically takes **1-10 Days**
- ✦ The wound will cause Tissue injury & blood vessel damage ➔ So the **Aim** of this phase is to : **Limit And Prevent Further Injury**, Maintain hemostasis, Sealing the wound's surface, Removing necrotic tissue and debris, Help the migration of cells into wound by chemotaxis, cytokines, and growth factors. **<u>We can divide this phase into 3 important events:</u>**

1) **Hemostasis:** **Initial** intense local **vasoconstriction** (for almost 10 minutes) of arterioles and capillaries (to stop the Bleeding) **followed by vasodilation**(Vasodilation is the end result of factors released by platelets and other cells) and vascular permeability
2) **Activation of the coagulation pathway :** Caused by the exposure of **subendothelial collagen** to **platelets** and **vWF** **(Von Willebrand factor**, is a blood glycoprotein, it helps in the platelet adhesion to the wound site**) .**

- **Plugging:** Platelet and fibrin.
- **Provisional Matrix:** Platelets, Fibrin, and Fibronectin (Fibrin and fibronectin cross-link together and form a plug that traps proteins and particles and prevents further blood loss)
- **Platelet Aggregation:** Thromboxane (vasoconstrictor), Thrombin, Platelet Factor 4

[Read More About It Here]



1- Platelets

They are the first cells to arrive at the site of injury.

- (platelet have 4 Granules: Alpha, Delta, Gamma and Lambda)

1st : **Alpha Granules** contain:

- **Platelet factor 4:** aggregation
- **β-ThromboModulin**: binds thrombin
- **PDGF:** chemoattractant
- **TGF-β** (released by platelets): key component tissue repair

2nd: **Dense Granules**(Delta "δ"): contain vasoactive substances, which are :

- **Adenosine** (The form of ADP in blood)
- **Serotonin**
- **Calcium** (ionized)

- **Other factors released are :**

- **TXA (T**hrombo**X**ane **A**) (it stimulates activation of new platelets + increases platelet aggregation)
- **Platelet Activating Factor** (PAF)
- **Transform Growth Factor α** (TGF-α)
- **Fibroblast Growth Factor**
- **β-lysin** (anti-microbial)
- **PGE2** and **PGI2** (vasodilator)
- **PGF2** (vasoconstrictor).

2- PolyMorphoNuclear Cells (PMNs) "Neutrophils"

✓ They Attract Chemotoxins after extravasation.

✓ They Migrate through the ECM by transient interaction with the help of integrin

(**Integrins** are transmembrane receptors that are the bridges for cell-cell and cell-extracellular matrix (ECM) interactions)

✸ **PMNs Functions:**

- Scavenge
- Present antigens
- Provide Cytotoxicity-free Radicals (H2O2)

✓ Migration of PMNs **stops** with wound contamination control, usually a few days.

✓ **Persistent contaminant:** continuous influx of PMN's and tissue destruction, necrosis, abscess, & systemic infection.

✓ PMNs are **not essential** to wound healing (it means that wound can heal without neutrophils)

3- Macrophages

- **Necessary** for wound healing
- Monocytes (precursor of macrophages) migrate & activate: Macrophages
- Appear when PMNs disappear 24-48 hours
- Do the **same** activities as PMN's

✸ **Plus orchestrate release of:**

1- Enzymes: Collagenase, Elastase
2- PGE (Prostaglandin E)
3- Cytokines (IL-1, TNF-α , IFN)
4- Growth Factors (TGF & PDGF)
5- Fibronectin
(scaffold/anchor for fibroblasts)

✸ **They Activate:**

1- Fibroblasts,
2- Endothelial Cells,
3- Epithelial Cells,
to form **Granulation Tissue**.

- They are the **most essential** cells in the inflammatory phase of wound healing.

2nd : Proliferative Phase (Incremental Phase)

- Regenerative or Reparative Phase.
- **Start at day 3-5** and usually end by the 3rd week.
- **Angiogenesis** (first thing to happen in this phase): endothelial cells activate & degrade basement membrane, migrate, and divide to form more tubules
- **Angiogenesis:** the growth of new capillary blood vessels

✸ **Granulation Tissue is made of** :

1- Capillary Ingrowth
2- Collagen (produced by fibroblast),
3- Macrophages
4- Fibroblasts,
5-Hyaluronic Acid (GAG)

- Increase production of collagen usually type 3
- Old collagen undergoes lysis and new collagen is laid down
- The Proliferative phase depends on **Fibroblasts.**

fibroblast

collagen

Fibroblasts	Collagen	Wound Strength
• Differentiate from the resting mesenchymal cells in connective tissue **3-5 days** migrate from wound edge • **Fibroplasia**: Fibroblasts proliferate replace fibronectin-fibrin (produced by platelets) with collagen contribute ECM.	• Days 1-2 ➛ Mainly **Type III** • Days 3-4 ➛ start Type I • In 3 weeks :Type III **replaced** by Type I • Most common collagen type in **normal skin is type1** followed by type2 and the most common type in wounded (scarred) skin is type 3	• **Week 6 = 60%** original (tensile strength, because of increase in collagen), 80% final strength • **Week 8 to 1 year ≈ 80%** original (Max) • Net Collagen = 6 weeks amount stays the same but continues crosslink increase strength = maturation (there will be change in the ratio of type 3 to type 1 collagen, which will add 20% to 60% = 80%)

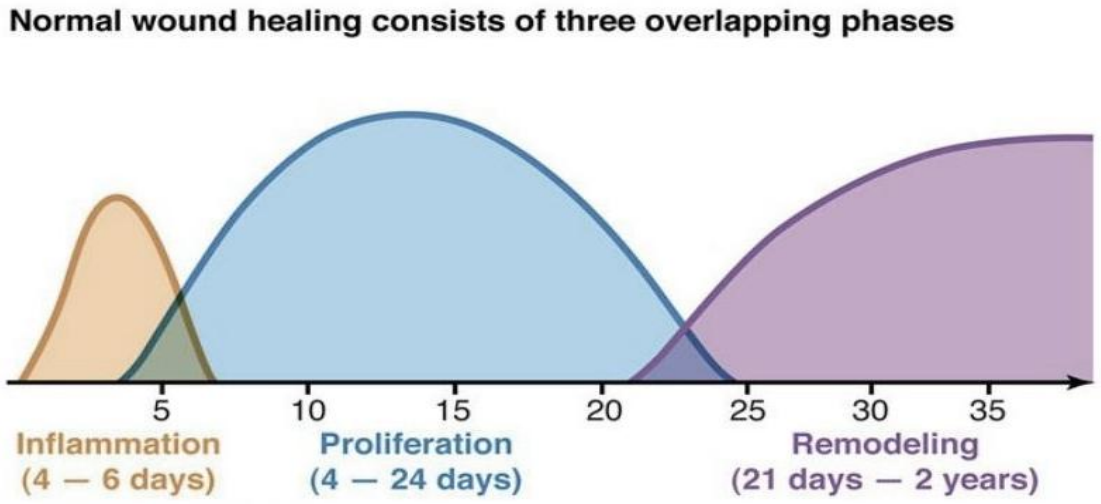
Collagen Type:	
I	• 80% of skin • Most Common: skin, bone, tendon. Primary type in wound healing
II	Cartilage
III	• 20% of skin • Increased Ratio in healing wound, also blood vessels and skin
IV	Basement Membrane
V	Widespread, particularly in the cornea

3rd : Maturational Phase (Plateau Phase)

(organizing the collagen and replacing type 3 collagen with type one)

- **Remodeling Phase. Start within 3 weeks of injury and continue up to +1year**
- **Type I replaces Type III Collagen:** net amount doesn't change after 6 weeks, organization & cross-linking
- Decreased vascularity, less fibroblasts & hyaluronic acid.
- Peripheral **nerves regenerate** at 1mm/day
- Accelerated Wound Healing: reopening results in quicker healing 2nd time around
- **Contraction**(it is a physiological process, the body is trying to decreases the size of the wound): **centripetal movement of the whole thickness of surrounding skin reducing scar** by myofibroblast
- When contraction affect movement, then it become pathological and we call it contracture.

- **Myofibroblasts**: special Fibroblasts express smooth muscle and bundles of actin connected through cellular fibronexus to ECM fibronectin, communicate via gap junctions to pull edges of the wound
- In children, scars take longer to resolve, whereas in the elderly they tend to mature and fade very quickly.



Abnormalities

Contracture

- A minimization for wound's size due to **Myofibroblasts.**
- The physical constriction or **limitation of function** as the result of Contraction (scars across joints, mouth, eyelid)
- **When burn-caused contractions affect the function of a joint it is called** a Contracture
- **Most common sites**: Perineum and Trunk, then Head and neck, then Extremities

Hypertrophic Scar

(happen **under healing tension**)

- **Excess collagen** deposit causing raised scar remains within the original wound confined.
- This is an exaggeration of the normal maturation process, but never continue to worsen **after 6 months.**
- **Darker pigmented skin** & flexor surfaces of upper torso
- Often occurs in **burns or wounds** that take a long time to heal, sometimes preventable.
- Can regress spontaneously (tend to heal with time)
- ✸ **Treatment:** : steroids, silicone, pressure garments
- Can **be treated surgically**.

Keloids

- Excess deposition of collagen causes scar growth **beyond the border** of the Original wound
- These are similar to hypertrophic scars, except that they **continue to enlarge after 6 months** and **invade** neighboring uninvolved skin.
- ✸ **Treatment:** XRT, steroids, silicone sheeting, pressure, excise, often **Refractory to Treatment & but not preventable.**
- Occur in specific areas such as: earlobes and **sternum**
- Common in **black patients**
- They are difficult to treat successfully and, **Surgical** excision make it **worse,** except intralesional excision followed immediately by low-dose radiotherapy is sometimes considered.

Impediments To Wound Healing (Factors Affecting Wound Healing)

- **Bacteria** >105/cm2 (infection is the major adverse factor) : Decreased O2 content, collagen lysis, prolonged inflammation, and delay wound healing
- **Devitalized Tissue & Foreign Body:** Retards Granulation Tissue formation and healing
- **Cytotoxic drugs:** **5FU, MTX, Cyclosporine, FK-506** can impair wound healing. **D Penicillamine- inhibit collagen x-linking**
- **Chemotherapy:** no effect after 14 days (we can't operate before two weeks)
- **Radiation:** Collagen synthesis abnormal, fibrosis of vessel
- **Diabetes:** impedes the **early phase** response
- **Malnourishment:** **Albumin<3.0, Vit-C**
- **Smoking:** vasoconstriction (due to nicotine, which decrease blood supply to wound), atherosclerosis, carboxyhemoglobin, decreased O2 delivery
- **Steroids:** inhibit macrophages, PMNs, Fibroblast collagen synthesis, cytokines, and decreased wound tensile strength
- **Vit A:** (25,000 IU QD) counteracts effect of steroids
- denervation has **no** effect on wound healing
- **Blood supply:** wounds in ischemic tissue heal slowly or not at all. They are prone to infection and frequently break down.
- **Age:** wounds in the elderly may heal poorly because of impaired blood supply, poor nutritional status or intercurrent disease. However, as mentioned above, they tend to form 'good' scars.
- **Nutritional status:** malnutrition has to be severe before healing is affected. Protein availability is most important, and infection are common when the serum albumin is low.

Diseases Associated With Abnormal Wound Healing

- **Osteogenesis Imperfecta:** Type I Collagen defect
- **Ehler-Danlos Syndrome:** Collagen disorder, 10 types
- **Marfan Syndrome:** fibrillin defect (collagen)
- **Epidermolysis Bullosa:** Excess fibroblasts .. Treatment: phenytoin
- **Scurvy:** Vit C required for proline hydroxylation

Wound Infection

Headlines starting from here and the upcoming slides, were not covered in the lecture but required from dr. Adnan's objectives.

Surgical procedures can be classified according to the likelihood of contamination and wound infection to:

1) Clean Procedures:

are those in which **wound contamination should not occur**.

- **Example:** An incision for a clean elective procedure.
- In **clean operations**, the wound infection rate should be **less than 1%.**

2) Clean-contaminated Procedures:

are those in which no frank focus of infection is encountered but where a significant risk of infection is nevertheless present, perhaps because of the **opening of a viscus, such as the colon.**

- Infection rates in excess **of 5%** may suggest a breakdown in ward and operating theatre routine.

3) Contaminated Or 'Dirty' Wounds:

are those in which gross contamination is inevitable and the **risk of wound infection is high.**

- **Example: emergency surgery** for perforated diverticular disease, or drainage of a subphrenic abscess.

(Antibiotic prophylaxis is appropriate for the first two types of operation. Dirty wounds require therapeutic antibiotics.)

Involvement Of Other Structures

- Some wound may conceal extensive damage to deeper structures such as body cavities, tendons, nerves or blood vessels.
- **Damage To Muscles, Tendons Or Nerves**: assessed by checking relevant **motor and sensory function**.
- **If the injury involves a limb,** the distal circulation must be checked.
- **To Check for injury to peritoneal, pericardial or pleural cavities & underlying bony injury: X-rays**

Devitalized Skin Flaps

- In some cases, the flap is **blue-black** in color and obviously **non-viable**, but in most cases viability is uncertain.
- The wound must be **cleansed** and non-viable tissue excised.
- **No attempt** should be made to **suture** the flap back into place (because of the post-traumatic edema)

Crushing/Degloving Injuries And Gunshot Wounds

Wounds of this type should **never be closed** primarily due to the extensive tissue destruction. After thorough irrigation and the removal of any obviously dead tissue and foreign material, such wounds should be lightly packed and dressed.

Wounds With Skin Loss

- A small skin defect at a functionally or aesthetically **unimportant** site may be allowed to heal by **secondary intention.**
- However, it is often better to speed healing by importing skin to close the wound by means of a skin graft, which requires a vascular bed as it **has no blood supply of its own,** or a flap.

Skin Grafts: 2 types:

1) **Split-thickness Skin Graft (STSG):** is a skin graft including the epidermis and part of the dermis. It can be processed through a skin **mesher** which makes apertures onto the graft, allowing it to expand up to **nine times its size**.
2) **Full-thickness Graft:** leaves a donor defect (which needs to be sutured or grafted) as large as the one to be filled and **requires a well-vascularized bed to survive.**

- They are strong, do not shrink, and look better than a split-skin graft.
- They are commonly used in reconstructive surgery: on the lower eyelid (where a good functional and/or cosmetic result is important).

Flaps

- Flaps **bring their own blood supply** to the new site.
- They are thicker and stronger than grafts and **can be applied to avascular areas** such as exposed bone, tendon or joints. **Flaps can be divided into:**
    1. **Local Flaps:** The simplest flaps, uses **local skin** and fat.
    2. **Distant Flap:** A flap may have to be brought from a distance and remain attached temporarily to its original blood supply until it has picked up a new one locally. This usually takes 2–3 weeks.

Summary

Burns

- **First degree burns:** result in erythematous skin
- **Second degree burns:** classified into
  - Superficial : where epidermis and superficial dermis are affected, blisters are

typically present

  - Deep : where Epidermis +most of dermis are affected with thicker blisters.
- **Third degree burns:** all the layers are affected, Escher is typically present with needed of surgical intervention

What to do in the ER:

ABCDEF : Airway, Breathing & ventilation, Circulation, Disability(neurological status), Environmental control(keep warm), Fluid resuscitation.

2. Take detailed history
3. IV access
4. Blood test
5. Allergy (mainly to sulfa because Flamazine contains it)
6. Quick general exam
7. Estimate the percentage and depth of the burn.

Wound Healing

- **Contraction** i**z**process to reduce the size of the wound, while

contracture is a pathological process which affect function of the joint.

- **Hypertrophic scar** is an excess collagen deposit causing raised scar which

Remains within the original wound, while **keloid** causes scar growth beyond the border of the original wound.

Thank You..

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