MED437
KING SAUD UNIVERSITY

SURGERY TEAM 437

Burn Injury & Wound Healing

Objectives:

1. To know basic principles about wounds.
2. Classification of wounds
3. Classes of operative wounds.
4. Factors affecting wound healing
5. Phases of wound healing
6. Collagen types
7. Scars and pressure sores
8. Burns

Team leaders: Alanoud Almansour, Ghaida Al Musma , Moath Alhamoud and Mohammed Alqwaifli

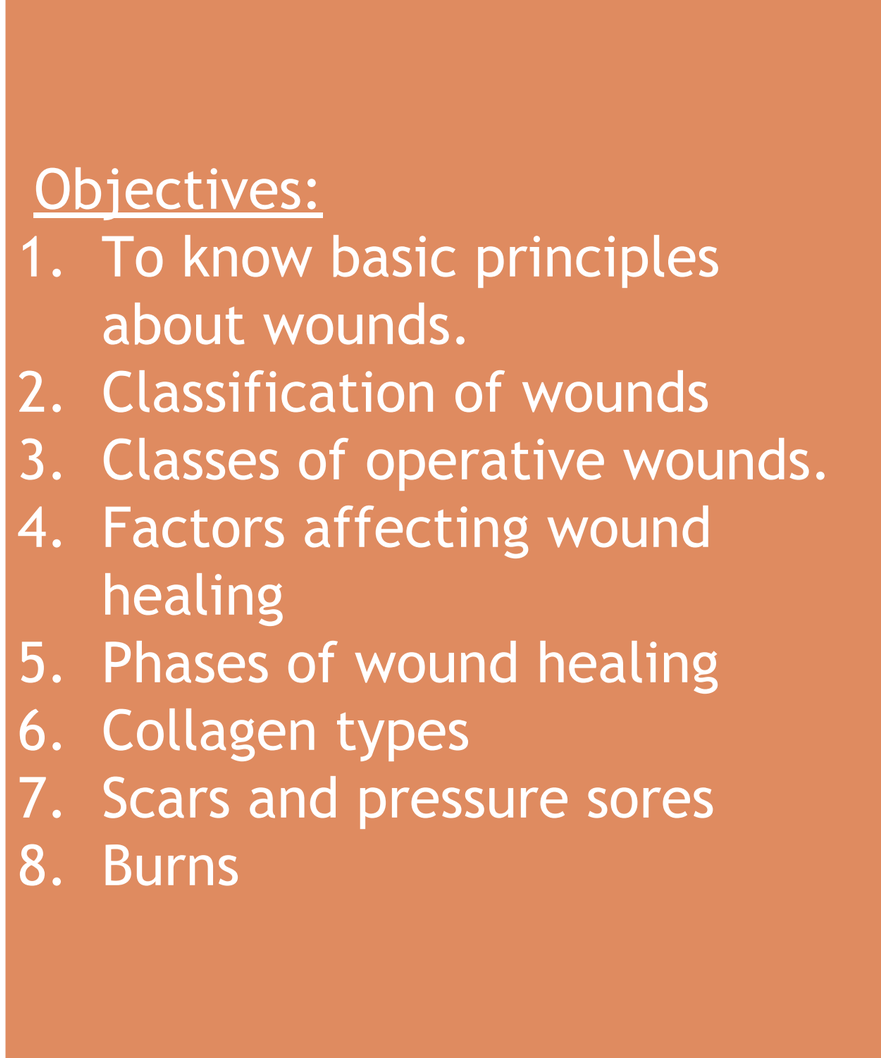
Done by: Alanoud Alessa, Ghaida Alsanad, Mohammed Alasqah and Mohammed Nouri

Revised by: Yazeed Al-Dossare

Color Index:

- Important
- Doctor's Notes
- Extra
- Davidson's

Editing File / Feedback



Wounds, Scars & Wound Healing

We highly advise you to watch this video before studying this part of the lecture!

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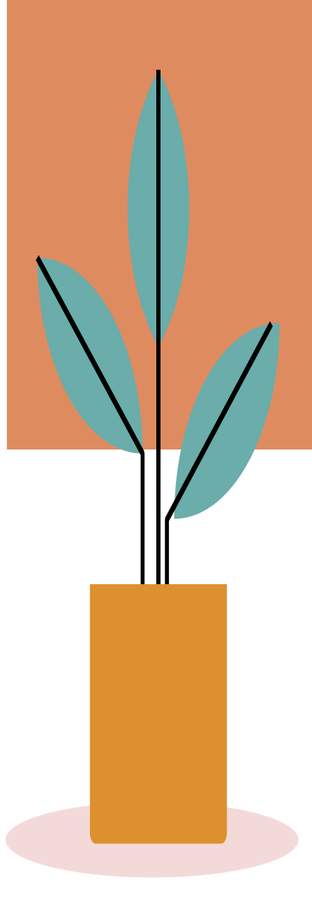
Wound:

- Is a disruption of normal anatomical structure, function and relations as a result of intentional or unintentional injuries.
- Classified as Acute vs. Chronic.
- Wound healing main goal is restoration of integrity and continuity of injured tissue to reestablish homeostasis of that tissue and stabilize the entire organism's physiology.
- Wound healing requires the coordinated completion of a variety of cellular activities including phagocytosis, chemotaxis, mitogenesis, synthesis of collagen and extracellular matrix components.
- During a wound healing process there are very different cellular activities that happen, the end result of the process is synthesis of collagen.
- The vancouver scale is used to evaluate the scars

Classification of Healing

Type	1. Primary a. proximation of the edges and migrations of cells from edge to edge (horizontal) 2. Delayed primary (rarely used) a. Wait for 2-4 days then we proximate by primary healing 3. Secondary a. Horizontal contraction by myofibroblast and epithelization. 4. Partial thickness wound healing. a. No contraction, only vertical epithelization happens.
Timing	1. Acute (less than one week) 2. Sub Acute (1-6 weeks) 3. Chronic (more than 6 weeks)
Abnormal Healing	1. Overgrowth (Hypertrophic vs. Keloid). 2. Undergrowth (chronic unstable wounds; like diabetic wounds) 3. Abnormal pigmentation. 4. Contour abnormality.



Classification of Wound Closure

Primary healing (1st intention)	- Primary closure. - Within hours of repairing full thickness surgical incision. (As soon as you suture the wound). - Result in mortality of minimal number of cellular constituents. - Usually there's 2 edges and you suture these edges approximate them.
Secondary healing (2nd intention)	- Wound left open to heal by processes of granulation contraction and epithelialization. - Results in more intense inflammatory response. - Larger quantity of granulation tissue with pronounced contraction of wounds. - You keep the wound open (for example you do dressing and wound care but no suturing) and it heals by itself by contraction of myosin and actin, as well as epithelialization of dermis and epidermis, and it usually takes longer than primary healing.
Tertiary healing (3rd intention)	- Delayed primary closure. - Desired for contaminated wounds. - Phagocytosis of contaminated tissues well underway by 4th day Foreign materials walled off by macrophages. - when the wound is dirty you should clean it, wait for about 3 days and then re-approximate it by suturing (like primary healing).

Epithelial repair

Epithelial continuity is re-established across a wound :

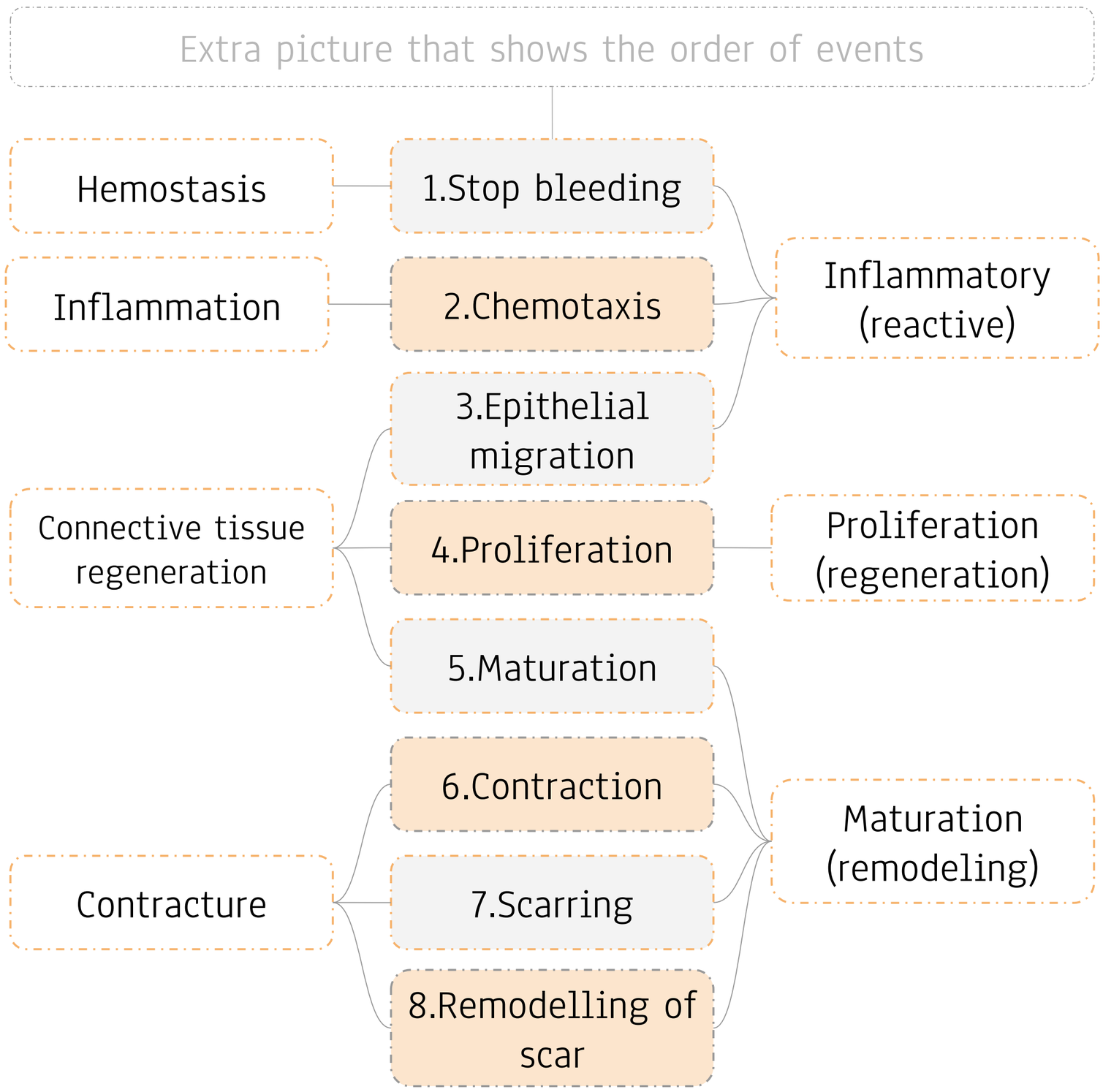
1. Mobilization

2. Migration: Stimulus is loss of contact inhibition (if the cells reach the edges together they stop migration and mitosis start)

3. Mitosis

4. Cellular differentiation

Summary: during wound healing, multiple events happen so for example you have two edges; the cells mobilize (migrates to the middle) and gets in proximity then duplicate by mitosis and differentiate to different cells.



Phases of Wound Healing :

1. Hemostasis.
5-10 min

2. Inflammatory-Migratory (lag) Phase.
1-4 days

3. Proliferative (fibroplasia) phase.
3 days to 3 weeks

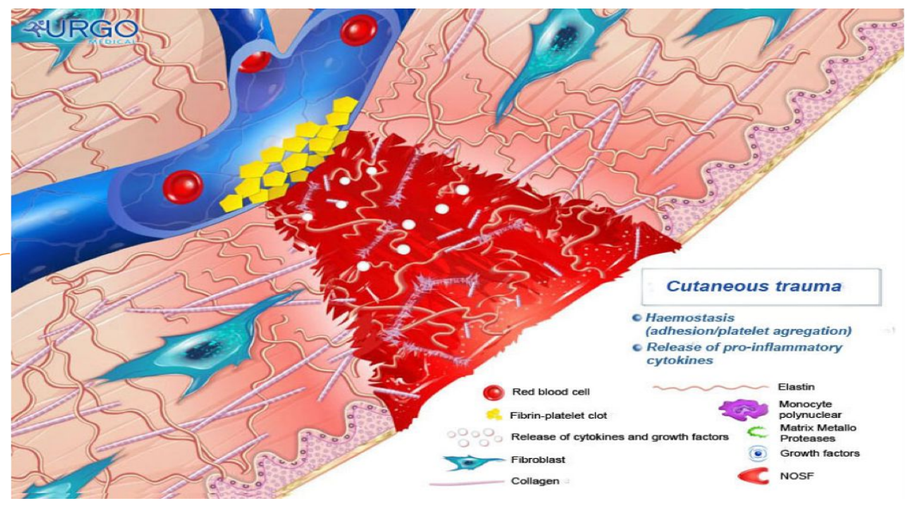
4. Maturational-Remodeling (plateau) phase.
3 weeks to 1 year

Phases of Wound Healing

Hemostasis

- Usually considered part of the inflammatory phase in some resources.
- Takes 5-10 minutes.
- Initial response to injury = constriction.
- Platelet plug forms after adherence to exposed subendothelial collagen via vWF.
- Platelets degranulate releasing: ADP, Thromboxane A2, Bradykinin, and 5-HT lead to Further Vasoconstriction and platelet aggregation.
- **Platelets stimulated to release:**
  - ★ **Platelet derived growth factor (PDGF):** Made by macrophages, endothelial cells, fibroblasts (Chemotaxis and Fibroblast stimulation).
  - ★ **Transferring growth factor beta (TGF B):** Made by macrophages, platelets, fibroblasts a.Fibrinogenesis, angiogenesis, chemotaxis, immune suppression.
  - ★ **Fibroblast growth factor:** Made by macrophages and endothelial cells (Angiogenesis and chemotaxis).

- Form platelet plug.
- Degranulation of platelets (release of cytokines and growth factors).
- Activation and recruitment of neutrophils.



Inflammatory-Migratory (lag) phase:

- Typically starts immediately after hemostasis and takes 1-4 days, main cells are macrophages.
- Aim:to stop bleeding.
- Initial intense local vasoconstriction of arterioles and capillaries followed by vasodilation and vascular permeability.
- Clinically represented by:

1. Rubor (Redness)

a) Caused by vasodilation. **b)** Primarily result of prostacyclin (PGL2) and histamine, also caused by prostaglandin A,D and E (PGA, PDD, PGE).

2. Tumour (Swelling)

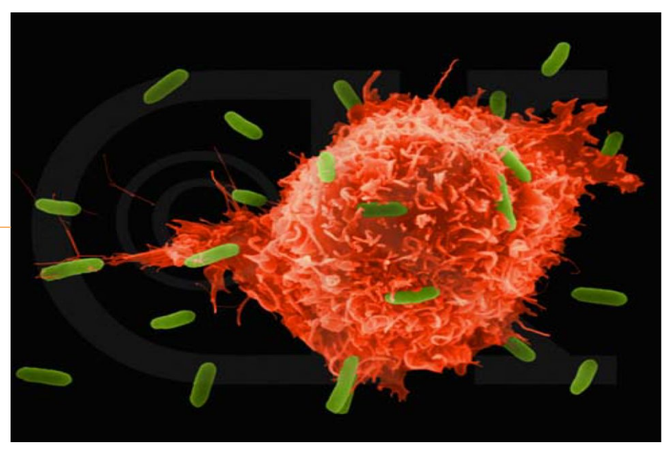
a) Caused by leakage of plasma proteins through gaps in vascular endothelium. **b)** Edema potentiated by PGE2, Prostaglandin F2 alpha, (PGF2 alpha).

3. Calour (Heat): Increased local temperature secondary to both increased blood flow and elevated metabolic rates.

4. Dolour (Pain)

Macrophages:

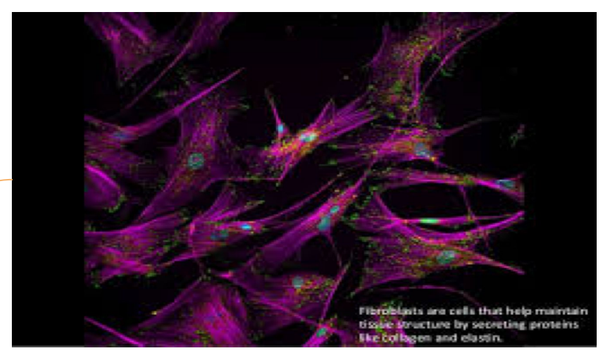
- Phagocytosis.
- Activation of fibroblast.
- Angiogenesis.
- Matrix synthesis (granulation tissue formation) regulation.



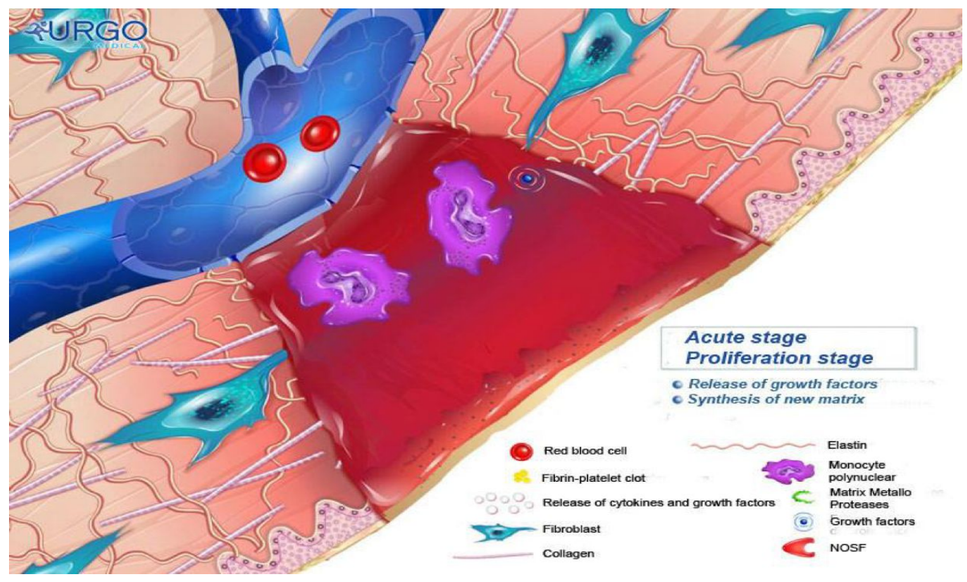
Phases of Wound Healing

Proliferative (fibroplasia) phase

- Aim: to start healing.
- Regenerative or Reparative.
- Begins 2-3 days after wounding and last for 3 weeks (The Proliferative phase depends on Fibroblasts).
- Signalled by arrival of fibroblasts(main cells):
  - ★ Driven by macrophage-derived bFGF, TGF beta, PDGF to proliferate and synthesize glycosaminoglycans (GAGs) and proteoglycans (building blocks of new extracellular matrix of granulation tissue and collagen).
  - ★ Also produce bFGF, TGF beta, PDGF, Keratinocyte growth factor, insulin-like growth factors-1.
  - ★ Dominant cell type peaking at 7-14 days.
- Collagen synthesis (Net production for next 3-6 weeks).
- Elevated (Keratinocyte mitosis, number of endothelial cells, Angiogenesis "From vessels at wound margins").
- Lasts 2-4 weeks depending on site and size of wound with slowing of fibroblast migration and proliferation.
- Starting a chemotherapy after surgical resection of a tumor and wound healing needs to be minimum after 14 days.
- Different cells differentiate into different types and new blood vessels are formed (angiogenesis).

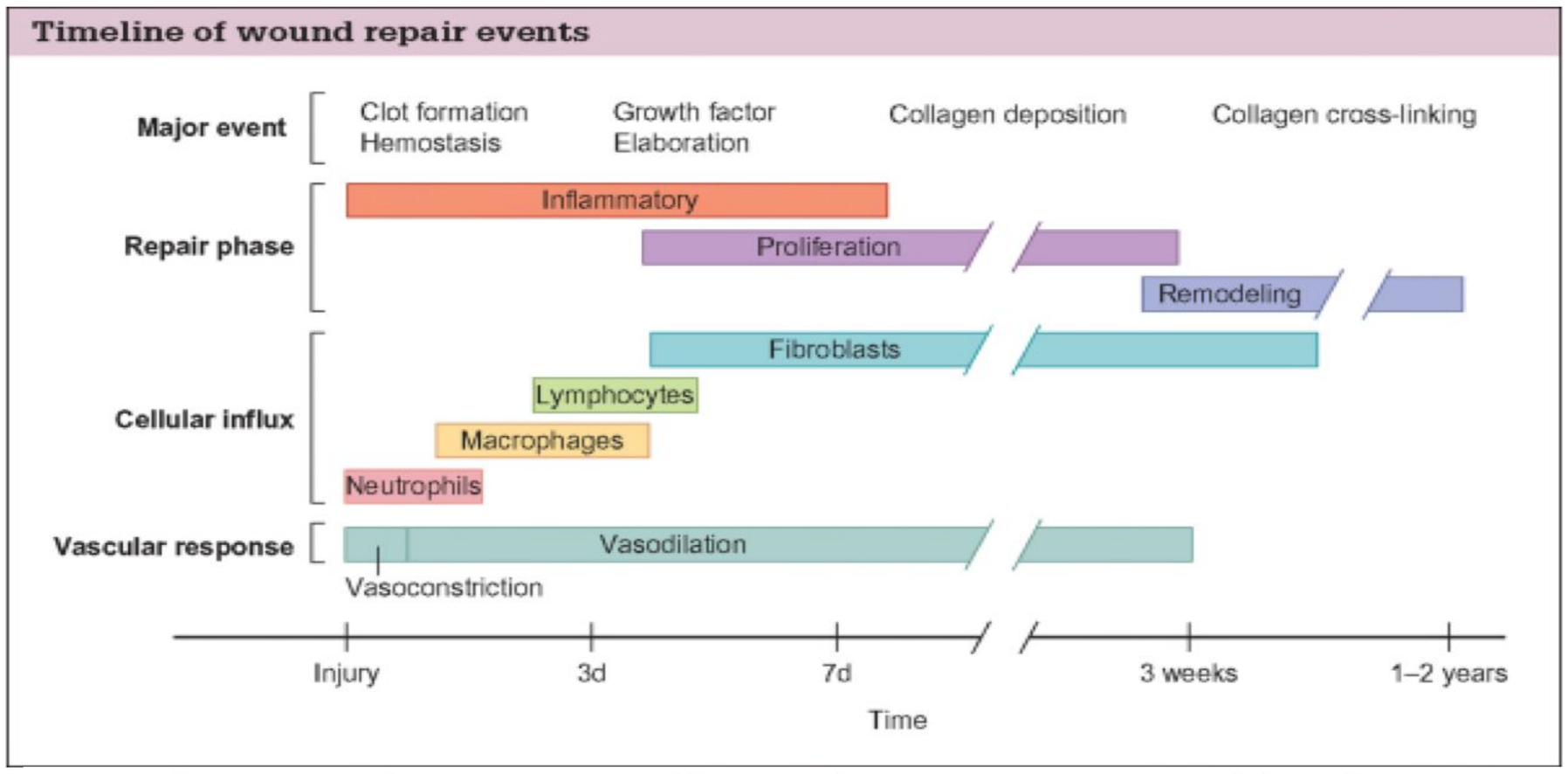


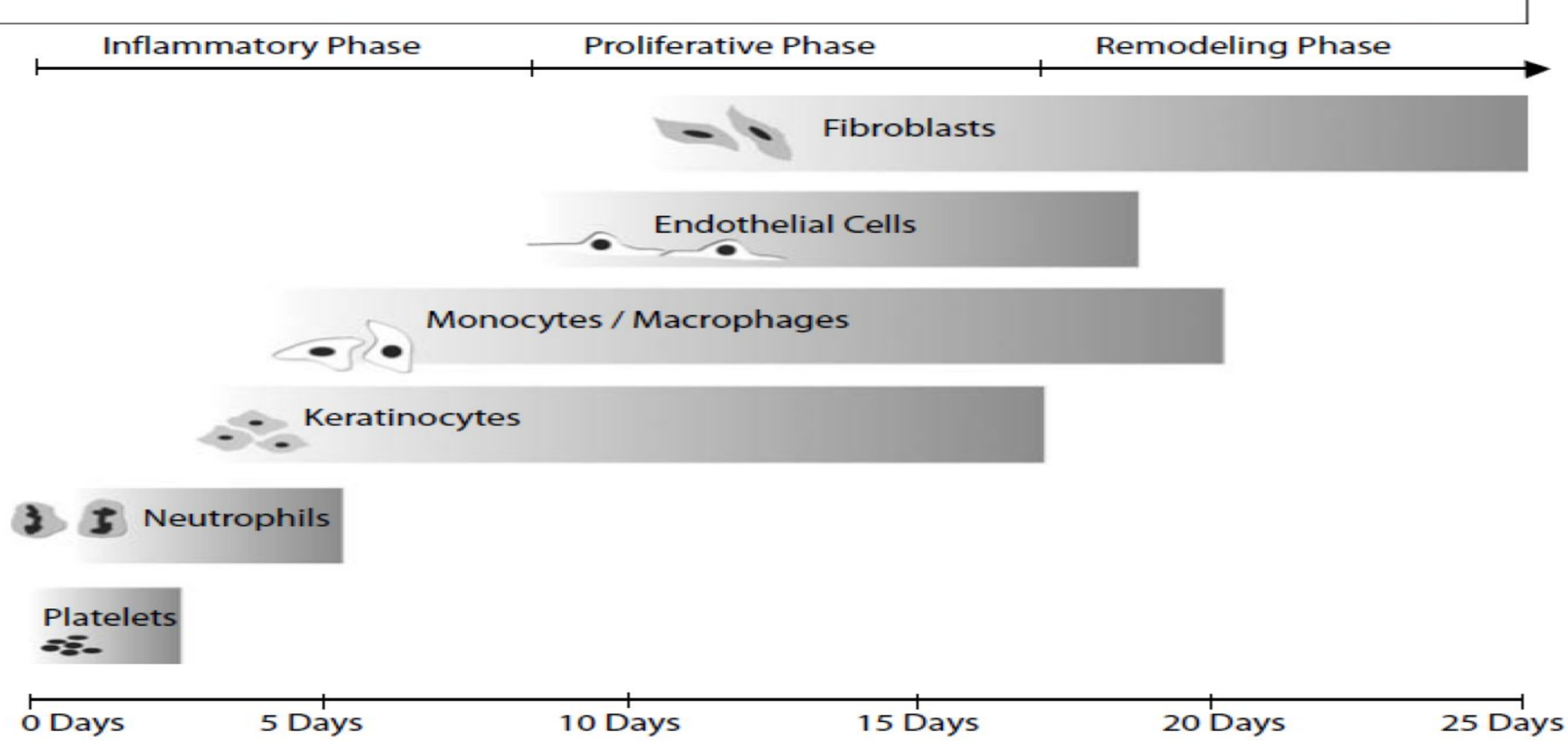
Fibroblast:
Use to synthesize collagen & elastin.



Maturational - Remodeling (plateau) phase

- Aim: to increase strength.
- Type III collagen replaced by type I collagen.
- Start at 3 weeks after the injury until 1 year.
- Collagen synthesis and degradation are accelerated but in equilibrium with collagen breakdown (no net increase in collagen content).
- Collagen deposition peaks by 3rd week.
- Large capillaries growing into wound regress/disappear.
- Indurated, raised, pruritic scar becomes mature scar.
- Collagen fibers become organized.
- Re-established normal 4:1 ratio (I:III) : Duration depends on age, genetics, type of wound, location (1-2 years). Type three collagen is the main collagen present in the wound healing process. for example in abnormal wound healing (such as in hypertrophic scars and keloids) we have a higher ratio that could reach up to 1:30 so you'll have high collagen type 3 compared to the normal ratio,and you'll have abnormal scarring.
- Tensile strength increases to 80% of pre injured skin. Depends on the site of injury, for example for tendons it reaches up to 60-80% maximum, but for normal wounds it usually reaches 100%.

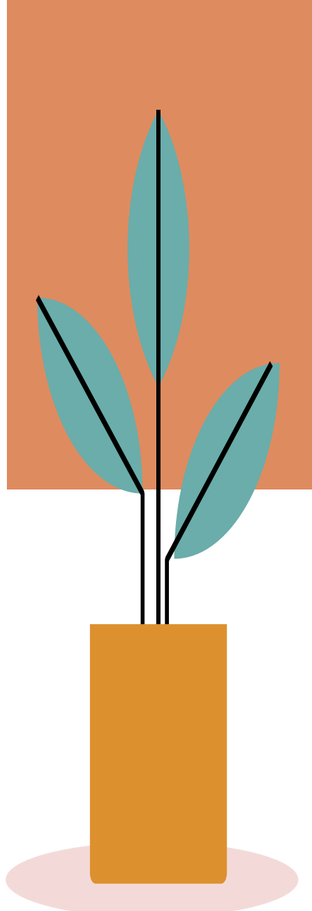




Factors Affecting Wound Healing

Important in taking history bc wounds will never heal if any of those factors are distributed

General (patient)	- Nutrition (patients with pressure sore are usually malnourished so the wound healing would be delayed in such patients). - Smoking (reduces oxygen delivery). - Drugs (e.g. penicillin or steroids) - Toxins (chemotherapy) - Vascular diseases - Obesity - Age (elderly patients more prone to have chronic wounds) - DM - Systemic & Inherited diseases. - Idiopathic
Local (wound)	- Reduction of delivery of Oxygen (in smokers) - Cancer patients who receive chemo and radiotherapy (because they lead to fibrosis of the skin as well as stenosis of the arteries). - Infection. - Acidity - Radiation (fibrosis) - Loss of growth factors. - Denervation (in diabetic patients) - Iatrogenic - Edema - Foreign body



Collagen

★ Left handed helix involving 3 polypeptides.
★ Most abundant family of proteins in the human body (30%).

Types of collagen: there are nearly 23 types of collagen but you only need to know the first 5 types:

Type I (80% skin):
Most Common major structural component in skin, bones, tendons & muscles.

Type II:
Found predominantly in cartilage.

Type III (20 % skin):
found in association with type 1 in varying ratios depending on the type and maturity of tissue (predominant type in granulation tissue) increased ratio in healing wound, also blood vessels & skin.
(associated with healing)
Can also be found in newborns

Type IV:
Basement membrane of arteries, nerves, & tendons

Type V:
Widespread, particularly in the cornea.

- The most common collagen type in normal woundless skin is type 1 followed by type 2).
- The most common type in wounded (scarred) skin is type 3 specially in proliferative phase.

★ Wound Strength is 80% of original after remodelling (healing)
  - For example if a patient has a tendon injury, the strength of the tendon will only reach up to 80% after complete healing not a 100%
★ Lysine and proline hydroxylation are required for cross-linkage.
  - Biochemistry: collagen synthesis events: procollagen gets converted to collagen by proline and lysine hydroxylation (essential component to have complete collagen synthesis).
★ Differs in relative composition of hydroxylysine and hydroxyproline and cross-binding.
  - Type 1 90% of collagen in body.
  - Normal skin ratio – Type I/Type III – 4:1.
  - hypertrophic / immature scar 2:1 ratio.
★ Formation inhibited by : they activate collagenase which degrades collagen synthesis and inhibits cross linkage hydroxylation of lysine and proline.
  1. Colchicine.
  2. Penicillamine.
  3. Steroids.
  4. Vitamin C deficiency as it has a role in the hydroxylation process.
  5. Fe deficiency.

Types of Surgical Wounds

Why is it important to know these things? to know if you need to cover the patient with antibiotics or not.

Clean	- Non traumatic, non infected wounds & no breach of respiratory, GI, or GU tract. - No spillage of the content of the tract itself - E.g. thyroid and breast surgery). - No need for antibiotics
Clean-contaminated	- Small breach in protocol; respiratory, GI, or GU tract are entered with minimal contamination. - Very minor spillage of the content - E.g. cholecystectomy, uncomplicated appendicitis, intestinal resection ONLY if there was no spillage
Contaminated	- Fresh traumatic wounds; major break in sterile technique, nonpurulent inflammation in or near contaminated skin. - Major spillage - E.g. hemicolectomy or resection of the intestine with spillage
Infected	- Purulent infection. - Traumatic & severe wounds - E.g. open bone fractures, purulent pyogenic perforated appendicitis - (usually covered with triple dose of antibiotics) - Not closing the wound or not well drained wounds creates a suitable environment for infections.

Acute Wound Management:

- ★ Cleansing
- ★ Exploration of diagnosis
- ★ Debridement
- ★ Tetanus immunization status
- ★ Replacement of lost tissue where indicated
- ★ Skin cover if required
- ★ Dressing
- ★ Skin closure without tension

Extra image recommended by the doctor

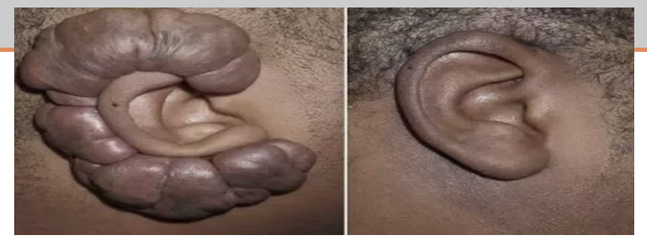
Table 2. Wound management, tetanus prevention and passive immunity administration

Vaccination status	Clean, minor wounds including infection-related ones	All other wounds including infection-related ones
Unknown or <3 doses of TT-containing vaccine	TT and recommend catch-up vaccination	TT and recommend catch-up vaccination: TIG <5 years 75 IU, 5 - 10 years 125 IU, >10 years 250 IU
≥3 doses of TT-containing vaccine and <5 years since last dose	No indication	No indication
≥3 doses of TT-containing vaccine and >5 years since last dose	TT recommended	TT recommended

TT = tetanus toxoid; TIG = tetanus immunoglobulin.

You first clean the wound then check for tetanus then take history then check the diagnosis then debritment if needed ..etc (in case of a neck wound, take the pt to the operating room immediately. Fear of vessels injuries)

Abnormal Scars (Important!)

Features	Hypertrophic Scar	Keloid Scar
		
Genetic	Not familial	May be familial
Race	Not race related	Black > white
Sex	Female = male	Female > male
Age	Children	10-30 years E.g. an african 20 year old female.
Borders	Remain within wound (the boundaries of the scar)	Outgrow wound area (go beyond the scar)
Natural history	Subsides with time	Rarely subsides
Site	Flexor surface	Sternum, shoulder, face
Etiology	Related to tension	Unknown

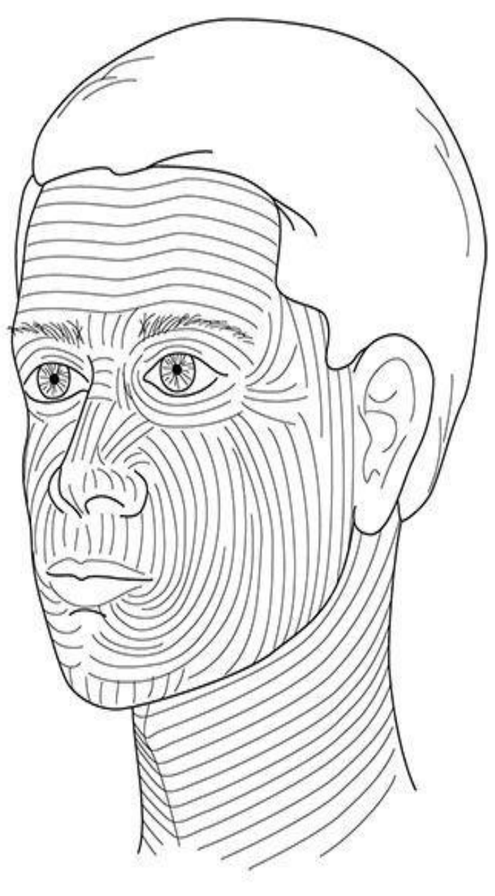
Wide Scars

Wide scars: traumatic wounds that are not closed properly

Ideal Scar

- ★ Flat & narrow.
- ★ Good color & contour match to surrounding skin.
- ★ Parallel to or within resting skin tension lines (RSTL).
  - RSTL are perpendicular with the muscles
  - It's the area we want to create a scar at b/c it decreases the tension thus less visible scar & decrease the risk of hypertrophic scar
- ★ Pliable
- ★ Doesn't restrict function or distort normal anatomy.
- ★ Matures within 6-18 months.
- ★ Asymptomatic (not painful)

RSTL



Treatment of Hypertrophic Scars

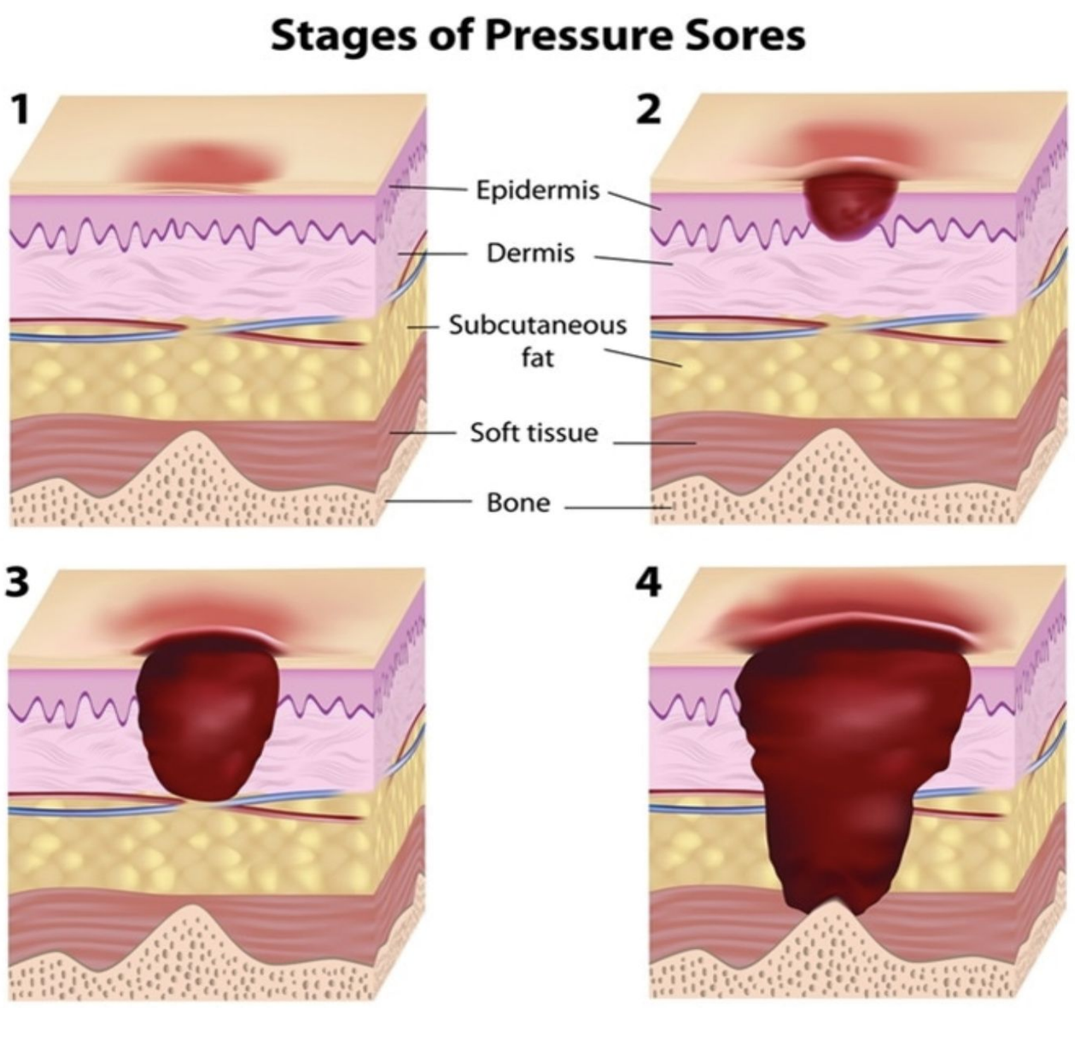
- ★ Best thing is **prevention** of HTS, by avoiding tension in creating a scar parallel to the RSTL, minimal undermining (raising the skin and going underneath it), minimal electrocauter (leads to seroma formation → hight tension) closing layer, no strangulation (put spaces between each suture).
- ★ Pressure (by compression garments).
- ★ Silicone.
- ★ Prevention.
- ★ 5-FU (Fluorouracil) (chemotherapy).
- ★ Intra-lesion Steroids (first line in treatment)
- ★ Radiation.
- ★ Laser.
- ★ Surgery.
- ★ The best treatment for keloids scars is a combination of surgery, intralesional steroids and radiation therapy.
- ★ You may ask how does radiation and chemotherapy heal HTS while it leads to reduced wound healing? the unit of given radiation therapy is the guide, so patients that receive radiation therapy for cancer receive compared to HTS which receive minimal doses, the second thing is that HTS has abnormal collagen synthesis (high turnover of collagen) and radiation stops this by leading to fibrosis and less formation of collagen.
- ★ There's still a 10-9-% risk of recurrence even after treatment


Intra-lesion steroid

Silicone


Pressure garments

AKA Ulcer, bed sores

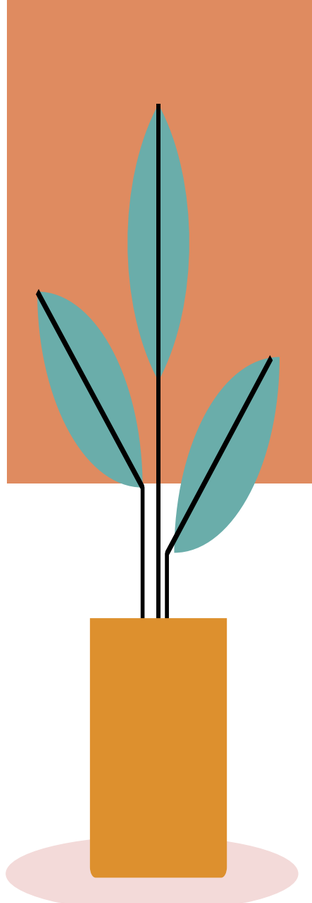


Stage 1: developed if the person doesn't move while sleeping for 2 hours (bed sore): mainly involved the **epidemics** and produces **erythema**, avoided by changing the position every 30 min.
Stage 2: involved **epidermis and dermis.**
Stage 3: deep dermis up to the subcutaneous tissue
Stage 4: up to the fascia and can reach to the muscle, tendons and bones and they usually develop osteomyelitis.
Stage X: When there's a necrosis in top of the ulcer → can't determine the depth

vancouver scar scale

Not important

	Feature	Score
Vascularity	Normal	0
	Pink	1
	Red	2
	Purple	3
Pigmentation	Normal	0
	Hypo-pigmentation	1
	Mixed-pigmentation	2
	Hyper-pigmentation	3
Pliability (Elasticity)	Normal	0
	Supple (flexible with minimal resistance)	1
	Yielding (giving way to pressure)	2
	Firm (inflexible, not easily moved, resistant to manual pressure)	3
	Banding (rope-like tissue that blanches with extension of the scar)	4
	Contracture (permanent shortening of scar, producing deformity or distortion)	5
Height	Flat	0
	< 2 mm	1
	2-5 mm	2
	> 5 mm	3
Pain	None	0
	Occasional	1
	Requires medication	2
Itchiness	None	0
	Occasional	1
	Requires medication	2



Burns & Burn Management

Definition:

- **Burns:** are thermal, chemical or electrical injury sufficient enough to cause tissue disruption, denaturation, or even death.
- Carry the risk of permanent: disfunction or impairment of function

Epidemiology:

- Males > females
- 2 peaks at:
  - 0-5 years and 25-35 years
  - 80% of burns are less than 20% TBSA
- Pediatrics:
  - Scald burns >80%
  - Account for 45% of hospital admission
  - 33% due to **child abuse**
- Elderly:
  - Impaired mobility, poor coordination, decrease awareness to pain
  - Abuse/neglect
- Factors that increase mortality each factor increases mortality for about 30% (3 factors→90% chance of mortality)
  1. Age greater than 60
  2. Greater than 40% TBSA (total body surface area)
  3. Inhalation injury
- Alcohol is a common contributing factor

Types of burns:

- Scalds (Hot liquid) → Most common type in children
- Flame (Thermal) → Most common type in adults
- Chemical
- Flash
- Electrical
- contact
- Frictional (in traffic accidents)

Pathophysiology:

★ Increased fluid loss from the surface.
  - Normally 15 ml/m^2 increase to 200 ml/m^2.

★ In deep burns, the dermis is converted to coagulum called ESCHAR.

★ Inflammatory response ranges from:
  - Capillary dilation in sunburns.
  - To damaged capillaries and increase permeability and interstitial edema.

★ 2 cm increase in leg diameter represent 2L of increase in fluid.

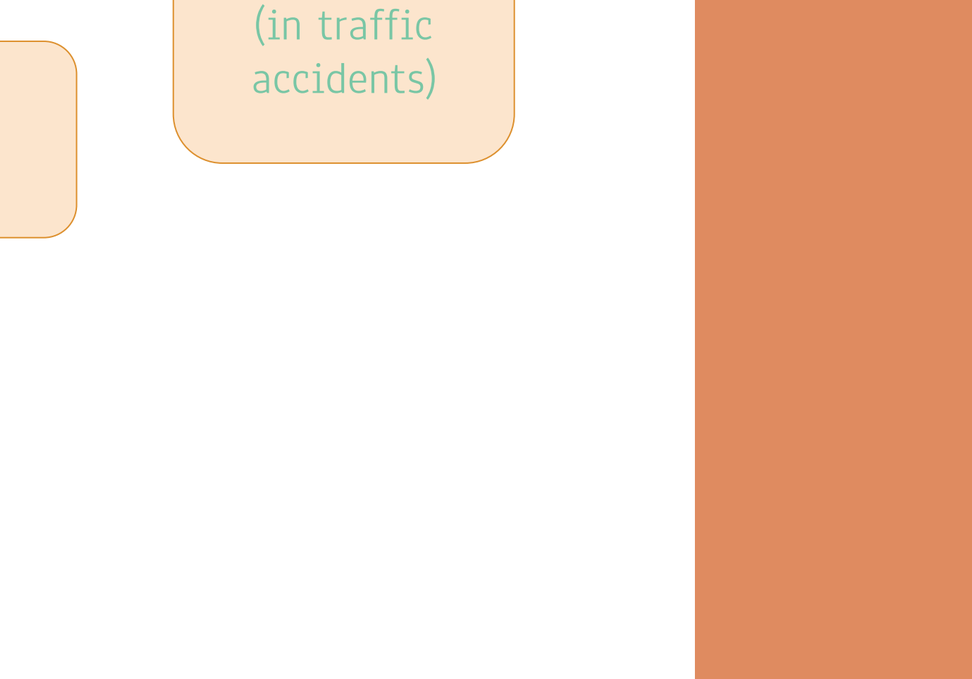
★ Destruction of epidermis removes the protective bacterial barrier → contamination → sepsis → death.

There's 3 zones called Jacksonian zones:

- Zone of coagulation
- Zone of stasis
- Zone of hyperemia

- **Coagulation:** loss of oxygen and proteins (dead necrotic tissue)
- **Stasis:** most important zone: why is this important? because it is the key for fluid resuscitation, in which we give fluids to turn into the normal hyperemia zone.
- **Hyperaemia**: there's still viable normal cells

So we need to transfer the injury **from coagulation to hyperaemia**



General Effect of Burns

- The effect of the burn depends on the size.
- The bigger the burn the more the physiological changes:
  - Water, salt, & protein loss with daily wait loss of 0.5 kg.
  - Increased catabolism & hematocrit
  - Edema due to fall in circulating plasma & hypovolemic shock.
  - Damage to RBC's: immediate or delayed.
  - Increase metabolic rate: 7000 Kcal expended daily.

We highly advise you to watch this video before studying this part of the lecture!

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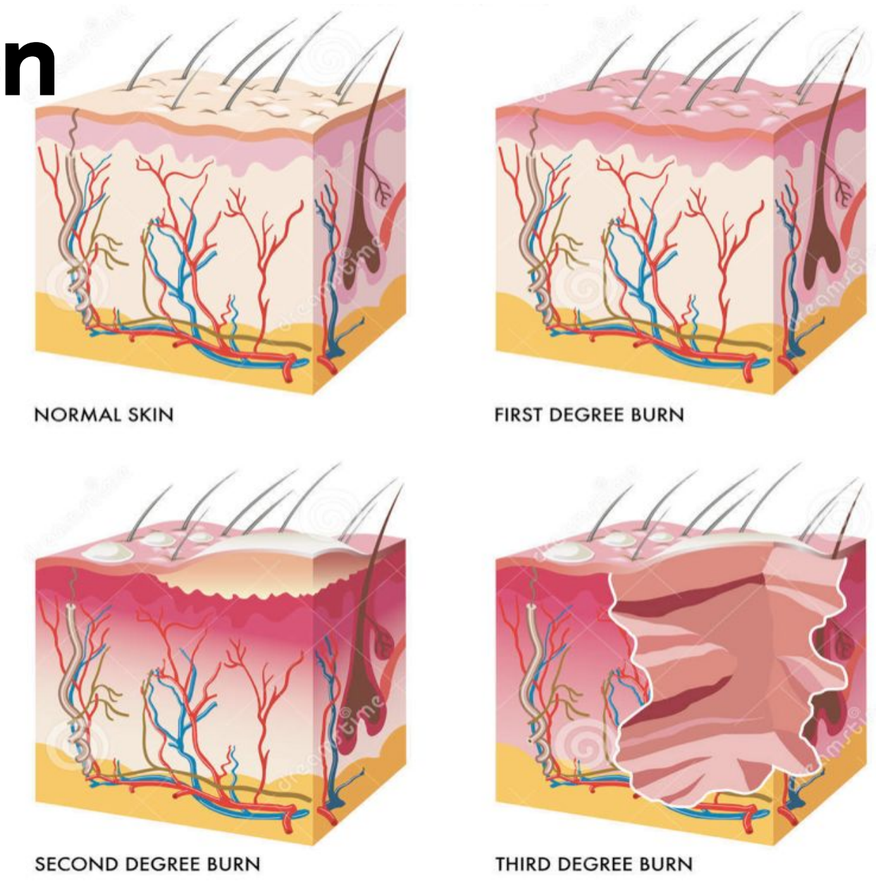
Mortality

- In the **early** post burn period:
  a. Inadequate (resuscitation) hydration.
  b. Respiratory issue (inhalation or infection).
- In the **late** post burn period:
  a. Wound sepsis.
  b. Delayed healing.
  c. Increased energy expenditure.

Burn Classification

1. By Degree/ Thickness:

Old	- 1st degree burn - 2nd degree burn - 3rd degree burn - 4th degree burn
New	- Superficial burn (1st degree) - Superficial partial thickness (2nd degree) - Deep partial thickness (2nd degree) - Full thickness (3rd & 4th degrees)

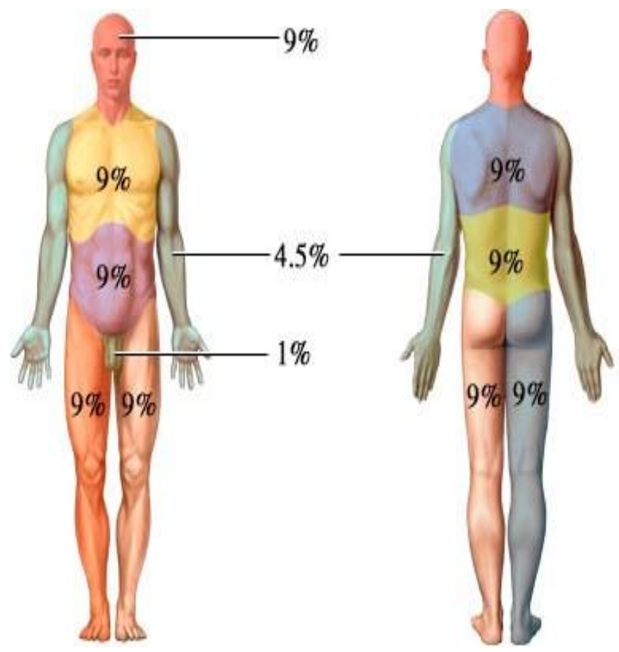


Superficial (1st degree)	Superficial Partial thickness (2nd degree):	Deep Partial thickness (2nd degree):	Full thickness (3rd degree)	Full thickness (4th degree)
- Damage to the **epidermis** only - No need for admission - Heal within 5 – 7 days - No scarring - No need for treatment - Needs only analgesics and hydration - e.g. tanning	- **Epidermis and upper dermis** - Pink, painful and swollen - Fluid loss - Blisters - Heal within 2 weeks - From epidermal appendages - Requires daily dressing - Minimal scarring - You don't need to treat it by debridement	- **Epidermis and most of the dermis** - Treat like 3rd degree burn - Less or not painful - Less sensation - Rarely blister - Prolonged inflammatory phase cause scarring - Leaves an ugly hypertrophic scars needs debridement & skin grafting - Heals in 3-10 weeks	- **Epidermis and total dermis including the epidermal appendages** - Destroyed tissue undergoes coagulative necrosis - Not painful - No blisters - Marble or leathery like appearance - Thrombosed veins - Cause significant scarring due to inward growing and movement of the cells - Needs debridement and skin grafting	- Injury extends to the underlying structures; **muscle, fascia & bone.** - Charring of the tissue. This type definitely needs debridement, if you don't treat it > HTS and contractions

Calculation of Total Body Surface Area:

a. Wallace rule of nines.
   (Anterior and posterior separately)
   E.g. The whole right arm = 9% (4.5 anteriorly and 4.5 posteriorly).
b. The rule of palm: used for fast evaluation (emergency) otherwise we use the rule of 9.
c. Patients palm (each palm) is equal to 1 % of their TBSA: Good for scattered burns.
d. Lund browder chart (for paediatrics).
   i. Bc they lose fluid more commonly

Wallace rule of nines



Determination of Burn Depth:

Mechanism	Appearance	Sensation	Time to heal
Scald: short vs long Flame, chemical or electrical	Erythema, blister, eschar & thrombosed veins		It's important to wait for 5 days (3 to 7 days) before determining the extent of the thickness, because as we mentioned in the stasis zone, the thickness is determined after fluid resuscitation and if the patient goes to coagulation zone, he will need debridement, but if it goes to hyperaemia then it will heal normally.

Prognosis:

★ Age and general condition
★ Extent of the burn: increases mortality rate by 30%
   ○ The smaller the TBSA the better the burn prognosis and vice versa
★ Depth of the burn: increases mortality rate by 30%
   ○ Superficial burns heal within 2-3 weeks
   ○ The deeper the burn the higher the risk of infection
★ Site of the burn: increases mortality rate by 30%
   ○ Due to appearance & functional impairment
★ Inhalation injury

Transfer Criteria (when do we transfer patients to burn centers?)

1. Partial-thickness and full-thickness burns totaling greater than 10% TBSA in patients under 10 or over 50 years of age.
2. Partial-thickness and full-thickness burns totaling greater than 20% TBSA in other age groups.
3. Partial-thickness and full-thickness burns involving the face, hands, feet, genitalia, perineum, or major joints
4. Full-thickness burns greater than 5% TBSA in any age group.
5. Electrical burns. including lightning injury
6. Chemical burns
7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong the recovery period, or affect mortality
8. Any burn with concomitant traurna (e.g. fractures) in which the burn injury poses the greatest risk of morbidity or mortality. trauma poses the greater immediate risk, the patient may be treated initially in a trauma center until stable, before being transferred to a burn center. The physician's decisions should be made with the regional medical control plan and triage protocols in mind _
9. Burn injury in children admitted to a hospital without qualified personnel or equipment for pediatric care.
10. Burn injury in patients requiring special social, emotional, and/or long-term rehabilitative support, including cases involving suspected child abuse

Inhalation Injuries

★ The mechanism of inhalation injury can be divided into three broad areas:

1. Inhalation of products of combustion
2. Carbon monoxide inhalation
3. Direct thermal injury to the upper aero-digestive tract

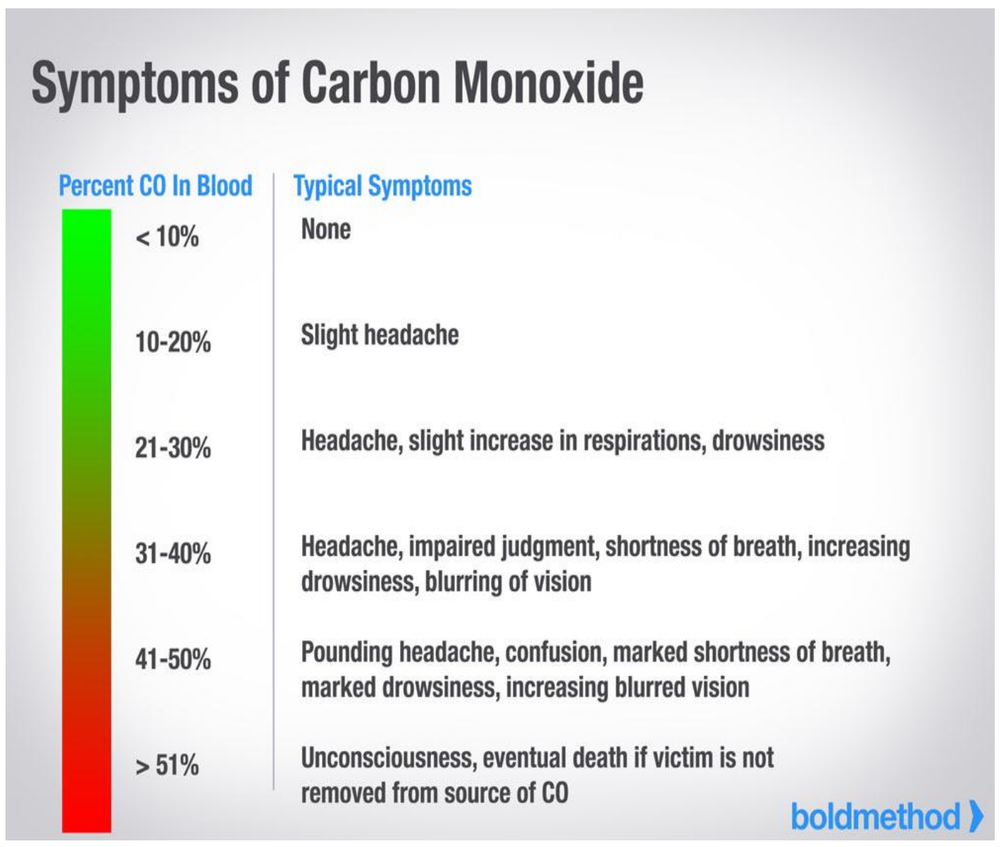
when you're in a **closed area** and there's fire, there will be a lot of gases for example carbon monoxide & cyanide which lead to inhalation injury b/c the gas goes inside & leads to burn and sometimes desloughing of the mucosa.

★ Suspect inhalation injury if: IMPORTANT: do a bronchoscopy to determine the extent of burn.

- Flame burn in a closed space
- Singed (burned) nasal hairs
- Facial or oropharyngeal burns
- Expectoration of carbonaceous (blackish) sputum
- Signs of upper respiratory obstruction – such as crowing, dyspnea, cough, stridor, or air hunger
- Symptoms: distress, hoarseness of voice, sputum production.

Carbon Monoxide:

- Odorless, tasteless gas
- Impairs tissue oxygenation by preferentially binding to Hgb
- Affinity 240 times that of oxygen
- **Shifts the Hgb dissociation curve to the left decreasing O2 delivery**
- **Signs include:**
  - Headache
  - Cherry red lips
  - Arrhythmias
  - Acidosis
  - Seizures
  - LOC "Lower level of Consciousness"



Management

Treatment of inhalation injury	Indication of hyperbaric oxygen "HBO" therapy
- 100% O_2 +/- intubation & ventilation - T ½ of CO is 5-6 hours on R/A - 45 minute on 100% O_2 or 27 minutes HBO at 3 atm	- Coma - LOC - Ischemic ECG change - Focal neurological deficit +/- CO Hb>40%

Burn Management: In the ER you start with checking (ABC: Airway, breathing, circulation) then:

Stop the burning process	Chemical Burns	Electrical Burns	Avoid wound contamination
- Victim should stay flat to avoid inhalation of smoke and fumes. - Remove all burned clothes. - Apply cold water vs - hypothermia.	- Copious irrigation - ATLS Advanced Life Trauma Support - Remove the etiology + including cloth - Ensure no inhalation, GI involvement, or ocular involvement - Antidote if available + Burn treatment - Acid Vs. Alkali - Administer normal saline or water (don't add acid if the burn caused by alkaline or vice versa, bc both agents will increase the burn)	- Switch of the current or by pushing the victim away from the current source with a non-conducting object. - High Voltage Vs. Low Voltage - ATLS - IVF add 30% to TBSA - Cardiac, kidney & airway monitor - Fasciotomy & Burn Management	- Burn must be covered w/ clean sheet - Avoid using household items as it might convert partial injury to a full thickness one

- **ABC's** (airway, breathing, circulation) **- Life preservation**
  - ★ History:
    - Causative agent of injury
    - Medical comorbidities
  - ★ Physical exam:
    - Inhalational component?
    - Is it still active? You need to stop it! And if the patient is wearing clothes on the burned area take them off.
    - Estimation of depth
    - Estimation of TBSA of burn
  - ★ Determination: severity of injury and triage/transfer.
  - ★ Irrigation and debridement of wounds.

Types of Burn Management	
1. Non Surgical	2. Surgical
A. Tetanus vaccine B. Nutrition C. Physiotherapy D. Dressing E. Fluid	A. Escharotomy B. Debridement C. Skin grafting D. Fasciotomy

1. Non Surgical

B. Nutrition:

- ★ Due to increased energy expenditure following severe burns.
- ★ Requires high caloric protein diet once the patient can take orally or via NGT
- ★ Daily requirement is 20 Kcal + 70 Kcal/kg/ % of burn (1g/kg + 3g/kg/ % of burn of protein)
- ★ Vitamins supplement : Vitamin C, Zinc & general multi-vitamins.

C. Physiotherapy:

- ★ Splints to prevent contractures & range of motion exercise to prevent stiffness.

D. Dressing:

Local Wound Management	Cover burn regularly to avoid infection which is the main threat to life once the 1st 24 hours have passed
Initial Cleansing and Debridement	- Cleanse wound with antiseptic and saline - Blister are punctured
No role for IV or oral Antibiotics	
Do not forget tetanus	

D. Dressing:

- ➔ Destruction of the epidermis removes the normal barrier to infection (full thickness burns impair the normal response to infection.
- ➔ The organism colonize the burn wound (staph.C is the most common, pseudomonas remains troublesome in most burn units)
- ➔ Flamazine (silver sulfadiazine) the most common burn dressing used
  - ◆ Must be applied daily
  - ◆ S/E neutropenia
  - ◆ Can not be used in infants under 6/12 of age
- ➔ **Open vs closed dressing**
  - ◆ Fucidine or bacitracin ointment
  - ◆ To prevent superinfection of the burn wound from the colonized organisms

E. Fluid Resuscitation:

- Burns over 15% TBSA in adults or 10% in children
- Require IVF administration through a peripheral vein or internal jugular or subclavian vein line if peripheral line is not possible
- Withdraw blood for CBC, electrolytes, CO leve & Foley catheter

Parkland Formula:

- (Crystalloid) most common for first 24 hours injury.
- Estimate the amount of replacement fluid required for the **first 24 hours** in a burn patient so as to ensure they remain hemodynamically stable.
- 1st half of volume is given in the 1st 8 hrs after injury and 2nd half in the next 16 hrs
- Use Ringer Lactate solution: Weight in Kg X TBSA% X 4cc
- Only for 2nd degree burns or deepe
- Start counting from time of burn NOT when you see the patient in the ER.
- The main goal is to reach 1cc/kg/hour of urine output for adults, for children we give more fluids and so the main goal is to reach 2cc/kg/hour of urine output

More explanation :

مثال: مريض يحتاج ٨ لتر تعطيه نصف الكمية اللي هي ٤ بأول ٨ ساعات وتكمل الباقي اللي هي ٤ لتر في ١٦ ساعة الجاية >> هذا في حالة ان المريض جاك بعد الحرق مباشره ما تأخر .

لكن لو افترضنا ان المريض تأخر ساعتين تقوم تطرح ال٢ ساعتين من ٨ ساعات يعطيك ٦ ساعات, الحين تعطيه نصف الكمية بأول ٦ ساعات والباقي تعطيه ب ١٦ ساعه الجاية

مثال ثاني لو المريض جاء بعد ٨ ساعات من الحرق، هنا تعطيه نصف الكمية اللي يحتاجها دفعة وحدة والباقي تعطيه في ١٦ ساعة الجاية .

After 24 hrs you maintain the same IV fluid whether you decrease or increase the amount according to the urine output

Always ask the patient when did the burn happen.

Remember when we talked about the zones and how we said we wanna turn the coagulation zone to the hyperemia zone? This is how we do it!

Other Formulas & Requirements:

- ★ **Modified brooke's :** Weight in Kg x TBSA x 2cc
- ★ **Using hypertonic saline :** 250-300 mEq, decrease the fluid requirement, require regular Na monitoring
- ★ **Colloid replacement formula :** 0.5 ml/kg/ % of burn
- ★ **Blood transfusions :** After 24 hours, Mainly needed in patients with full thickness burns.
  - Regular hemoglobin, Hematocrit monitoring is mandatory

Children:

- ★ will need the maintenance IVF add to their fluid resuscitation (we need to overload the patient)
- ★ 100 ml/kg/24 hours 1st 10 Kg
- ★ 50 ml/kg/24 hours 2nd 10 kg
- ★ 20 ml/kg/24 hours 3rd on kg
- ★ To avoid hypoglycemia; use D5½NS fluid

Adequate fluid resuscitation is monitored by: Urine output

- ★ 0.5 – 1 ml/kg/hour for adult
- ★ 2 ml/kg/hour for children
- ★ In cases of electrical burns more urine is needed to protect the kidney 2-3 ml/kg/hour
- ★ Inhalation injury patients also need extra fluids

2. Surgical Burn Management:

Escharotomy :

- ★ Surgical procedure used to treat full-thickness (third-degree) circumferential burns. In full-thickness burns, both the epidermis and the dermis are destroyed along with sensory nerves in the dermis. The tough leathery tissue remaining after a full-thickness burn has been termed eschar.
- ★ For circumferential burns (e.g. burn in the chest; can't ventilate the patient)
- ★ Mid - Axial incision in the eschar only of full thickness burn
- ★ To relive the tourniquet effect of the circumferential full thickness burns on:
  - Extremity
  - Trunk
    - if breathing was an issue.
    - If increase in intra-abdominal pressure
- ★ Due to interstitial fluid accumulation

Fasciotomy

- ★ Surgical procedure where the fascia is cut to relieve tension or pressure commonly to treat the resulting loss of circulation to an area of tissue or muscle.
- ★ For compartment syndrome

Skin Grafts

	Split Thickness (STSG)	Full Thickness (FTSG)
Layer	Epidermis + part of the dermis	Epidermis and entire dermis
Donor Site	• Thighs • Back • Abdomen • Scalp • Any part of the body	• Post auricular • Supraclavicular • Groin • Forearm
Advantage	• Donor heals spontaneously (re-epthilize) • Large donor area, can be reused • Higher chance of take in less ideal conditions	• Less contraction • Grows with the patient • Secrets oil and sweat • Better donor site scar and less pain • More stable/durable • For areas that requires mobility
Disadvantage	• More contraction • More fragile • Loss growth potential • Donor site more painful	• Donor site must be closed • Less donor areas • Needs clean wound bed • May grow hair

Primary contraction refers to the immediate shrinkage that occurs after removal from the donor site
Secondary contraction is the phenomenon that occurs after you apply the skin graft

Summary

Classification		
By type	**By timing**	**By abnormal healing**
1- primary 2- delayed primary 3- secondary 4- partial-thickness wound healing	1- Acute 2-Chronic	1. overgrowth (hypertrophic, keloid) 2. undergrowth (chronic unstable wound) 3. abnormal pigmentation 4. contour abnormality

Classification of Wounds Closure		
Primary healing (1° intention)	**Secondary healing (2° intention)**	**Tertiary healing (3° intention)**
•Primary closure •Within hours of repairing full-thickness surgical incision •Results in mortality of minimal number of cellular constituents	•Wound left open to heal by processes of granulation, contraction, and epithelialization •Results in more intense inflammatory response •Larger quantity of granulation tissue with pronounced contraction of wounds	•Delayed primary closure •Desired for contaminated wounds •Phagocytosis of contaminated tissues well underway by 4^{th} day •Foreign materials walled off by macrophages

Phases of wound healing			
Haemostasis (5-10 min)	**Inflammatory (1-4 D)**	**Proliferative (3D - 3Wks)**	**Remodeling (3 wks - 1 year)**
Vascular constriction, Platelet aggregation, Degranulation and thrombus formation	Neutrophil infiltration, Monocyte infiltration and differentiation to microphage Lymphocyte infiltration	1- Re-Epithelization 2- Angiogenesis 3- Collagen Synthesis 4- ECM formation	1- Collagen Remodeling 2- vascular maturation and regression

Collagen Types				
Type I	**Type II**	**Type III**	**Type IV**	**Type V**
the major structural component of bones, skin, and tendons	found predominantly in cartilage	found in association with type I collagen in varying ratios depending on the type and maturity of tissue (predominant type in granulation tissue)	found in the basement membrane	found in the cornea

Summary

Factors affecting wound healing

General	Local
Nutrition	Oxygen
Drugs/Toxins	Infection
Age	Acidity
DM	Radiation
Smoking	Loss of growth factors
Vascular disease	Denervation
Obesity	Iatrogenic
Systemic diseases	Edema
Idiopathic	Cancer
Inherited diseases	Foreign body

Table 3.4 Comparison of hypertrophic and keloid scars

Features	*Hypertrophic scar*	*Keloid scar*
Genetic	Not familial	May be familial
Race	Not race related	Black > white
Sex	Female = male	Female > male
Age	Children	10–30 years
Borders	Remains within wound	Outgrows wound area
Natural history	Subsides with time	Rarely subsides
Site	Flexor surfaces	Sternum, shoulder, face
Aetiology	Related to tension	Unknown

Ideal scar

- Flat, Narrow
- good colour & contour match to surrounding skin
- parallel to *or within resting skin tension lines (RSTL)*
- pliable
- does *not restrict function or distort normal anatomy*
- matures within 6-18 months & asymptomatic

Pressure Sores Stages

Stage 1	Stage 2	Stage 3	Stage 4
developed if the person doesn't move while sleeping for 2 hours (bed sore): mainly involved the epidemics and produces erythema, avoided by changing the position every 30 min.	involved epidermis and upper dermis.	reaches up to the fascia, doesn't go beyond that.	beyond the fascia and can reach to the muscle, tendon and bones and they usually develop osteomyelitis.

Burns

Superficial (1st degree)	Superficial Partial thickness (2nd degree):	Deep Partial thickness (2nd degree):	Full thickness (3rd degree)	Full thickness (4th degree)
- Damage to the **epidermis** only - No need for admission - Heal within 5 – 7 days - No scarring - No need for treatment - Needs only analgesics and hydration - e.g. tanning	- **Epidermis and upper dermis** - Pink, painful and swollen - Fluid loss - Blisters - Heal within 2 weeks - From epidermal appendages - Requires daily dressing - Minimal scarring - You don't need to treat it by debridement	- **Epidermis and most of the dermis** - Treat like 3rd degree burn - Less or not painful - Less sensation - Rarely blister - Prolonged inflammatory phase cause scarring - Leaves an ugly hypertrophic scars needs debridement & skin grafting - Heals in 3-10 weeks	- **Epidermis and total dermis including the epidermal appendages** - Destroyed tissue undergoes coagulative necrosis - Not painful - No blisters - Marble or leathery like appearance - Thrombosed veins - Cause significant scarring due to inward growing and movement of the cells - Needs debridement and skin grafting	- Injury extends to the underlying structures; **muscle, fascia & bone.** - Charring of the tissue. This type definitely needs debridement, if you don't treat it > HTS and contractions

Quiz

A/Which of the following refers to the overgrowth of tissue beyond the initial wound edges?

1. Granuloma
2. Hypertrophic scar
3. Koebner reaction
4. Keloid

Answer is 4

B/ Which of the following statements is wrong ?

1. Keloids are scars that tend to overgrow.
2. Unlike a hypertrophic scar, keloids are malignant fibrotic tumor.
3. Both keloids and hypertrophic scars are a result of trauma or surgery.
4. African Americans and Asians tend to have a propensity to form keloids.

Answer is 2 (Both keloids and hypertrophic scars are benign fibrotic tumors that are very difficult to treat.)

C/ A 36 years old female had a split thickness skin grafting after a severe acid chemical burn, in the ER she was treated by adding tons of water, her husband suggested to put an alkaline solution to neutralize the acidity however the doctor did not respond to him.

Which of the following is wrong about Split Thickness Skin Grafting?

1. Donor heals spontaneously
2. There is a loss of growth potential
3. Donor site is more painful than in FTSG
4. There is less contraction than in FTSH

Answer is 4

D/ A 25 yo male came to the ER 2 hours ago with severe burn all over his back (TBSA=18) , you immediately noticed that he is in a hypovolemic shock, Fluid resuscitation is the most important step in non surgical management, knowing that the patient weighs about 70 kg how much does fluid does he need?

1. 2520 in 8 hours and 2520 in the next 16 hours
2. 5040 in the next 24 hours
3. 2520 in 6 hours and 2520 in the next 16 hours
4. 31500 in the next 24 hours

Answer is 3

E/ Which of the following applies on the Superficial Partial thickness only and not on the Deep Partial thickness burn?

1. It's Painful
2. It's a Second degree burn
3. Affect the epidermis
4. Leaves an ugly Scar

Answer is 1 (4 applies on deep but not on superficial)

F/ Which of the following results from large quantities of collagen during scar formation?

1. Skin tag development
2. Lipoma formation
3. Koebner phenomenon
4. Keloid formation

Answer is 4

G/Which of the following is the first line of treatment in hypertrophic scars?

1. Silicone.
2. Prevention.
3. 5-FU (Fluorouracil)
4. Intra-lesion Steroids

Answer is 4

Quiz From the Doctor's lecture

H/The following are the sequence of events and phases taking place in wound healing?

1. Remodelling, epithelization & contractur
2. Inflammatory, proliferative & remodeling
3. Vasoconstriction, epithelization & contracture
4. Proliferative, remodelling and wound synthesis

Answer is 2

I/ The major cell involved in the proliferative phase is/are

1. PMN
2. Fibronectin
3. Fibroblast
4. collagen

Answer is 3

J/ The difference between secondary & partial thickness healing is :

1. Contracture only in secondary healing
2. Contracture only in partial thickness healing
3. Epithelization only in secondary
4. Epithelization only in partial thickness healing

Answer is 1

K/ Perforated gastric ulcer or Perforated appendicitis is/are

1. Clean
2. Clean-contaminated
3. Contaminated
4. Infected

Answer is 3

L**/ All of the following is/ are characteristic of ideal scar except:**

1. Flat
2. No restriction of movement
3. Adequate color
4. Painful

Answer is 4

M/ Which of the following is characteristic of keloid:

1. Crosses border
2. Genetic predisposition
3. Common in earlobes/ chest in African
4. All of the above

Answer is 4

N/ Preventive measures of HTS is/are:

1. Adequate suture bite closure
2. Free tension closure
3. Non-strangulated sutures
4. Minimal undermining/ electrocautery
5. All of the above

Answer is 5