

# Wound Healing, Scar & Pressure Sores

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# Objectives

- Basic Principles
- Classification
- Classes of operative wound
- Phases of wound healing
- Collagen Types
- Factors affecting wound healing
- Scars
- Pressure sores
- Burn





QUIZ  
TIME!

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

- 1- Remodelling, epithalization, & contracture
- 2- inflammatory, proliferative & remodeling
- 3- vasoconstriction, epithalization & contracture
- 4- proliferative, remodelling and wound synthesis

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

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

The difference between secondary & partial thickness healing is :

- Contracture only in secondary healing
- Contracture only in partial thickness healing
- Epithilisation only in secondary
- Epithalization only in parial thickness healing

Perforated gastric ulcer or Perforated appendicitis is/are

- Clean
- Clean-contaminated
- Contaminated
- infected

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

- Painful
- Flat
- No restriction of movement
- Adequate color

All 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



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

# Wound:

- disruption of normal anatomical structure and function
- Classified as acute vs. chronic

# Definition

- Restoration of integrity and continuity of injured tissue to re-establish homeostasis of that tissue and to 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

# Classification

By type	By timing	By abnormal healing
<ul style="list-style-type: none"><li>1- primary</li><li>2- delayed primary</li><li>3- secondary</li><li>4- partial-thickness wound healing</li></ul>	<ul style="list-style-type: none"><li>1- Acute</li><li>2- Chronic</li></ul>	<ul style="list-style-type: none"><li>1. overgrowth (hypertrophic, keloid)</li><li>2. undergrowth (chronic unstable wound)</li><li>3. abnormal pigmentation</li><li>4. contour abnormality</li></ul>

# Classification of Wounds Closure

- **Primary healing (1° intention)**
  - Primary closure
  - Within hours of repairing full-thickness surgical incision
  - Results in mortality of minimal number of cellular constituents
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- **Secondary healing (2° 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
- 
- **Tertiary healing (3° intention)**
  - Delay primary closure
  - Desired for contaminated wounds
  - Phagocytosis of contaminated tissues well underway by 4<sup>th</sup> day
  - Foreign materials walled off by macrophages

# Epithelial Repair

- epithelial continuity is reestablished across a wound

1-mobilization

2-migration (stimulus is loss of contact inhibition)

3-mitosis

4-cellular differentiation

# PHASES

Heamostasis (5-10 min)

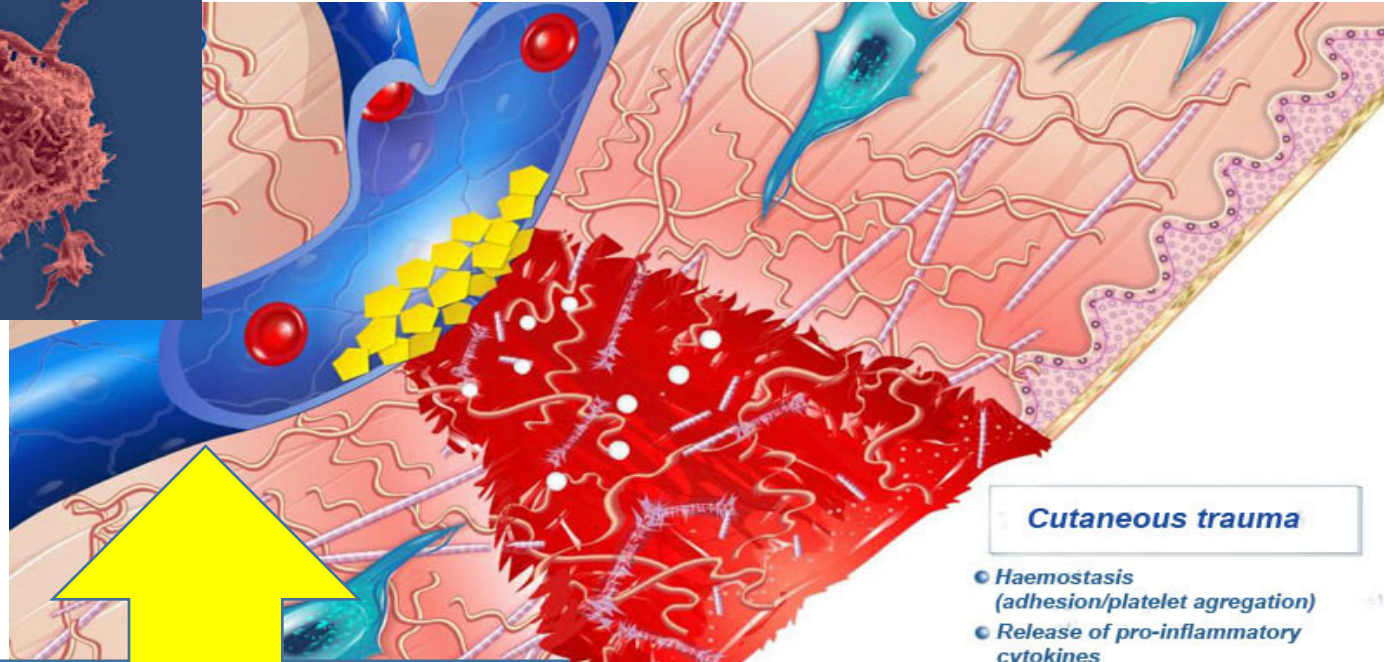
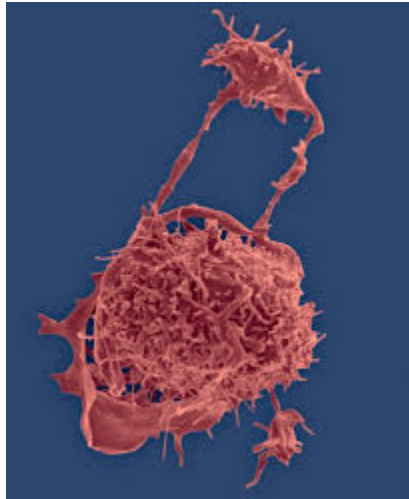


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graph TD; A[Heamostasis (5-10 min)] --> B[Inflammatory (1-4 D)]; B --> C[Proliferative (3D-3Wks)]; C --> D[Remodeling (3 wks - one year)];
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Inflammatory (1-4 D)











Proliferative (3D-3Wks)

Remodeling ( 3 wks -one year)



**Cutaneous trauma**

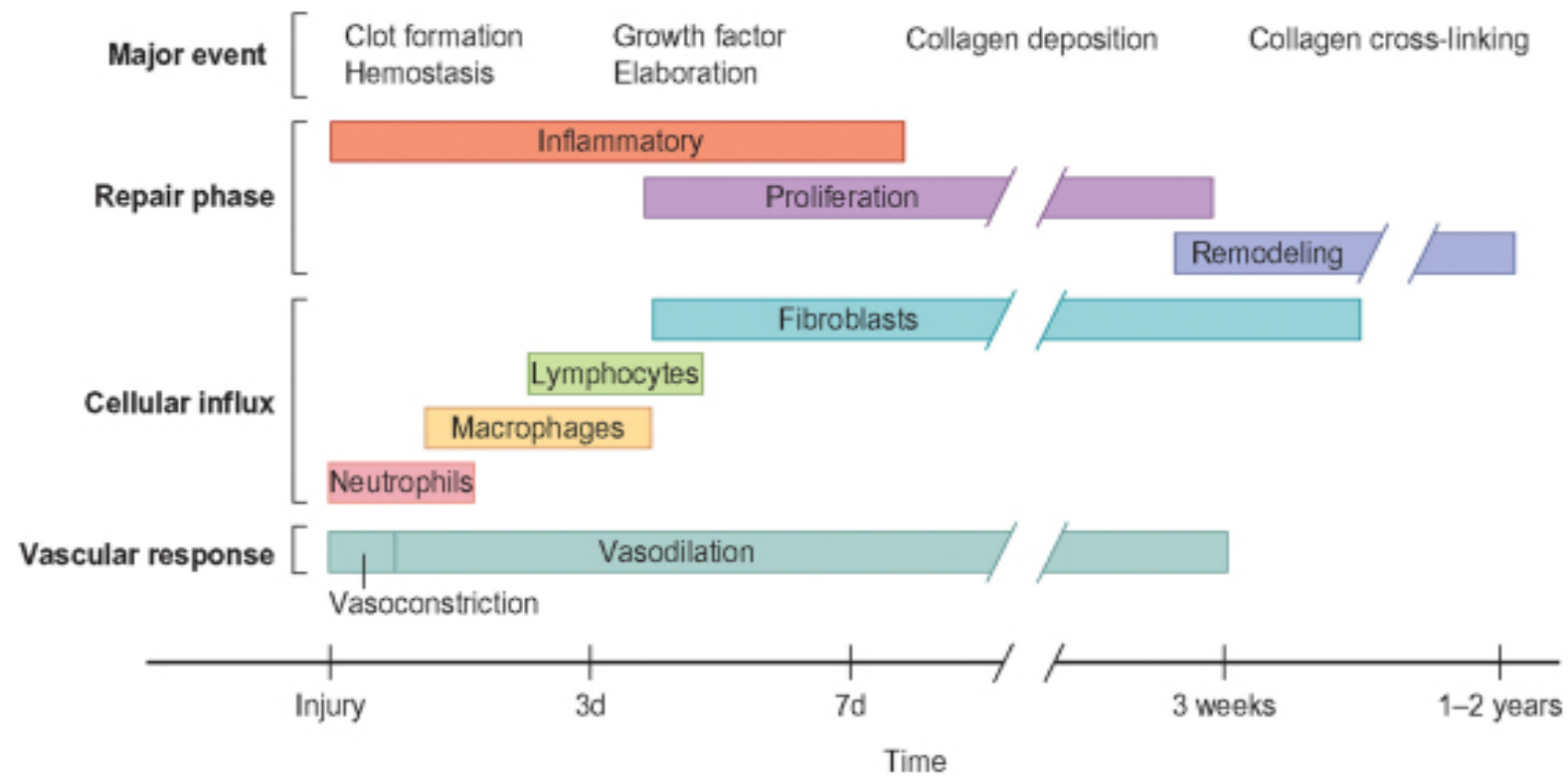
- Haemostasis (adhesion/platelet aggregation)
- Release of pro-inflammatory cytokines

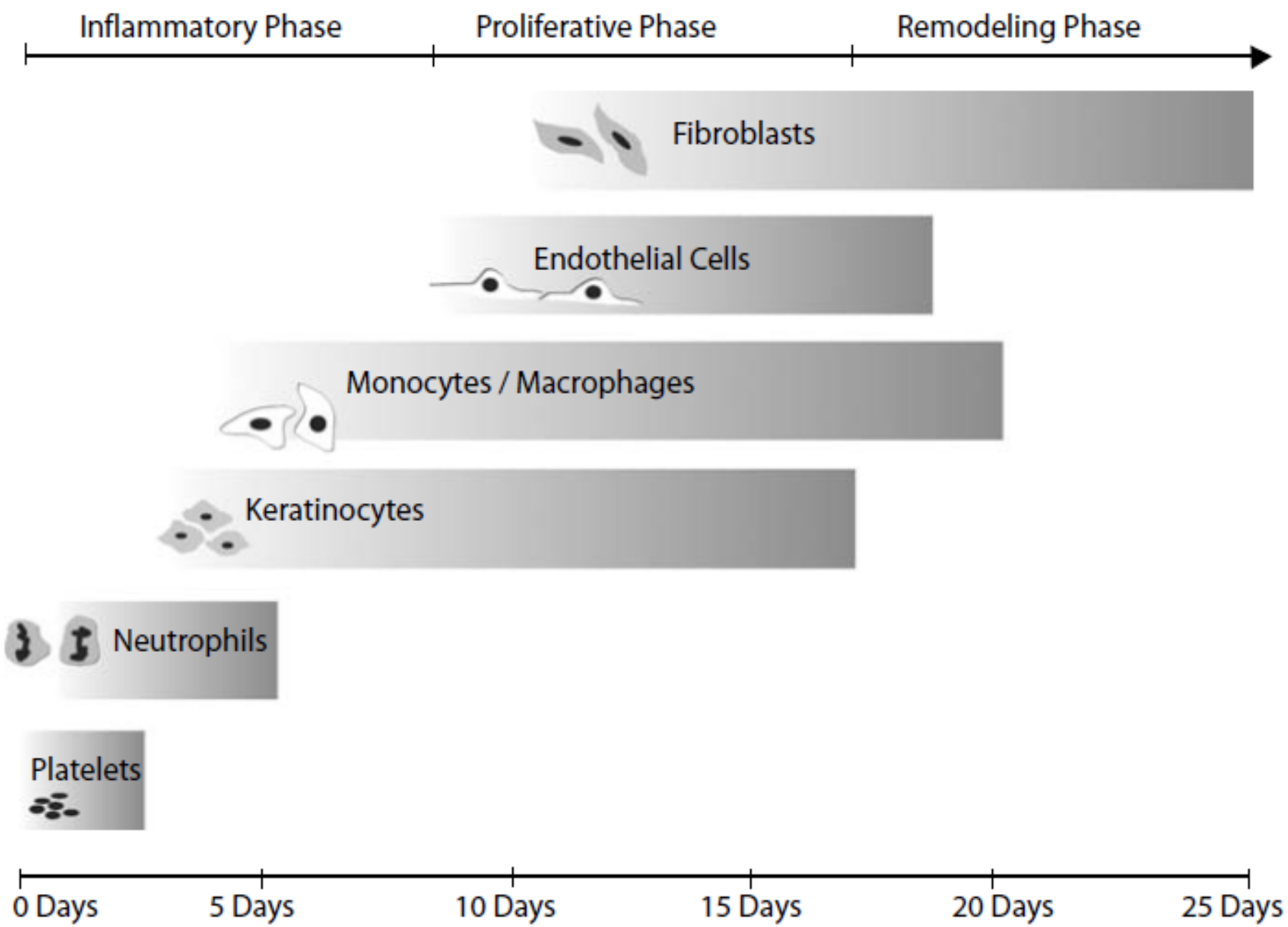
 Red blood cell	 Elastin
 Fibrin-platelet clot	 Monocyte polynuclear
 Release of cytokines and growth factors	 Matrix Metallo Proteases
 Fibroblast	 Growth factors
 Collagen	 NOSF

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



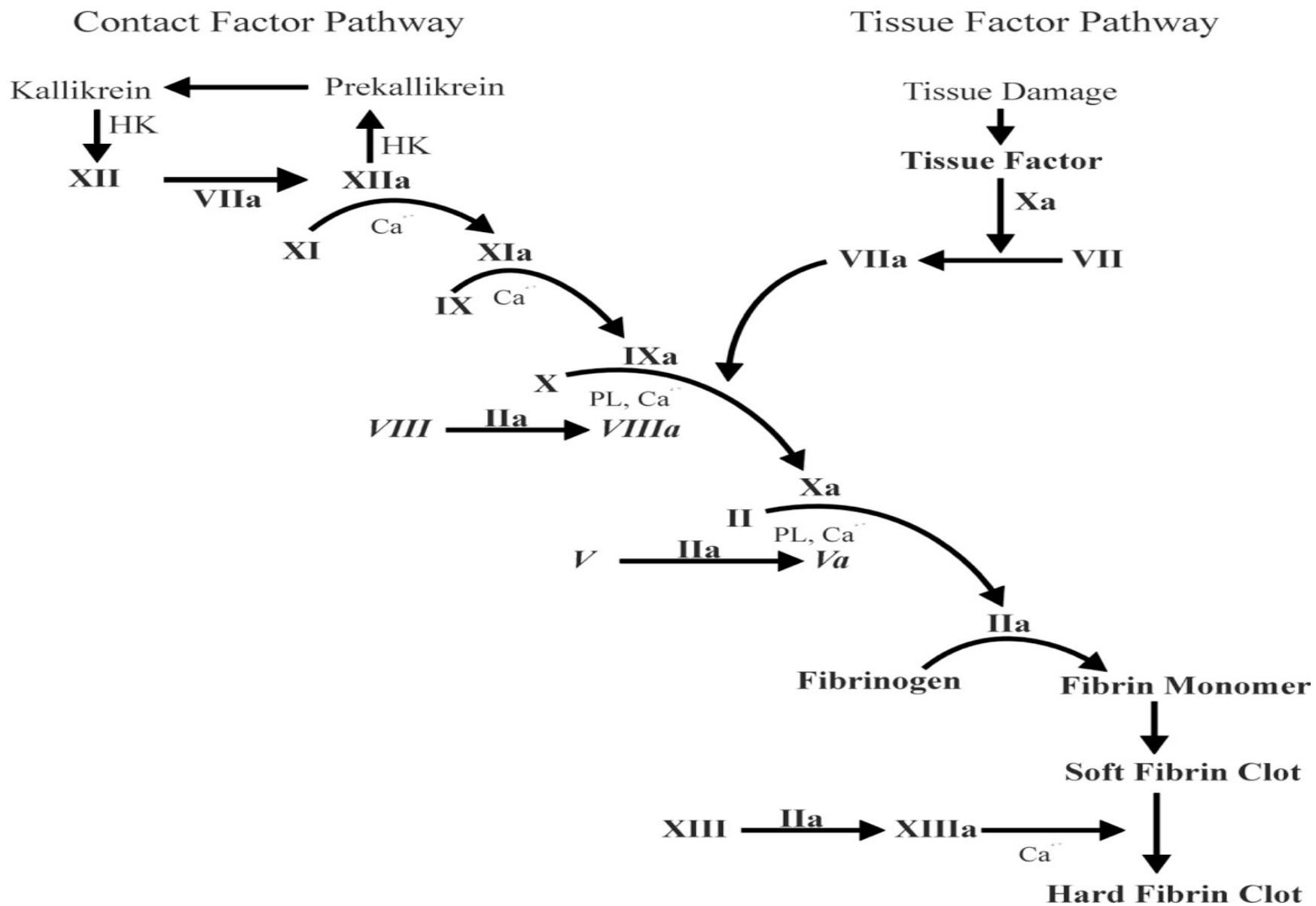
### Timeline of wound repair events





# Haemostasis

- Initial response to injury = constriction
- Platelet plug forms after adherence to exposed subendothelial collagen via vWF
- Platelets degranulate releasing: ADP, thromboxane-A<sub>2</sub>, bradykinin, and 5-HT → further vasoconstriction and platelet aggregation  
Platelets stimulated to release
- ○ **platelet derived growth factor (PDGF)**
  - -made by macrophages, endothelial cells, fibroblasts
  - -chemotaxis, fibroblast stimulation
- ○ **transforming growth factor  $\beta$  (TGF $\beta$ )**
  - -made by macrophages, platelets, fibroblasts
  - -fibrinogenesis, angiogenesis, chemotaxis, immune suppression
- ○ **fibroblast growth factor**
  - -made by macrophages and endothelial cells
  - -angiogenesis and chemotaxis



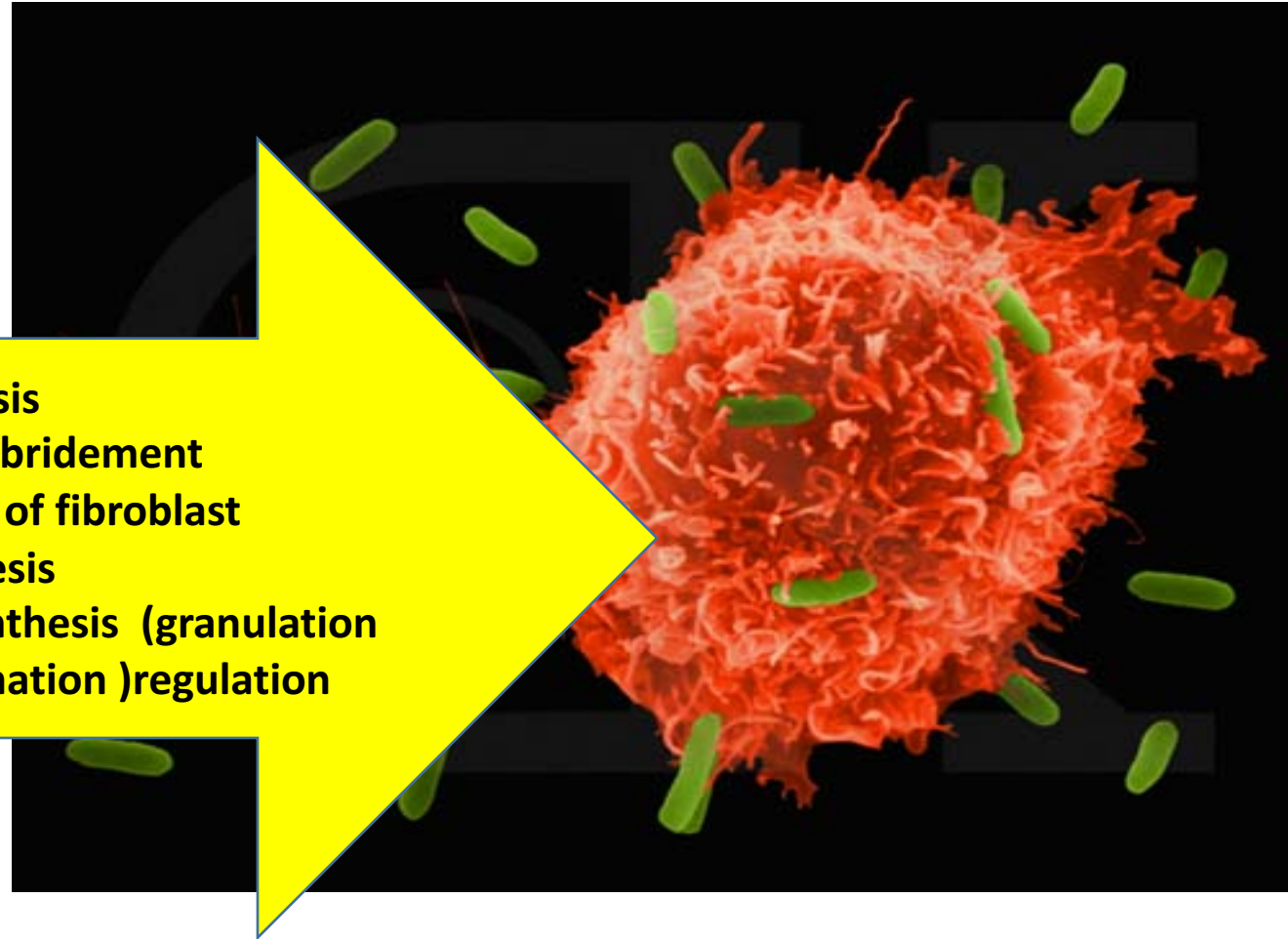
# *Inflammatory phase/ Migratory phase*

- Classically represented by:
  - Rubor (redness)
    - caused by vasodilation
    - primarily result of prostacyclin ( $\text{PGI}_2$ ) and histamine, also caused by prostaglandin A, D, and E (PGA, PGD, PGE)
  - Tumour (swelling)
    - caused by leakage of plasma proteins through gaps in vascular endothelium
    - edema potentiated by  $\text{PGE}_2$ , prostaglandin  $\text{F}_{2\alpha}$  ( $\text{PGF}_{2\alpha}$ )
  - Calour (heat)
    - Increased local temperature secondary to both increased blood flow and elevated metabolic rates
  - Dolour (pain)

# Macrophages

## Phagocytosis

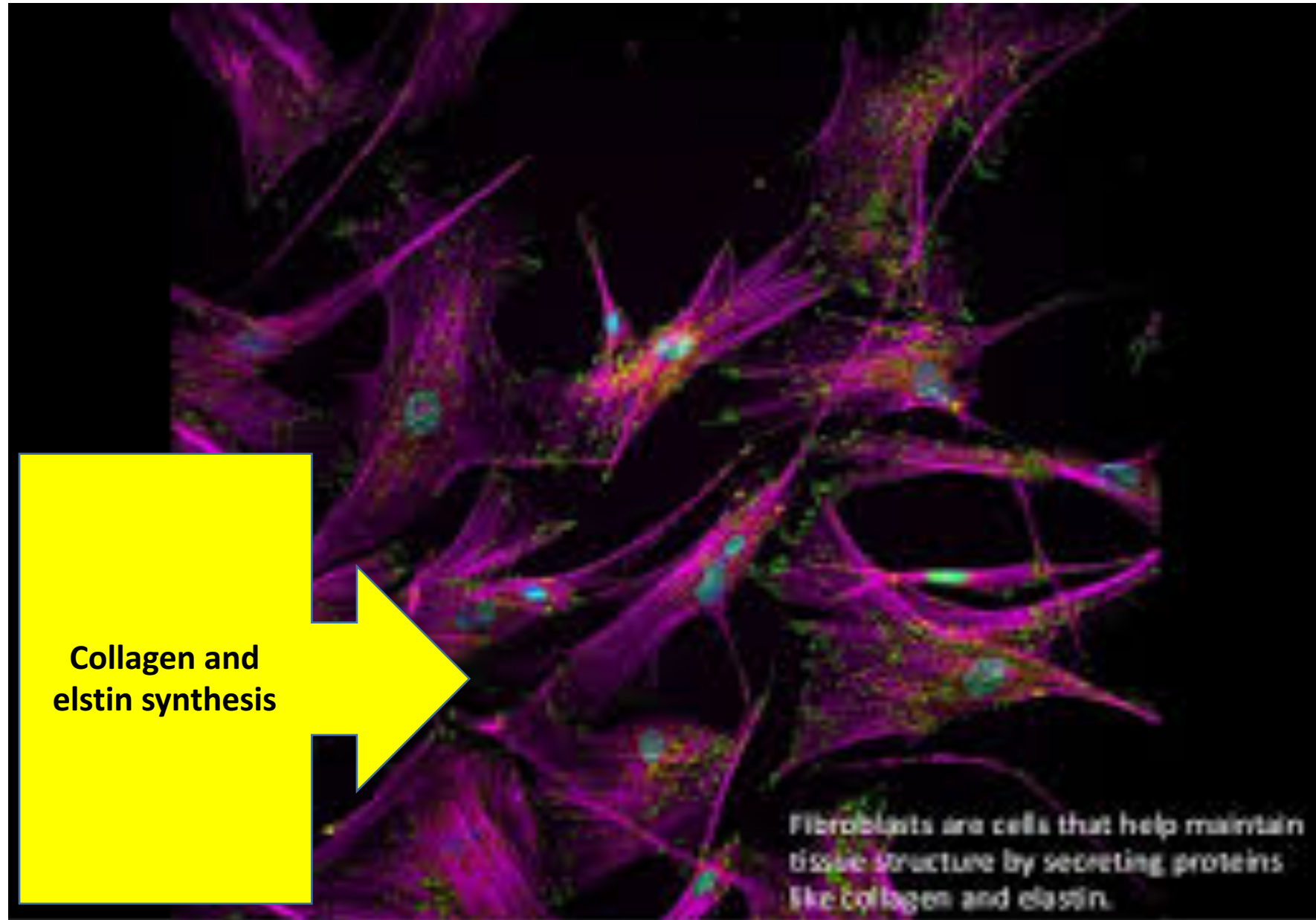
- .Wound debridement
- .activation of fibroblast
- .Angiogenesis
- .Matrix synthesis (granulation tissue formation )regulation



# *Proliferative Phase (fibroplasia)*

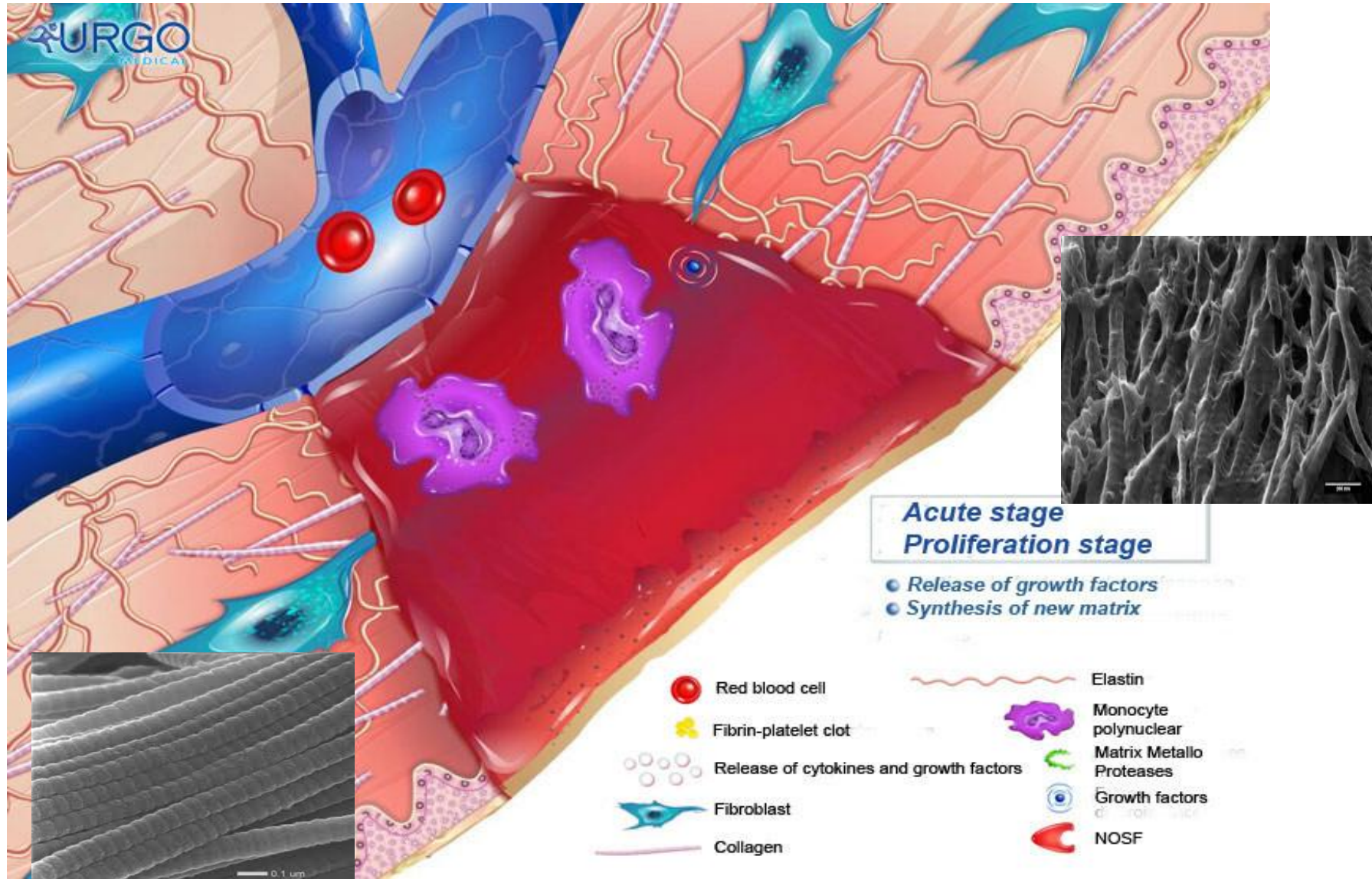
- Begins 2-3 days after wounding
- Signalled by arrival of **fibroblasts**
  - Driven by macrophage-derived **bFGF, TGF $\beta$ , PDGF** to proliferate and synthesize **glycosaminoglycans (GAGs)** and **proteoglycans** (building blocks of new extracellular matrix of granulation tissue and collagen)
  - 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)
- $\uparrow$  Keratinocyte mitosis
- $\uparrow$  Endothelial cells
- $\uparrow$  Angiogenesis (from vessels at wound margins)
- Lasts 2-4 weeks depending on site and size of wound with slowing of fibroblast migration and proliferation

# Fibroblast





# Proliferative phase



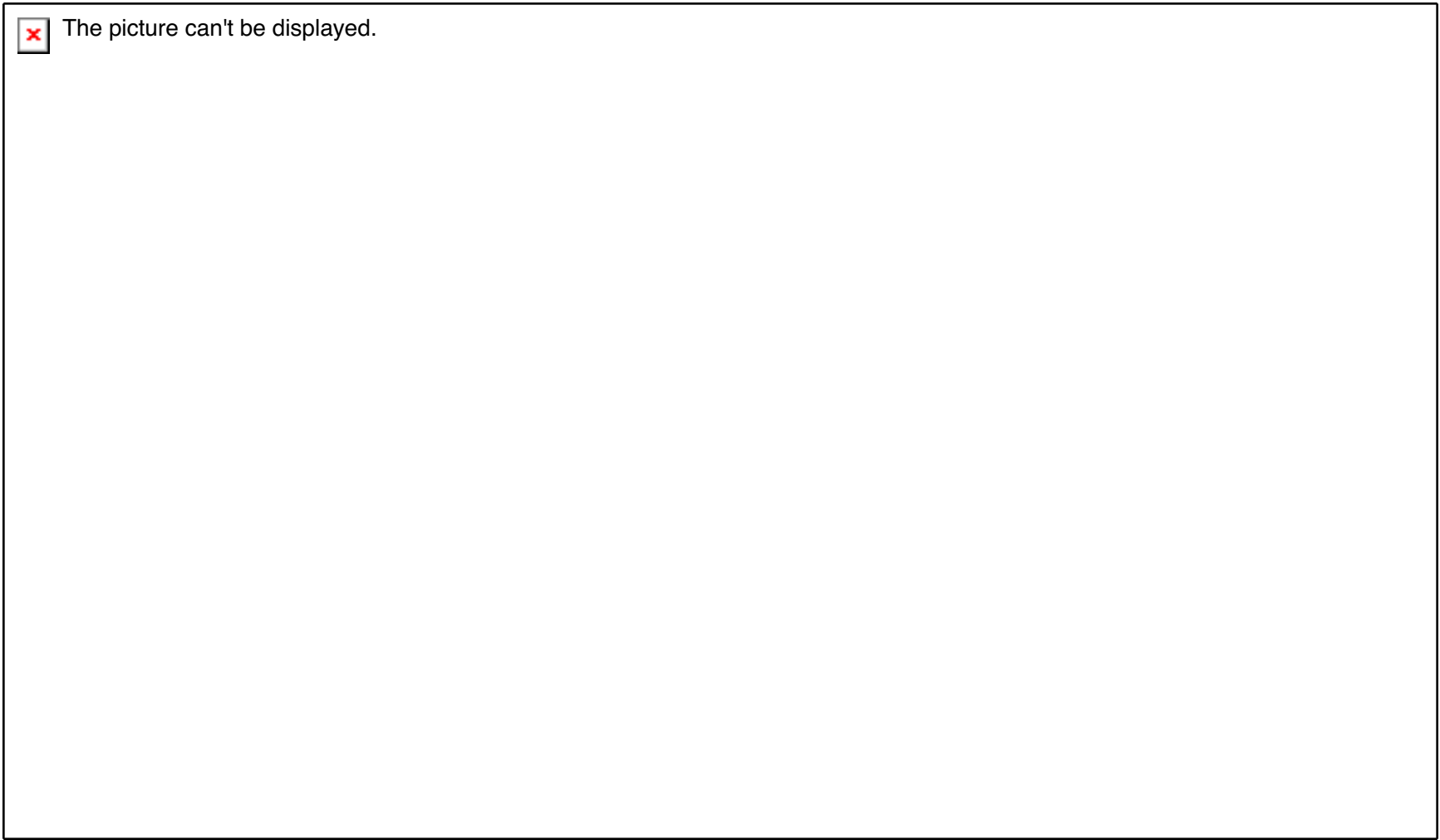
# *Maturation (remodelling)*

- Begins approx. 3 weeks after injury
- Collagen synthesis and degradation are accelerated but in equilibrium with collagen breakdown (no net increase in collagen content)
- Collagen deposition peaks by 3<sup>rd</sup> week
- Large capillaries growing into wound regress/disappear
- Indurated, raised, pruritic scar becomes mature scar
- Collagen fibers become organized
- Type III collagen replaced by type I collagen
- ○ re-establishing normal 4:1 ration (I:III)
  - Duration depends on age, genetics, type of wound, location (1-2 years)
- Tensile strength increases to 80% of pre-injured skin

# Collagen

- ***Left handed helix involving 3 polypeptides***
- Most abundant family of proteins in the human body (30%)
  - > 19 types of collagen have been identified
  - ***Type I collagen is the major structural component of bones, skin, and tendons***
  - ***Type II collagen is found predominantly in cartilage***
  - ***Type III collagen is found in association with type I collagen in varying ratios depending on the type and maturity of tissue (predominant type in granulation tissue)***
  - ***Type IV collagen is found in the basement membrane***
- ***Type V collagen is found in the cornea***
- ***Wound Strength is 80% of original after remodelling***
- ***Lysine and proline hydroxylation required for cross linkage.***

- Differs in relative composition of **hydroxylysine** and **hydroxyproline** and cross-linking
  - Type I  $\cong$  90% of all collagen in body
  - Normal skin ratio - Type I:Type III = 4:1
  - Hypertrophic / immature scare 2:1 ratio
- Formation inhibited by:
  - Colchicine
  - Penicillamide
  - Steroids
  - Vit. C deficiency
  - Fe deficiency



# Types of Surgical wounds

- ***Clean:*** nontraumatic, noninfected wounds & no breach of Resp, GI, or GU tract
- ***Clean-contaminated:*** small breach in protocol; Resp/GI/GU tract are entered with minimal contamination
- ***Contaminated:*** fresh traumatic wounds; major break in sterile technique, nonpurulent inflammation; in or near contaminated skin
- ***Infected:*** purulent infection

# Factors affecting wound healing

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





# Acute wound

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

# Abnormal Scars

- Keloid Vs. Hypertrophic scars Vs. Wide scar



# Scar

- ***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

# Vancouver Scale

Characteristic	Score	Description
Pigmentation (P)	0	Normal: color that closely resembles the color over the rest of one's body
	1	Hypopigmentation
	2	Hyperpigmentation
Vascularity (V)	0	Normal: color that closely resembles the color over the rest of one's body
	1	Pink
	2	Red
	3	Purple
Pliability (P)	0	Normal
	1	Supple: flexible with minimal resistance
	2	Yielding: giving way to pressure
	3	Firm: inflexible, not easily moved, resistant to manual pressure
	4	Banding: rope-like tissue that blanches with extension of the scar
Height (H)	0	Normal: flat
	1	<2 mm
	2	<5 mm
	3	>5 mm

\*Each scar characteristic is assessed and assigned a score as shown; the summation of these scores then forms the overall scar score.

# Comparison of Keloid and Hypertrophic scars

**Table 3.4** Comparison of hypertrophic and keloid scars

<i>Features</i>	<i>Hypertrophic scar</i>	<i>Keloid scar</i>
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

# Treatment of HTS !!

- Pressure
- Silicone
- Prevention
- 5-FU
- Steroids
- Radiation
- Laser
- Surgery

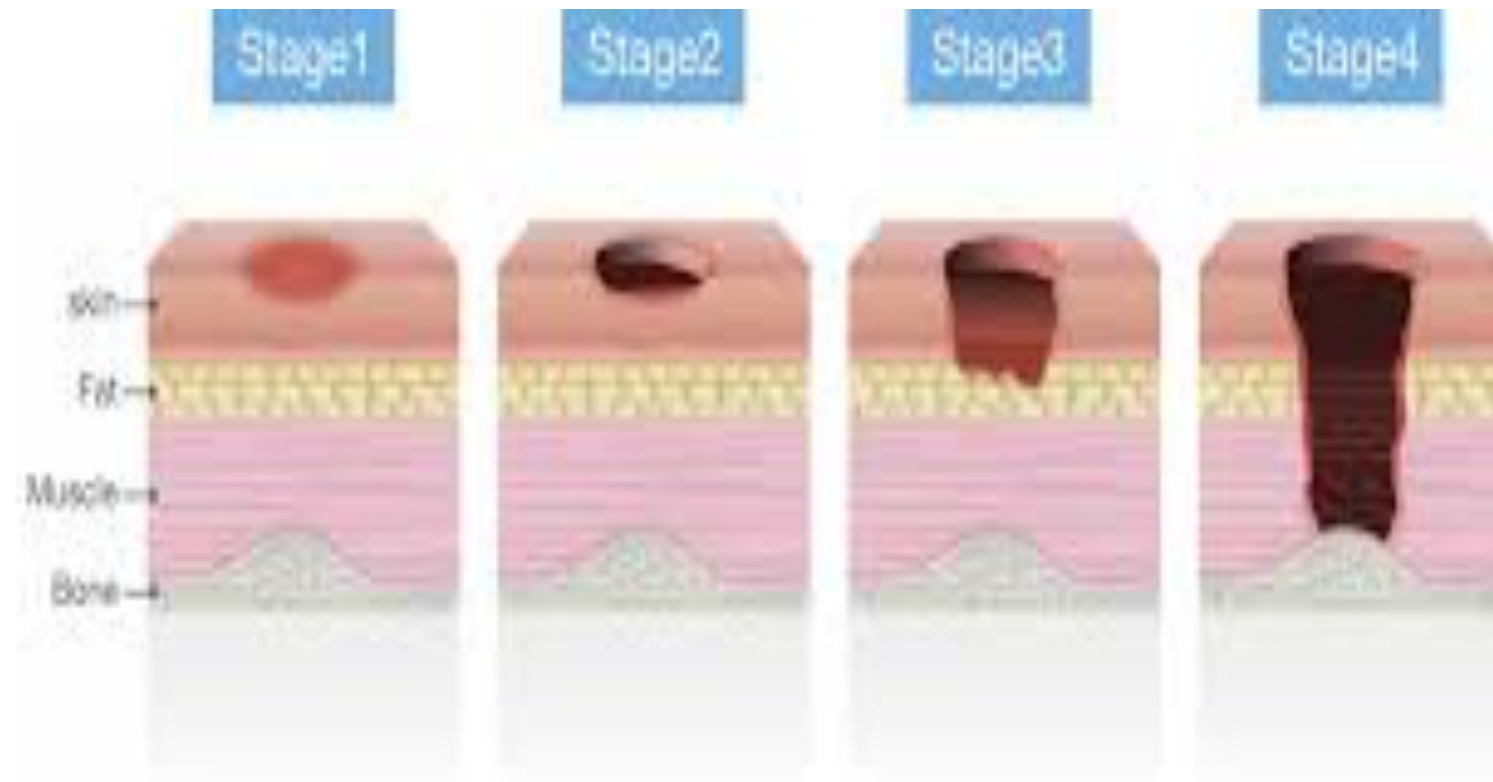






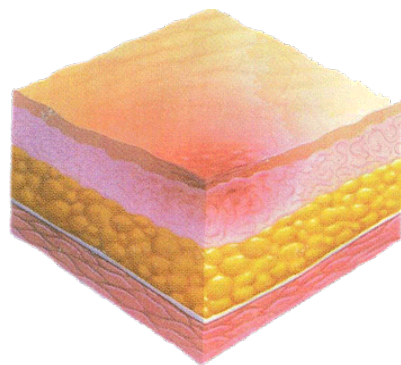


# Pressure Sores

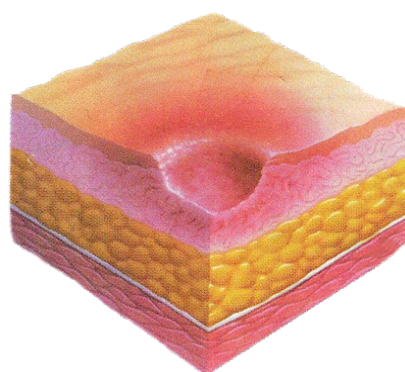
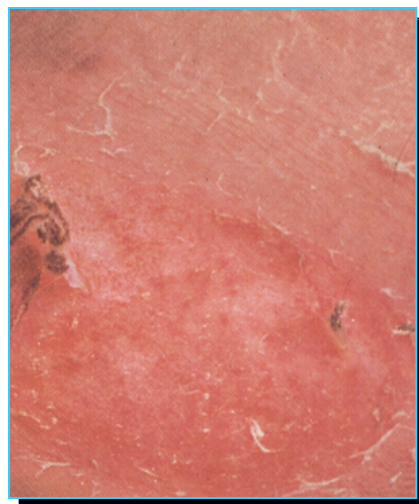


**PRESSURE SORES**

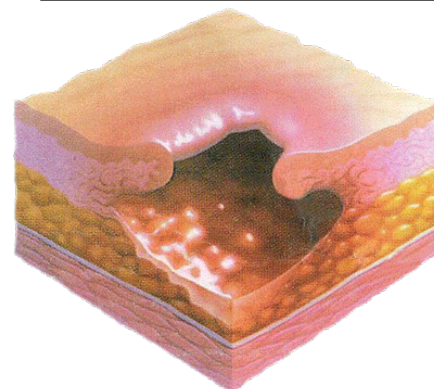
***Stage I***



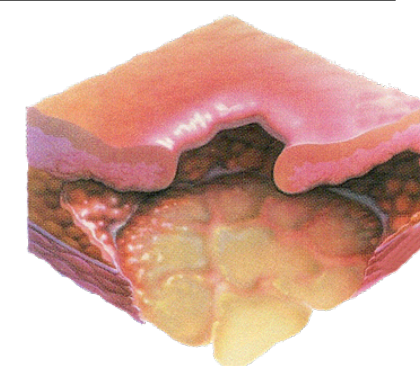
***Stage II***



***Stage III***



***Stage IV***



QUIZ  
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- 1- adequate suture bite closure
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- 3- non-strangulated sutures
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- 5- **all of the above**

*köszönöm* תודה *dekuji*

*mahalo* 고맙습니다

*thank you*

*merci* 谢谢 *danke*

Ευχαριστώ شكرا

どうもありがとう *gracias*

QUESTIONS ?

# Case Module Discussion



# Burns, & Burn Management

# Definition

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# Epidemiology

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# Types of Burns

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# Pathophysiology

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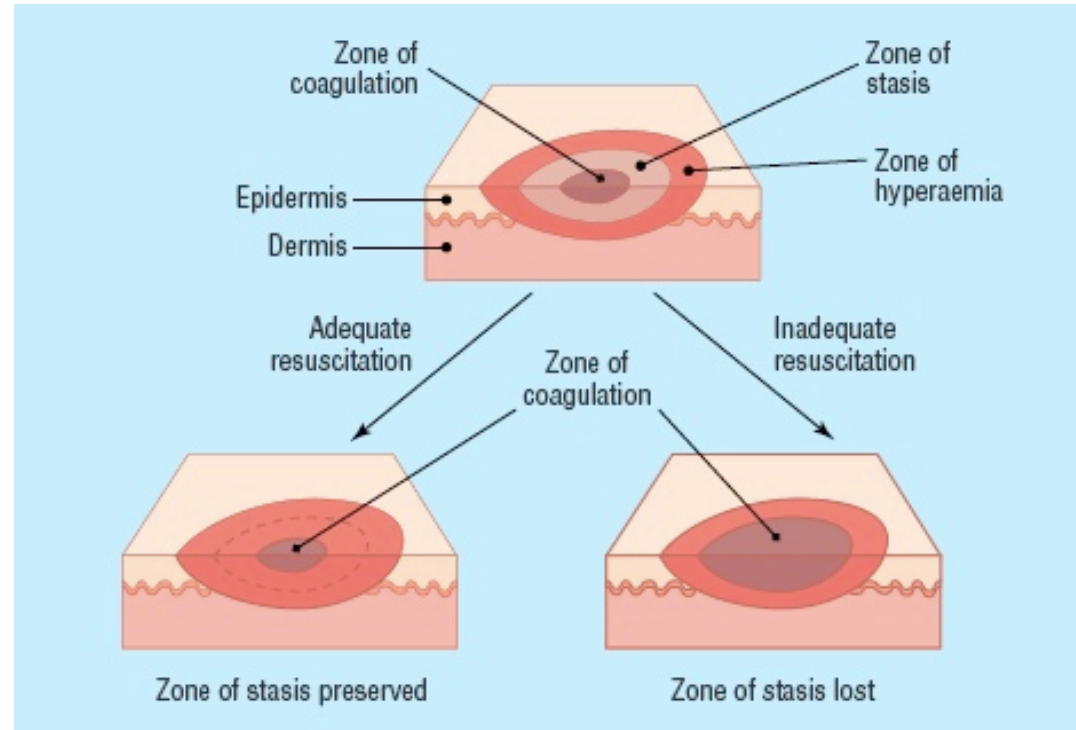
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# Pathophysiology

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# General Effect Of Burns



**Table 4.1 Classification of burn severity**

Minor burn	
15% TBSA or less in adults	
10% TBSA or less in children and the elderly	
2% TBSA or less full-thickness burn in children or adults without cosmetic or functional risk to eyes, ears, face, hands, feet, or perineum	
Moderate burn	
15–25% TBSA in adults with less than 10% full-thickness burn	:
10–20% TBSA partial-thickness burn in children under 10 and adults over 40 years of age with less than 10% full-thickness burn.	:
10% TBSA or less full-thickness burn in children or adults without cosmetic or functional risk to eyes, ears, face, hands, feet, or perineum	:
Major burn	:
25% TBSA or greater	:
20% TBSA or greater in children under 10 and adults over 40 years of age	:
10% TBSA or greater full-thickness burn	:
All burns involving eyes, ears, face, hands, feet, or perineum that are likely to result in cosmetic or cosmetic impairment	:
All high-voltage electrical burns	:
All burn injury complicated by major trauma or inhalation injury	:
All poor risk patients with burn injury	:
TBSA, total body surface area.	3

# Mortality

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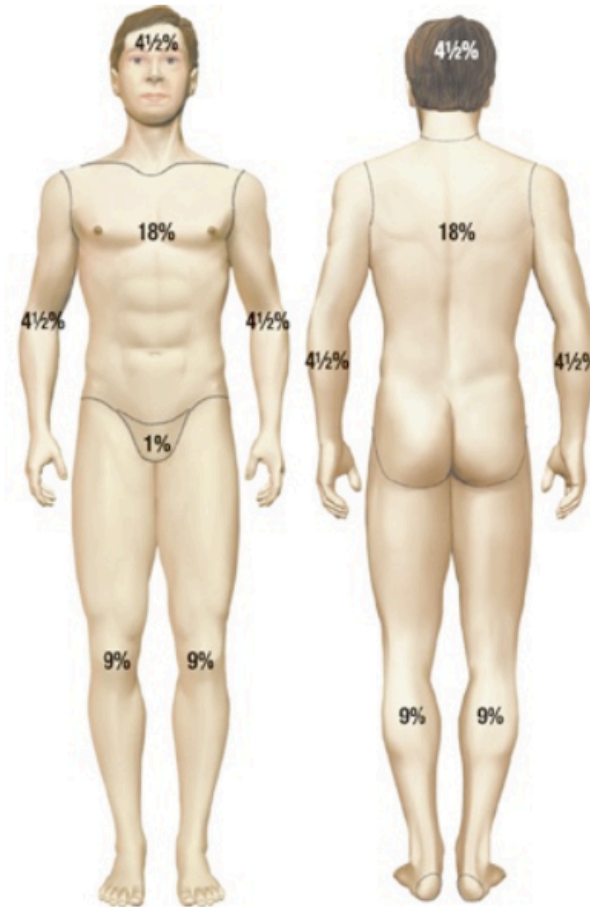
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# Burn Classification

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# Burn Classification

By Total Body Surface Area (TBSA)

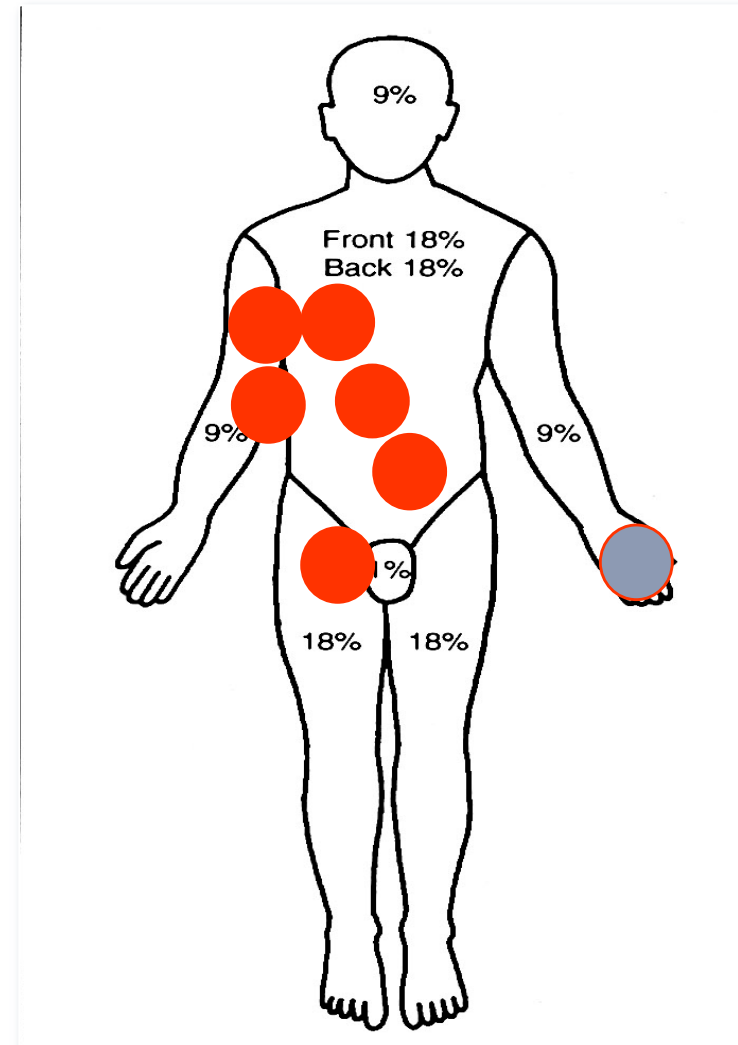


A. Rule of Nines

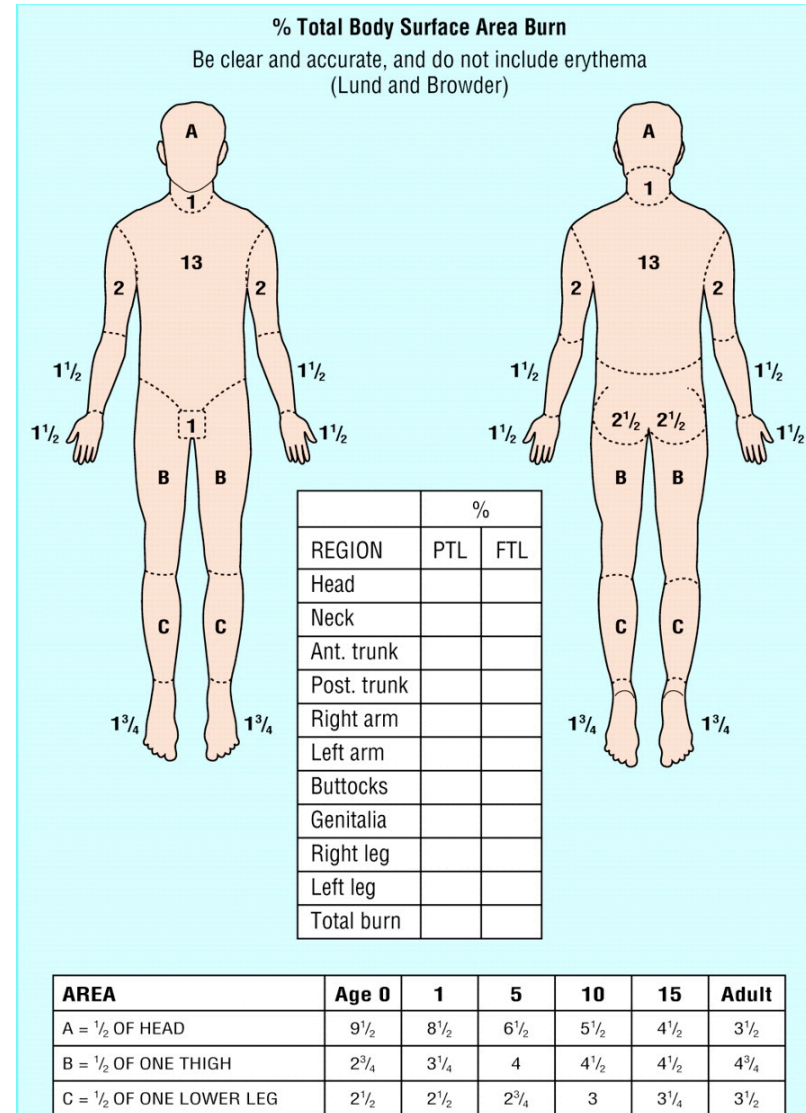


# Burn Classification By TBSA

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# Burn Classification By TBSA



# Burn Classification By Degree / Thickness



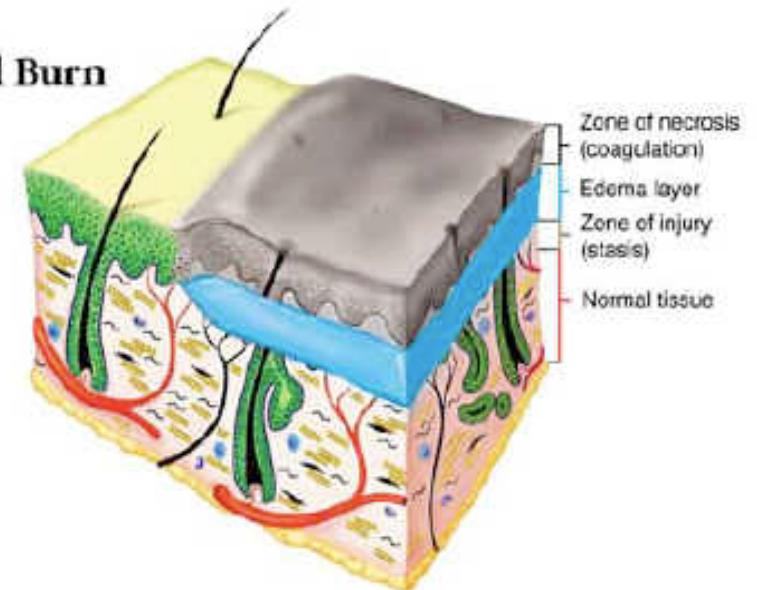
# Superficial (1<sup>st</sup> Degree)

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## Superficial Dermal Burn

### Characteristics

1. Necrosis confined to upper third of dermis
2. Zone of necrosis lifted off viable wound by edema
3. Small zone of injury









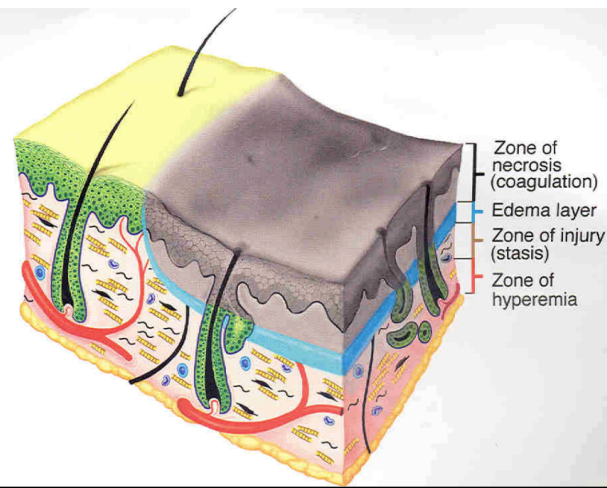


# Partial Thickness (2<sup>nd</sup> Degree)

## Mid-Dermal Burn

### Characteristics

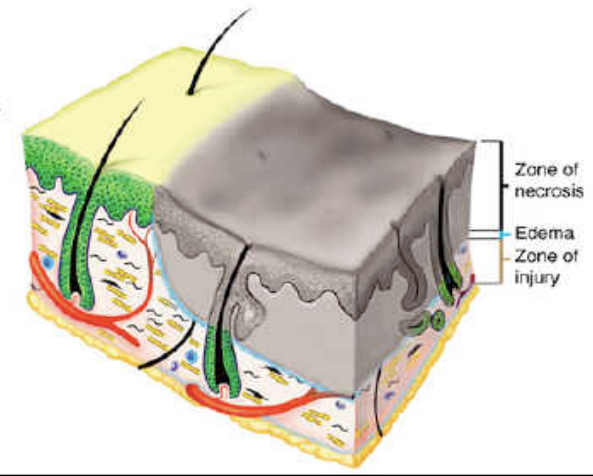
1. Necrosis to mid-dermis
2. Large zone of injury (potential conversion)
3. Eschar separated from viable tissue by edema layer



## Deep Dermal Burn

### Characteristics

1. Necrosis involving majority of skin layers
2. Zone of necrosis adherent to zone of injury
3. Smaller edema layer









# Full Thickness (3<sup>rd</sup> Degree Burns )

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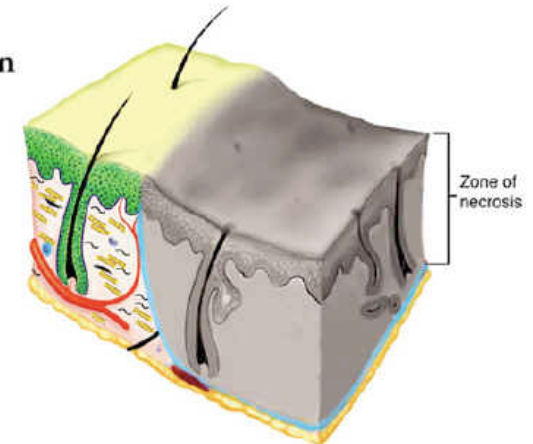
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## Full Thickness Burn

**Characteristic**  
No remaining viable dermis













# Full Thickness (4<sup>th</sup> Degree)

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# Determination of Burn Depth

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# Prognosis

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# Burn Management

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# Burn Management

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# History

## KEY POINTS OF A BURN HISTORY:

### **Exact mechanism**

- Type of burn agent (scald, flame, electrical, chemical)
- How did it come into contact with patient?
- What first aid was performed?
- What treatment has been started?
- Is there risk of concomitant injuries (such as fall from height, MVA, explosion)?
- Is there risk of inhalational injuries (did burn occur in an enclosed space)

### **Exact timings**

- When did the injury occur?
- How long was patient exposed to energy source?
- How long was cooling applied?
- When was fluid resuscitation started?

### **Exact injury**

#### *Scalds*

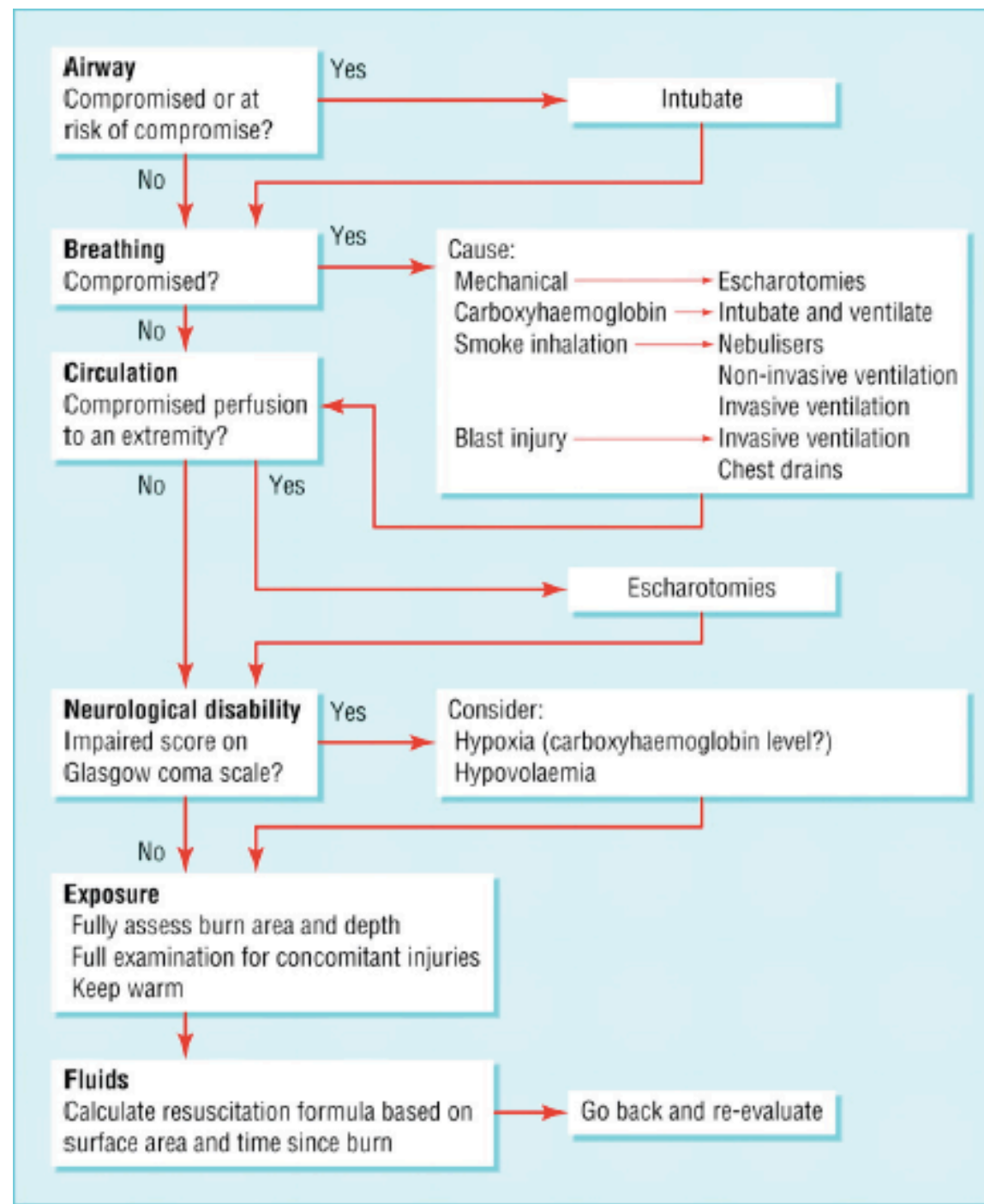
- What was the liquid? Was it boiling or recently boiled?
- If tea or coffee, was milk in it?
- Was a solute in the liquid?  
(Raises boiling temperature and causes worse injury, such as boiling rice)

#### *Electrical injuries*

- What was the voltage (domestic or industrial)?
- Was there a flash or arcing?
- Contact time

#### *Chemical Injuries*

- What was the chemical?



# Transfer Criteria

## **Burn Center Referral Criteria**

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.
9. Any burn with concomitant trauma (e.g., fractures) in which the burn injury poses the greatest risk of morbidity or mortality. If the 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.
10. Burn injury in children admitted to a hospital without qualified personnel or equipment for pediatric care.
11. Burn injury in patients requiring special social, emotional, and/or long-term rehabilitative support, including cases involving suspected child abuse.



# Inhalation Injuries

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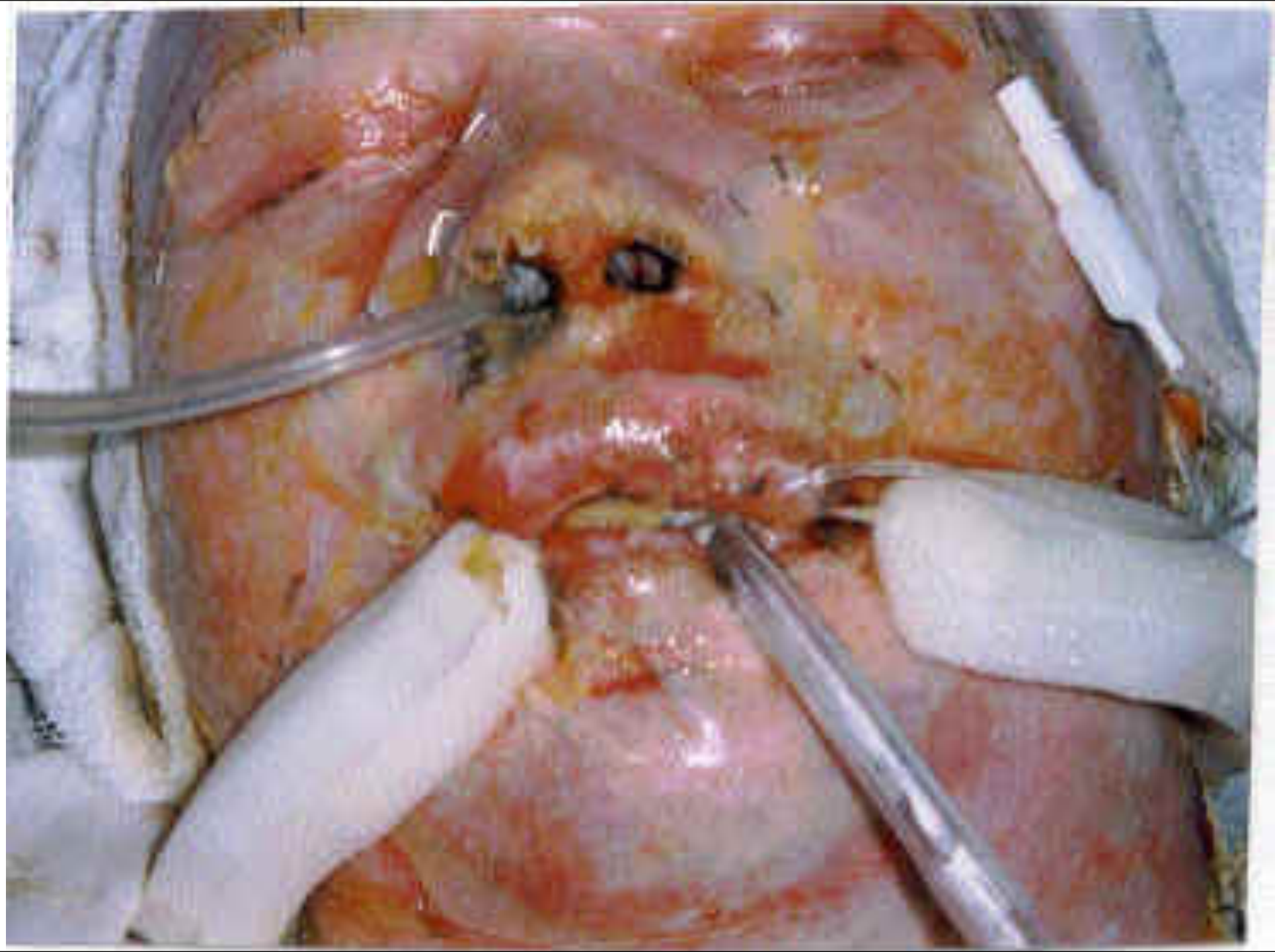
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# Inhalation Injury / CO

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# Inhalation Injury

## Carbon Monoxide

Co Level	Symptoms
<i>0 - 5</i>	<i>Normal Value</i>
15 - 20	Headache, Confusion
<i>20 – 40</i>	<i>Disorientation, Fatigue, Nausea &lt; Visual Changes</i>
40 – 60	Hallucinations, Coma < Shock
<i>60 or above</i>	<i>Mortality &gt;50%</i>

# Inhalation Injury Carbon Monoxide

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# Burn Management

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Fluid Resuscitations

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# Non-Surgical Burn Management

## Nutrition

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# Non-Surgical Burn Management Physiotherapy

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# Non-Surgical Burn Management Dressing

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# Non-Surgical Burn Management Dressing

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# Non-Surgical Burn Management Dressing

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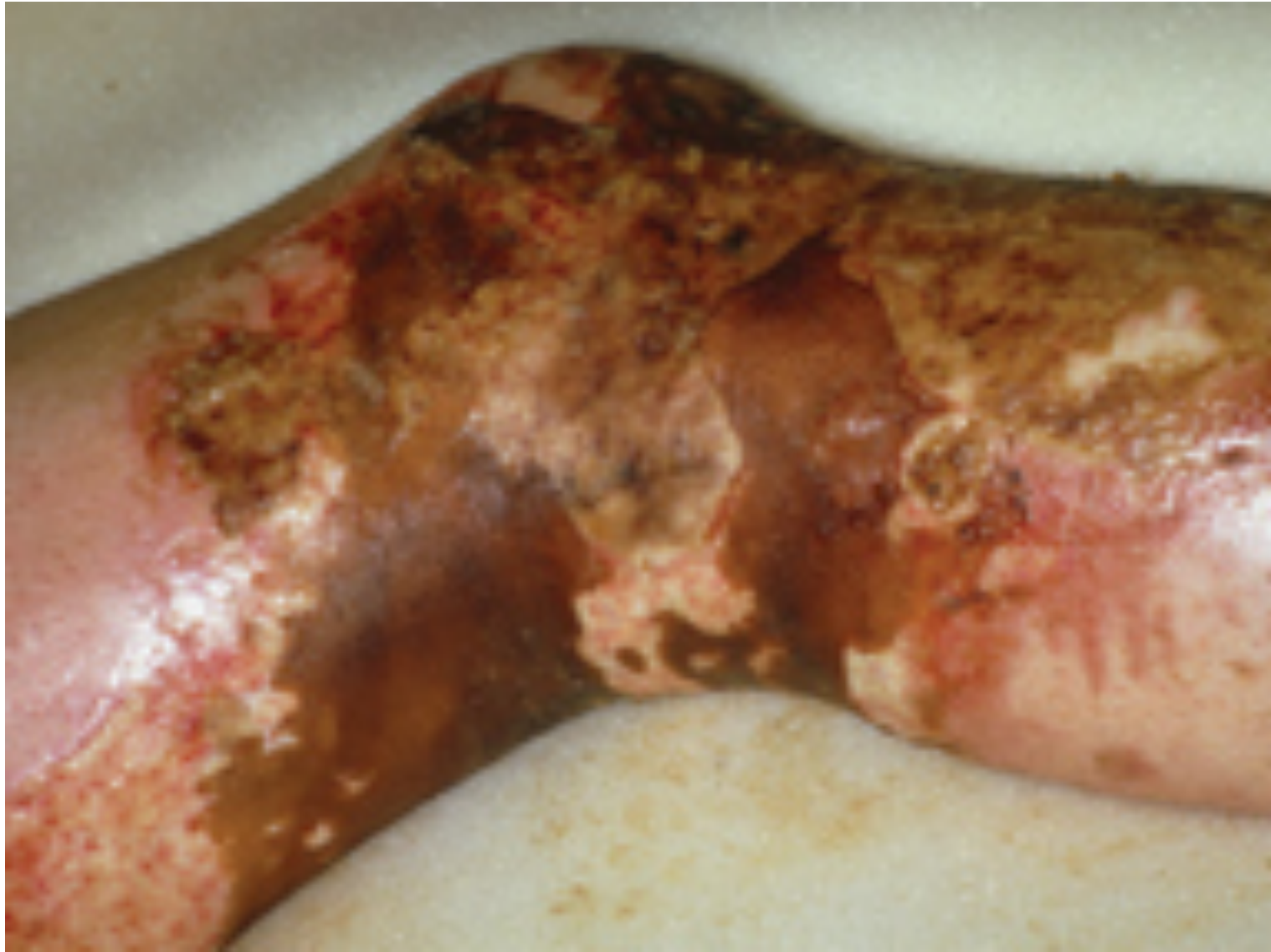
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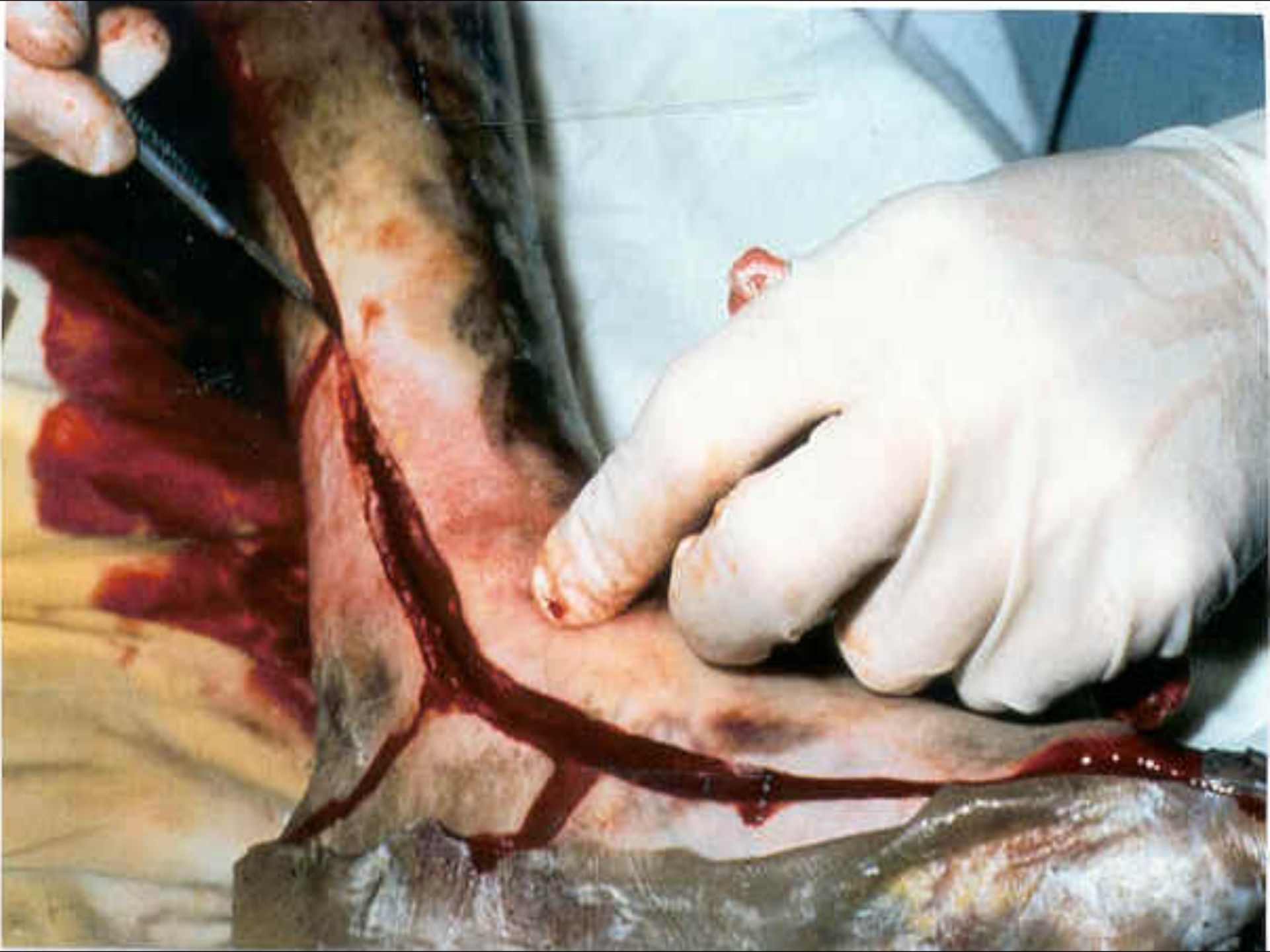


# Surgical Burn Management

## Escharotomy

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# Surgical Burn Management Escharotomy







# Skin Grafts

Split Thickness (STSG)	Full Thickness (FTSG)
<i>Epidermis + part of the dermis</i>	<i>Epidermis and entire dermis</i>
<i>Donor sites: Thighs - Back - Abdomen - Scalp - any part of the body</i>	<i>Donor sites: - Post auricular - supraclavicular - Groin - forearm</i>
<i>Advantages: Donor heals spontaneously Large donor area, can be reused Higher chance of take in less ideal conditions</i>	<i>Advantages: Less contraction Grows with the patient Secrets oil and sweat Better donor site scar and less pain More stable/durable</i>
<i>Disadvantages: More contraction</i>	<i>Disadvantage: Donor site must be closed</i>

# Surgical Burn Management Debridement, and Skin Graft



# Surgical Burn Management Debridement, and Skin Graft



# Surgical Burn Management Debridement, and Skin Graft



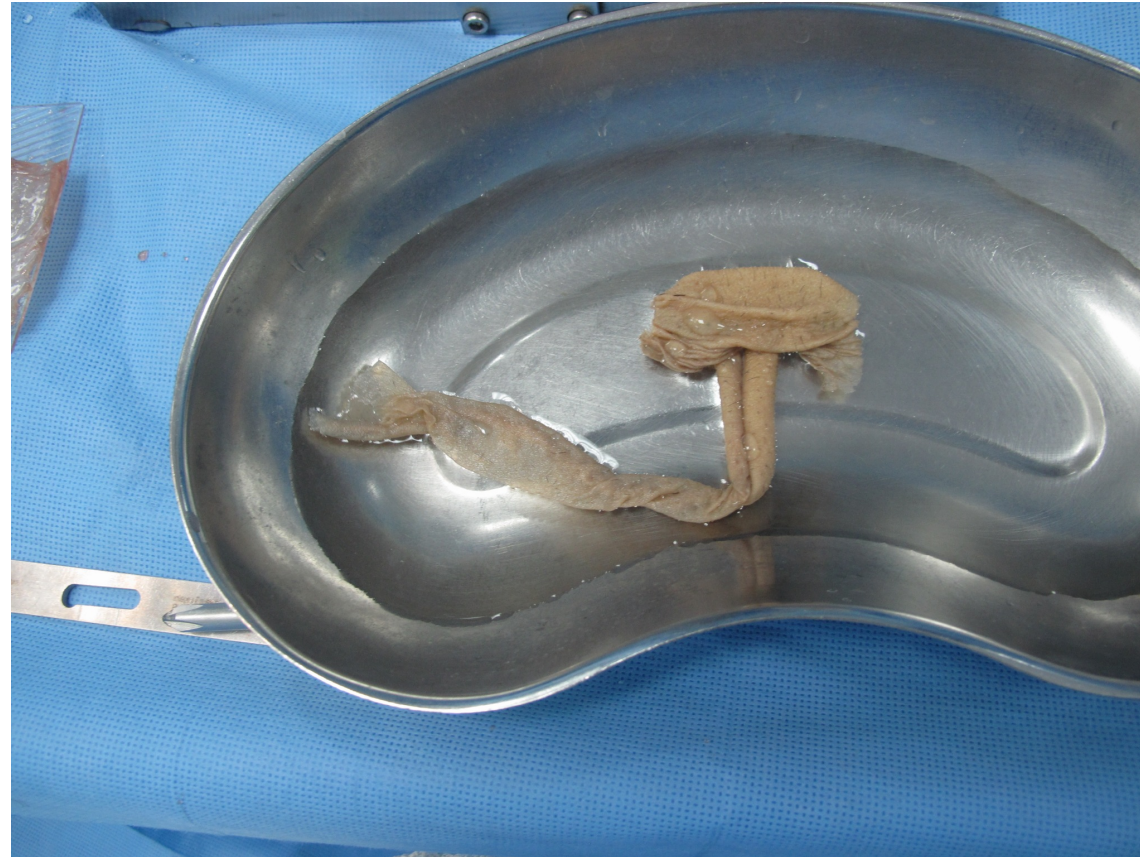


# Surgical Burn Management Debridement, and Skin Graft

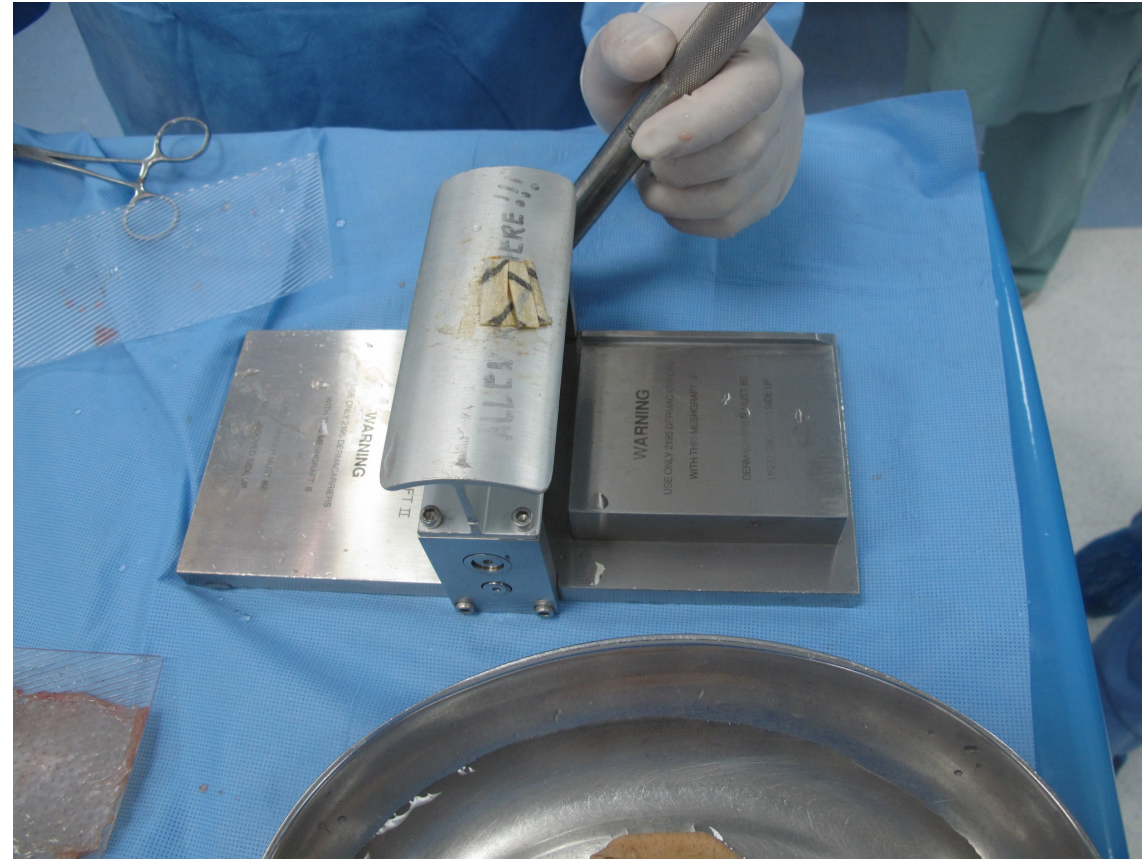




# Surgical Burn Management Debridement, and Skin Graft

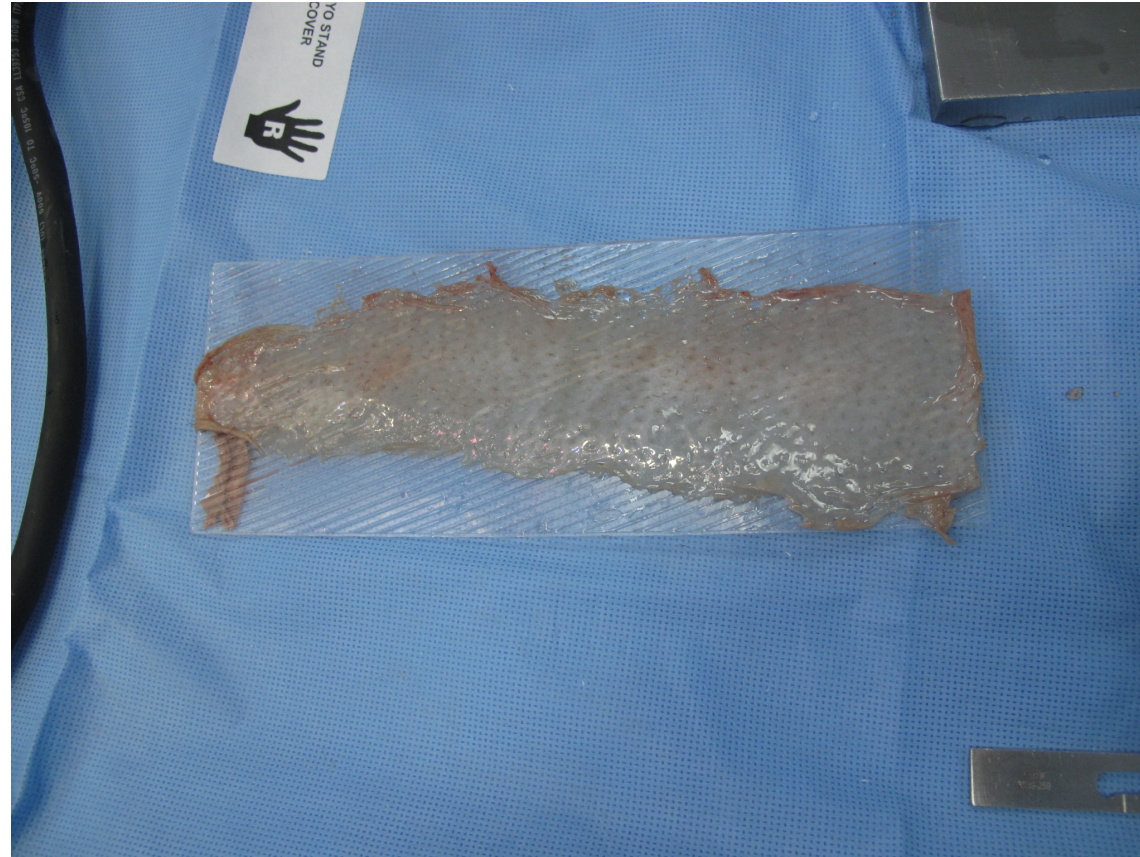


# Surgical Burn Management Debridement, and Skin Graft





# Surgical Burn Management Debridement, and Skin Graft

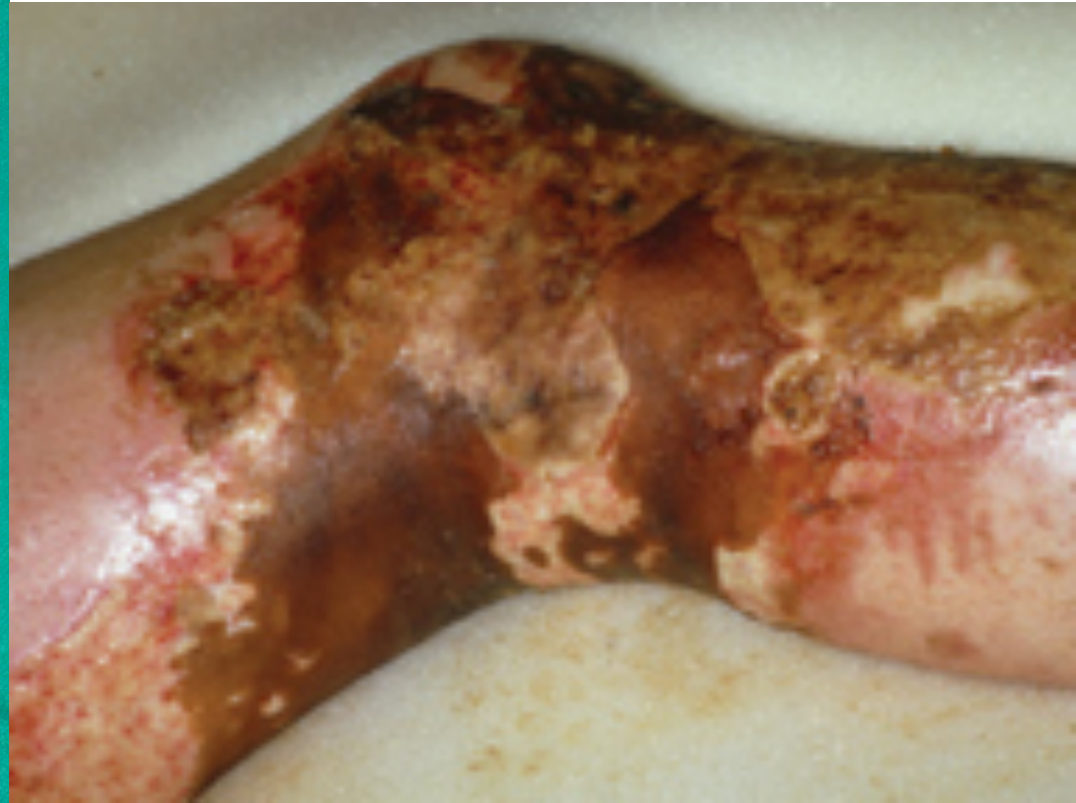








## Escharotomy Vs. Fasciotomy



# Surgical Burn Management

## Escharotomy





# Surgical Burn Management Fasciotomy



# Chemical Burn

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# Electrical Burn

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Questions ?













Jul 16, 08

















