

By the Name of ALLAH the Most Gracious the Most Merciful



Wounds, Tissue Repair and Scars

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To be read in

Bailey & Love's Short Practice of Surgery 27th Edition.

Wounds, healing and tissue repair Ch 3.

Learning objectives

To understand:

- Normal healing and how it can be adversely affected.
- How to manage wounds of different types, of different structures and at different sites.
- Aspects of disordered healing that lead to chronic wounds
- The variety of scars and their treatment.
- How to differentiate between acute and chronic wounds.

- Wound Definition.
Open (Penetrating / Blunt) / Closed .
- Wound Healing.
- Classification of wound closure and healing.
- Types of Wounds (Tidy Vs Untidy).
- Surgical wound classification.
- Some Specific Wounds.
- Managing the acute wound.
- Wound Complications:
 - Surgical Site Infection.
 - Wound Dehiscence.
 - Compartment syndrome.
 - Chronic Wound .
 - Necrotising Soft-Tissue Infections.
 - Scar and Contracture.

Wound definition

- (Break down / discontinuity in the integrity of cellular surface (i.e.an epithelial) with an extent to different depth down to deep structures.

- **Wounds can be : Open (exposed) / Closed (not exposed).**
- **Wounds can be : (Acute / Chronic).**
- **Wounds can be : (Tidy / Untidy).**
- **Trauma (Penetrating / Blunt).**
- **Trauma (force) Vs. (Injury = damage).**

Open Wound Types /Penetrating wounds:

- **Puncture wounds:** caused by an object that punctures and penetrates the skin (e.g. knife, splinter, needle, nail)
- **Surgical wounds and Incisions:** wounds caused by clean, sharp objects such as a knife, razor, or piece of sharp glass
- **Bites and stings.**
- **Gunshot wounds or other high velocity projectile** which penetrates the body (this may have one wound at site of entry and another at site of exit)

Open Wound Types/Blunt trauma wounds:

- **Abrasions:** superficial wounds due to the top layer of skin being traumatically removed (e.g. fall or slide on a rough surface).
- **Lacerations:** wounds that are linear and regular in shape from sharp cuts, to irregularly shaped tears from trauma.
- **Skin tears:** can be chronic like a wound in the base of a skin fissure, or acute due to trauma and friction.

Open Wound Types:

- **Thermal, chemical, or electrical burns**

Closed Wound Types

- **Contusions:** blunt trauma causing pressure damage to the skin and / or underlying tissues (includes bruises)
- **Blisters:** fluid filled pockets under the skin
- **Seroma:** a fluid filled area that develops under the skin or body tissue (commonly occur after blunt trauma or surgery)
- **Hematoma:** a blood filled area that develops under the skin or body tissue (occur due to internal blood vessel damage to an artery or vein)
- **Crush injuries:** can be caused by extreme forces, or lesser forces over a long period of time.

WOUND HEALING

- A mechanism whereby the body attempts to restore the integrity of the injured part.

Delayed healing may result in loss of function or poor cosmetic outcome (abnormal healing).

The aim of treatment is to achieve healing by primary intention and so reduce the inflammatory and proliferative responses.

CHRONIC WOUNDS

A chronic wound may be defined as one that fails to heal in the expected time for a wound of that type, which is usually less than 3 weeks. Delays in healing can occur at any phase but most often occur in the inflammatory phase.

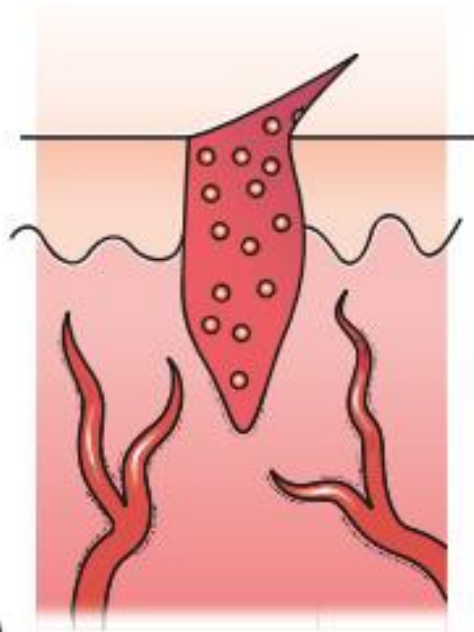
Factors influencing healing of a wound

- **Site of the wound.**
- **Structures involved.**
- **Mechanism of wounding:**
 - Incision**
 - Crush**
 - Crush avulsion**
- **Contamination (foreign bodies/bacteria).**
- **Loss of tissue.**
- **Other local factors**
 - Vascular insufficiency (arterial or venous).**
 - Previous radiation**
 - Pressure.**
- **Systemic factors:**
 - Malnutrition or vitamin and mineral deficiencies.**
 - Disease (e.g. diabetes mellitus).**
 - Medications (e.g. steroids).**
 - Immune deficiencies (e.g. chemotherapy, acquired immunodeficiency syndrome [AIDS]).**
 - Others :Smoking, Uremia, Jaundice, Anemia..**

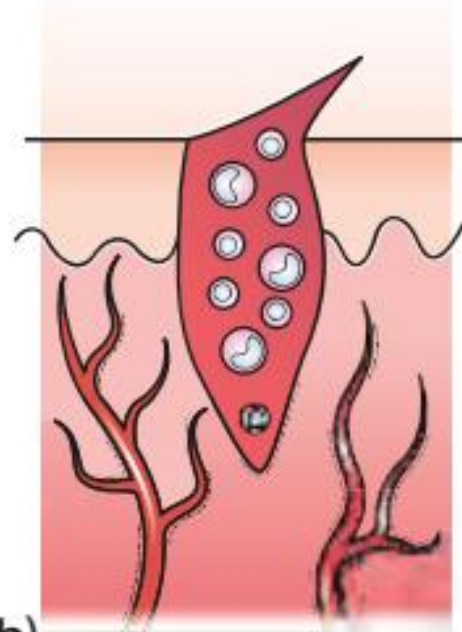
NORMAL WOUND HEALING

This is variously described as taking place in three or four phases, the most commonly agreed being:

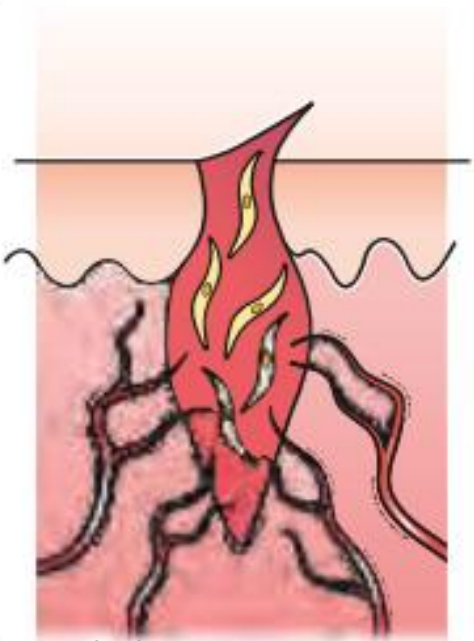
- A hemostatic phase.
- 1 the **Inflammatory phase**.
- A destructive phase :Cellular cleansing of the wound by macrophages.
- 2 the **Proliferative phase** (third day to the third week, fibroblast, collagen type III , (glycosaminoglycans and proteoglycans), (angiogenesis) [granulation tissue] and the reepithelialisation .
- 3 the **Remodelling phase** (maturing phase) maturation of collagen (type I replacing type III until a ratio of 4:1 is achieved). leads to increased tensile strength in the wound which is maximal at the 12th week.



(a)

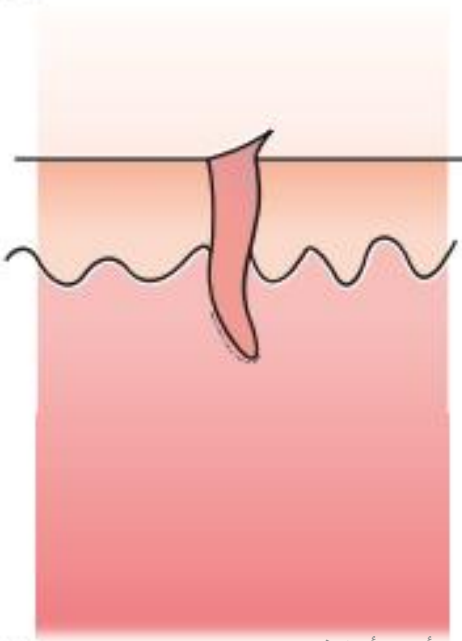


(b)



(c)

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(d)

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The phases of healing.

(a) Early inflammatory phase with platelet-enriched blood clot and dilated vessels.

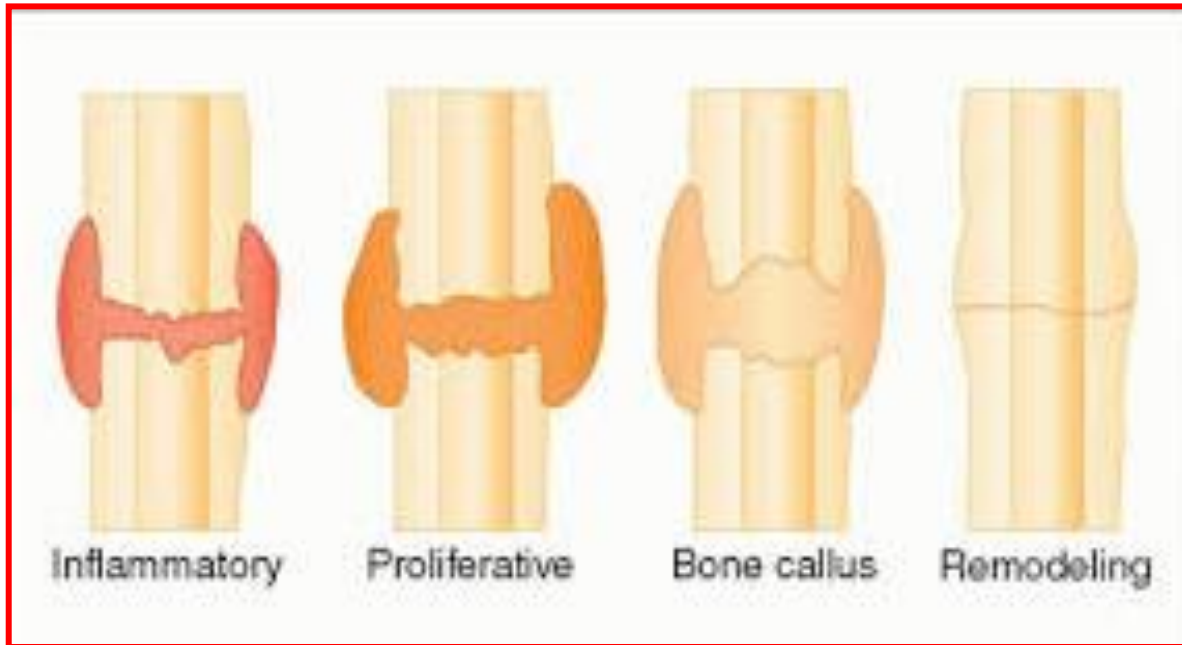
(b) Late inflammatory phase with increased vascularity and increase in polymorphonuclear leukocytes and lymphocytes (round cells).

(c) Proliferative phase with capillary buds and fibroblasts.

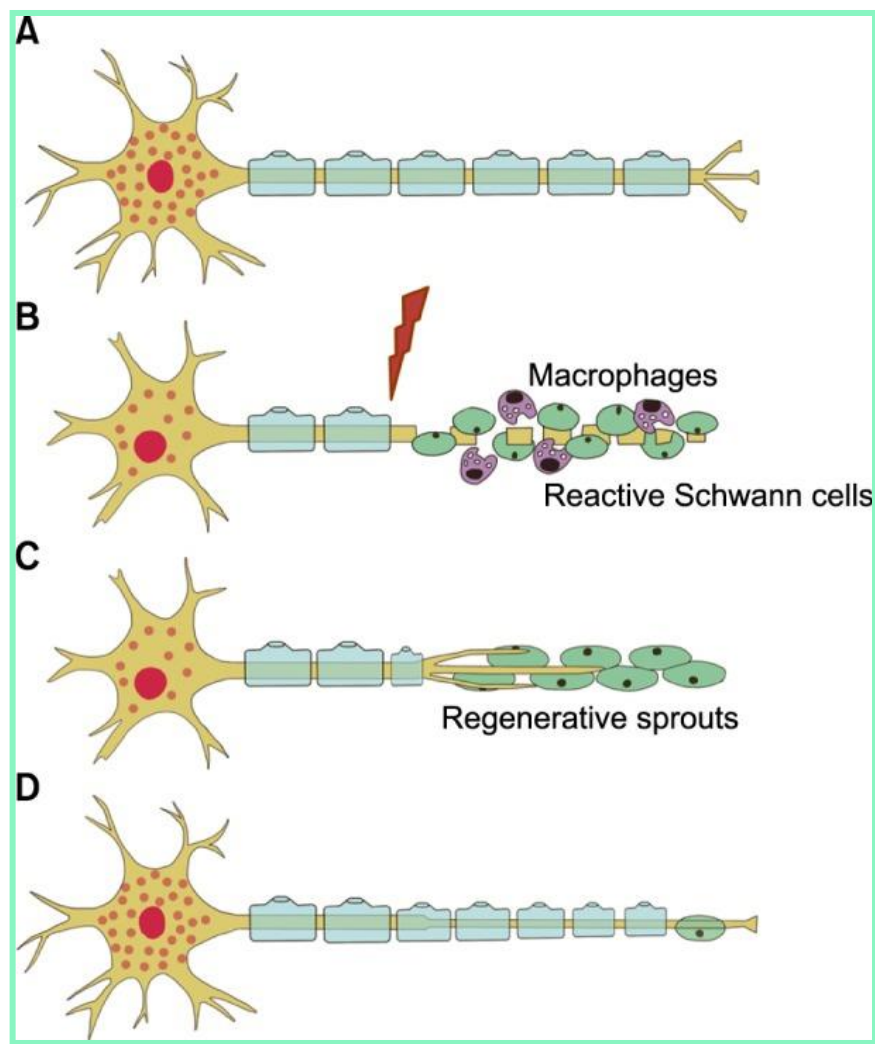
(d) Mature contracted scar.

NORMAL HEALING IN SPECIFIC TISSUES

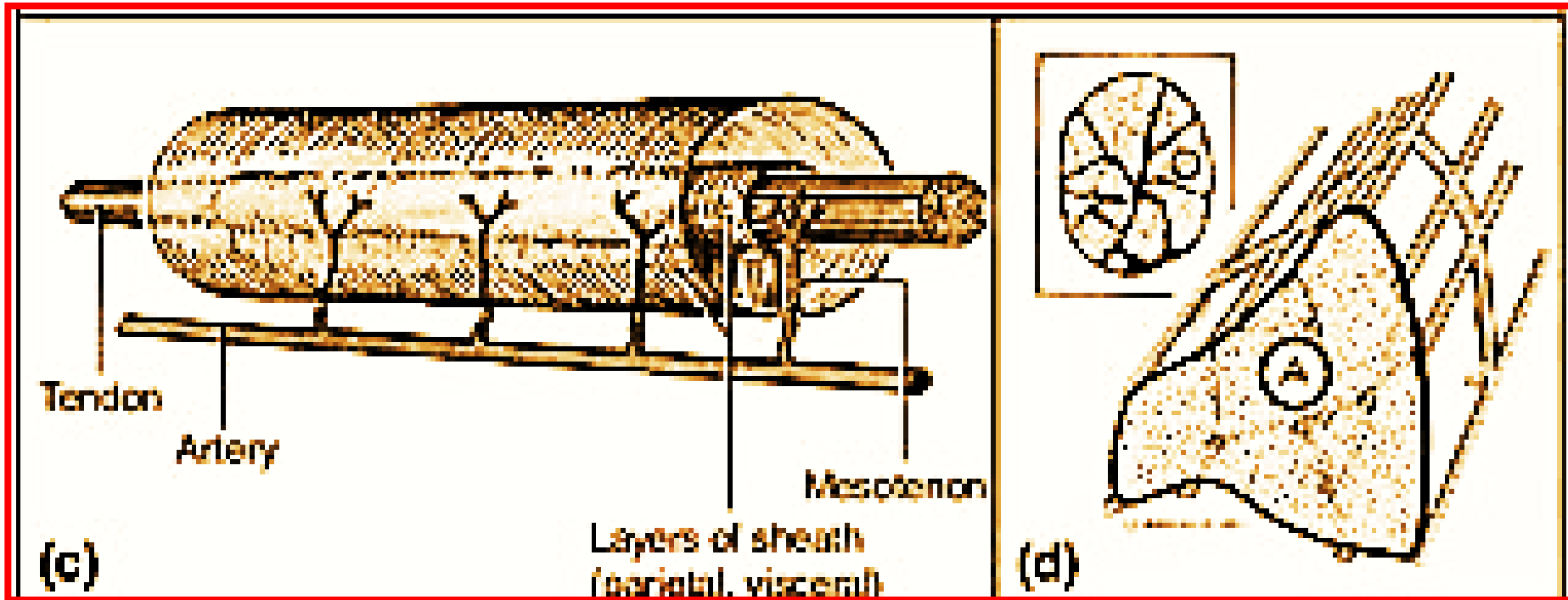
- Bone.
- Nerve.
- Tendon.



Periosteal and endosteal proliferation leads to the formation of callus, which is immature bone consisting of osteoid (mineralised by hydroxyapatite and laid down by osteoblasts). In the remodelling phase, cortical structure and the medullary cavity are restored. If fracture ends are accurately opposed and rigidly fixed, callus formation is minimal and primary healing occurs. If a gap exists, then secondary healing may lead to delayed union, nonunion or malunion.



Distal to the wound, Wallerian degeneration occurs. Proximally, the nerve suffers traumatic degeneration as far as the last node of Ranvier. The regenerating nerve fibres are attracted to their receptors by neurotrophism, which is mediated by growth factors, hormones and other extracellular matrix trophins. Nerve regeneration is characterised by profuse growth of new nerve fibres which sprout from the cut proximal end. Overgrowth of these, coupled with poor approximation, may lead to neuroma formation.



- Intrinsic, which consists of vincular blood flow and synovial diffusion.
- Extrinsic, which depends on the formation of fibrous adhesions between the tendon and the tendon sheath.

The random nature of the initial collagen produced means that the tendon lacks tensile strength for the first 3–6 weeks. Active mobilisation prevents adhesions limiting range of motion, but the tendon must be protected by splintage in order to avoid rupture of the repair.

ABNORMAL HEALING

Delayed healing may result in loss of function or poor cosmetic outcome. The aim of treatment is to achieve healing by primary intention and so reduce the inflammatory and proliferative responses.

Classification of wound closure and healing

- **Primary intention (first intention)**

 - Wound edges opposed.

 - Normal healing.

 - Minimal scar.

- **Secondary intention (dirty wound)**

 - Wound left open.

 - Heals by granulation, contraction and epithelialisation.

 - Increased inflammation and proliferation.

 - Poor scar.

- **Tertiary intention (also called delayed primary intention)**
(contaminated or untidy wounds)

 - Wound initially left open

 - Edges later opposed when healing conditions are favorable.

TYPES OF WOUNDS TIDY VERSUS UNTIDY

- The management of wounds based upon their classification into tidy and untidy.
- The surgeon's aim is to convert untidy to tidy by removing all contaminated and devitalised tissue.
- Primary repair of all structures may be possible in a tidy wound, but a contaminated wound with dead tissue requires debridement 'second look' .
- Injuries caused by explosions, bullets or other missiles, where the external wound itself may appear much smaller than the wider extent of the injured tissues deep to the surface.

TABLE 3.1 Tidy versus untidy wounds.

Tidy	Untidy
Incised	Crushed or avulsed
Clean	Contaminated
Healthy tissues	Devitalised tissues
Seldom tissue loss	Often tissue loss



Tidy Wound

Incised
Clean Healthy tissues
Seldom tissue loss

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(b)



Untidy wound

Crushed or avulsed, Contaminated, Devitalised tissues, Often tissue loss

Surgical wound classification

- Class I surgical wound : Clean.
- Class II surgical wound : Clean-contaminated.
- Class III surgical wound : Contaminated.
- Class IV surgical wound : Dirty / Infected.

Surgical Wound Classification Grades (I–IV) as Defined by the CDC

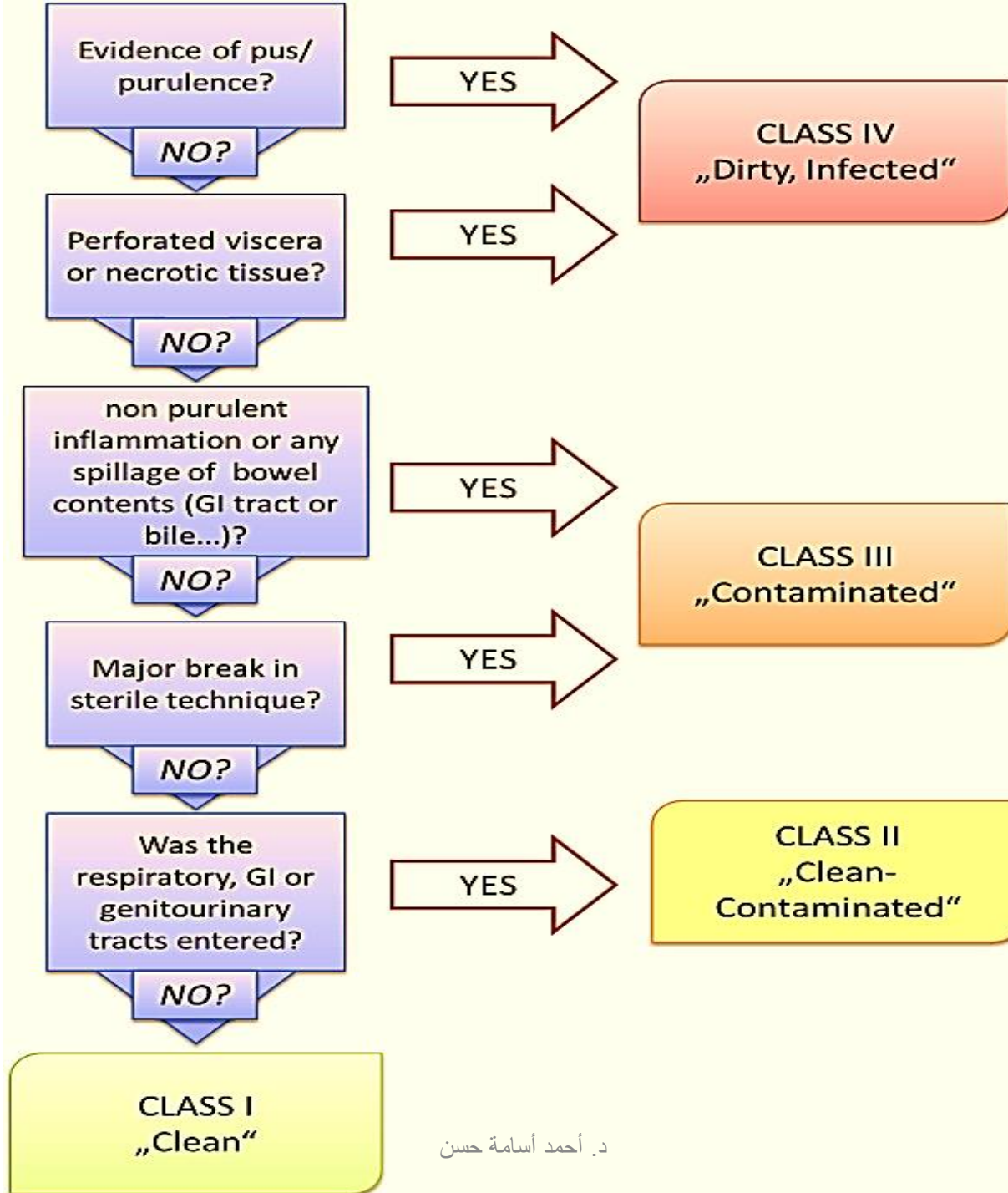
CDC Surgical Wound Classification Definitions

Class I/Clean: An uninfected operative wound in which no inflammation is encountered, and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow no penetrating (blunt) trauma should be included in this category if they meet the criteria.

Class II/Clean-Contaminated: An operative wound in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in a sterile technique is encountered.

Class III/Contaminated: Open, fresh, accidental wounds. In addition, operations with major breaks in a sterile technique (eg, open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute or no purulent inflammation is encountered are included in this category.

Class IV/Dirty-Infected: Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.



MANAGING THE ACUTE WOUND

- **Acute trauma life support (ATLS) principales (A,B,C,D,E,F).**
- **Hemostasis (pressure pad, clamping, tourniquet & ligation) .**
- **Swab (C + S).**
- **ATT vaccine.**
- **Body examination & wound assessment (ULA/GA).**
- **Cleansing (Irrigation with Normal saline) .**
- **Wound Toilet/Debridement/Exploration /Excision.**
- **Viability of the affected structure (Muscle :colour, bleeding pattern and contractility) . .**
- **Repair / replacemet of (vascular, nerve, tendon, bone, muscle) .**
- **Skin closure w/- (skin graft/flap).**
- **Careful tissue handling and meticulous technique**
- **NOT under tension.**
- **Drainage.**
- **Dressing (Wet media).**
- **Broad spectrum antibiotics (Anaerobic and aerobic bacteria) .**

SOME SPECIFIC WOUNDS

- Bites and Stings.
- Puncture wounds
- Haematoma
- Degloving (the skin and subcutaneous fat are stripped by avulsion from the underlying fascia, leaving neurovascular structures, tendon or bone exposed).
- Compartment syndrome.
- High-pressure injection injuries.

MANAGING SOME SPECIFIC WOUNDS

- **Bites** (animals, ear, tip of nose and lower lip are most usually seen in victims of human bites, teeth of a victim) .
- **Puncture wounds** (sharp objects should be explored. Needlestick injuries should be treated according to the wellpublished protocols because of hepatitis and HIV risks. Xray examination should be carried out in order to rule out retained foreign bodies in the depth of the wound).
- **Haematoma** (require release by incision or aspiration, may be associated with disruption of fat in the form of a fat fracture. An untreated haematoma may also calcify).
- **Degloving** (the skin and subcutaneous fat are stripped by avulsion from the underlying fascia, (neurovascular structures, tendon or bone), open :ring avulsion injury & closed degloving may be a rollover injury, caused by a motor vehicle over a limb. Exploration with assessment of skin viability +/- skin closure / approximaion.

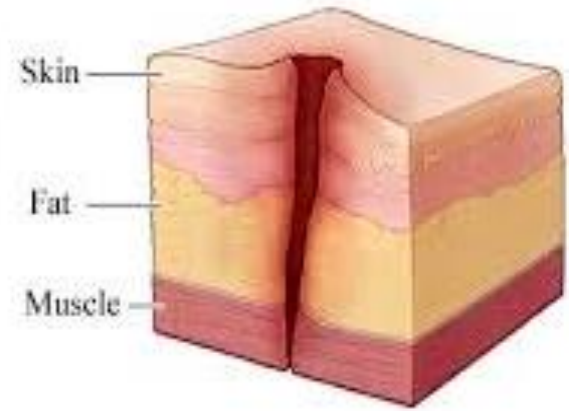


Bites



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Puncture wound

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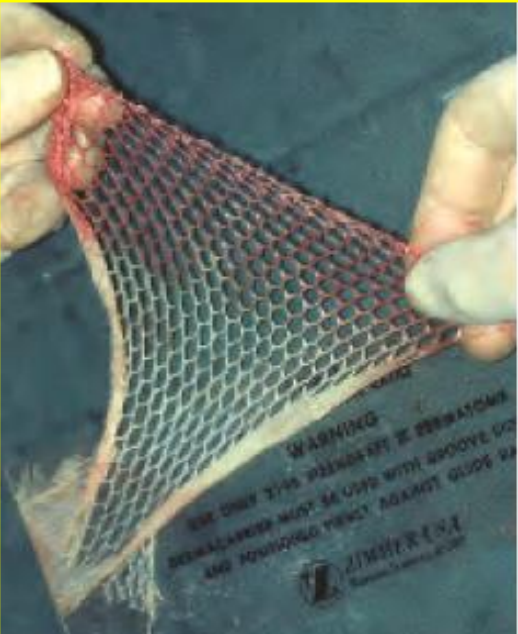
Haematoma



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Degloving hand injury



Meshed split-skin graft



Degloving buttock injury

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MANAGING SOME SPECIFIC WOUNDS

- **High-pressure injection injuries.**
- **Highpressure devices in cleaning, degreasing and painting can cause extensive closed injuries through small entry wounds.**
- **Preoperative xrays may be helpful where air or leadbased paints can be seen.**
- **wide surgical exposure, removal of the toxic substance and thorough debridement.**
- **Delayed or conservative treatment is therefore inappropriate.(Amputation).**



High-pressure injection injuries

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Wound Complications

- Surgical Site Infection.
- Wound Dehiscence.
- Compartment syndrome.
- Chronic Wound.
- Necrotising Soft-Tissue Infections.
- Scar and Contracture.

Postoperative wound Infection (Surgical Site Infection)

- Early and late.
- Management
 - Open the wound.
 - Wound swab for culture and sensitivity.
 - Broad spectrum antibiotics till the result of the wound swab.
 - Wound Toilet/Debridement/Excision.
 - Daily dressing .
 - Healing by (Tertiary or Secondary Intention).



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Wound Complications

- Surgical Site Infection.
- **Wound Dehiscence.**
- Compartment syndrome.
- Chronic Wound.
- Necrotising Soft-Tissue Infections.
- Scar and Contracture.

Wound Dehiscence

- Separation of the incision line prior to complete healing resulting in an open wound.
- Partial (incisional hernia).
- Complete : Need for (Vacuum Assisted Closure (V.A.C.) (Negative Pressure Wound Therapy)



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Partial Wound Dehiscence with intact skin (Incisional Hernia)



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Partial Wound Dehiscence with intact deep fascia, due to surgical site infection

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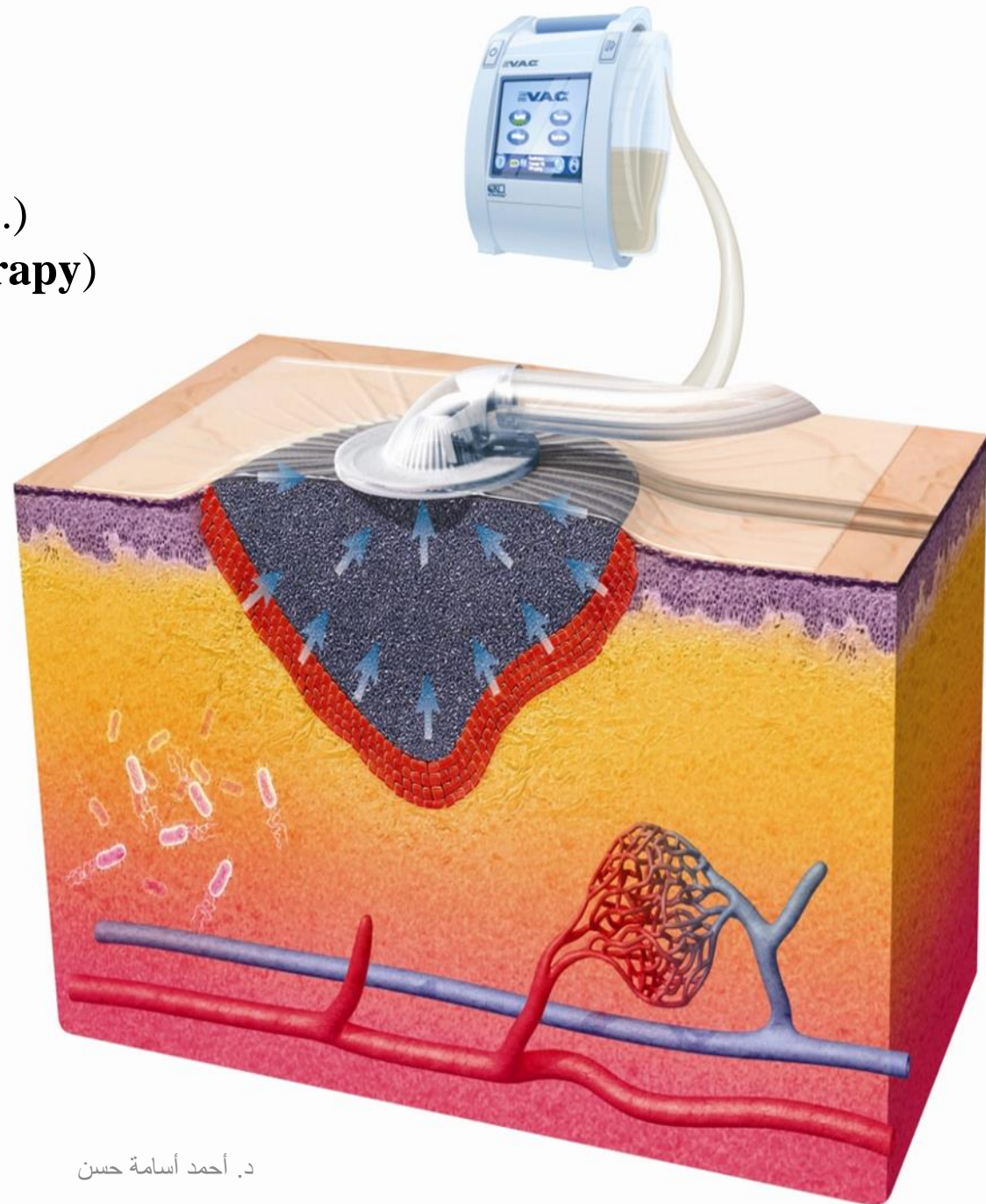
Complete Wound Dehiscence



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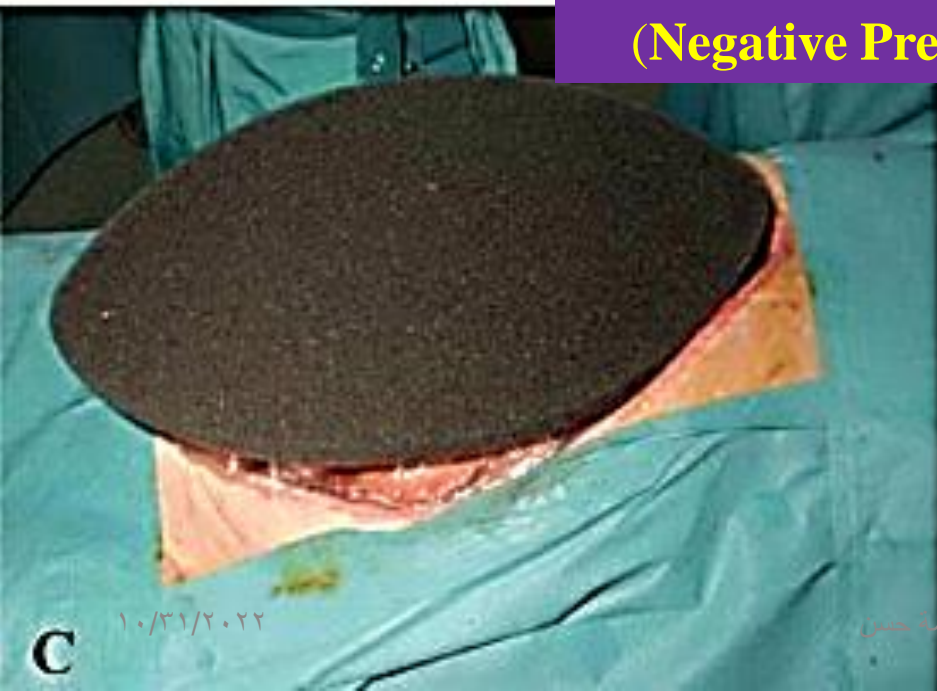
Complete Wound Dehiscence with through and through Technique

Vacuum Assisted Closure (V.A.C.) (Negative Pressure Wound Therapy)





**Vacuum Assisted Closure (V.A.C.)
(Negative Pressure Wound Therapy)**



Wound Complications

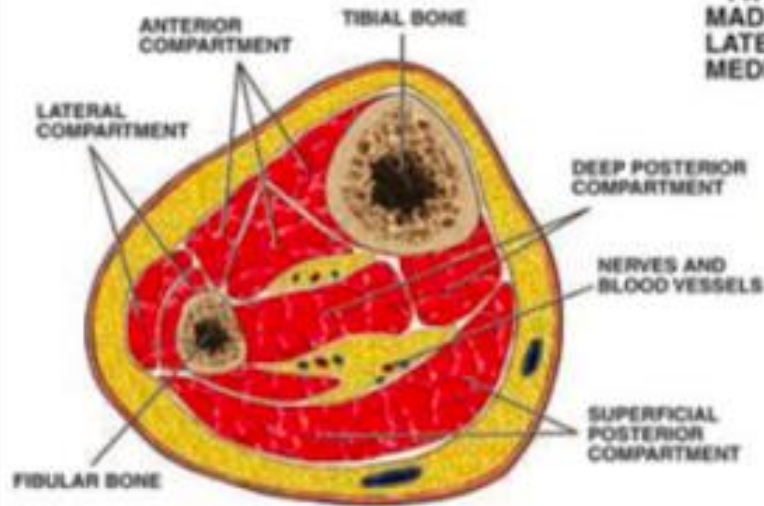
- Surgical Site Infection.
- Wound Dehiscence.
- **Compartment syndrome.**
- Chronic Wound.
- Necrotising Soft-Tissue Infections.
- Scar and Contracture.

Compartment Syndrome

- In crush injuries. Closed lower limb injuries.
- Pain on passive movement of the affected compartment muscles, distal sensory disturbance and, finally, by the absence of distal pulse. (a late sign).
- Fasciotomy (If pressures are constantly greater than 30 mmHg or if the above clinical signs are present). late fasciotomy can be dangerous because dead muscle produces myoglobin which, if suddenly released into the blood stream, causes myoglobinuria with glomerular blockage and renal failure.
- Amputation (nonviable tissues)

Compartment syndrome with fasciotomy

TWO LONG INCISIONS ARE MADE IN THE LOWER LEG, ONE LATERAL TO THE TIBIA AND ONE MEDIAL.



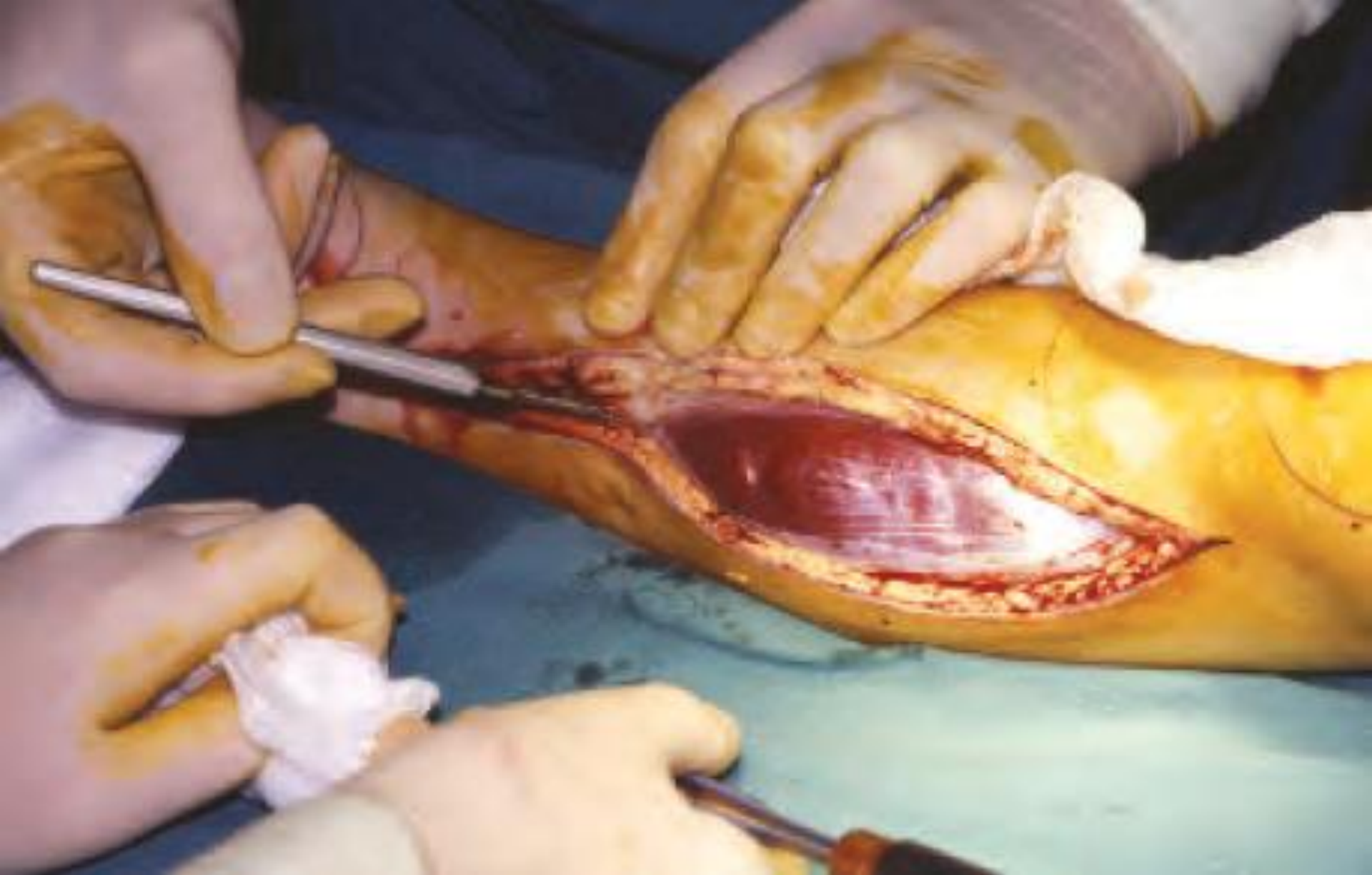
CROSS-SECTION THROUGH NORMAL CALF SHOWING MUSCLE COMPARTMENTS



COMPARTMENT SYNDROME: SWELLING OF MUSCLES CAUSING COMPRESSION OF NERVES AND BLOOD VESSELS



Anterior View



Fasciotomy involves incising the deep muscle fascia and is best carried out via longitudinal incisions of skin, fat and fascia . The muscle will then be seen bulging out through the fasciotomy opening.

Wound Complications

- Surgical Site Infection.
- Wound Dehiscence.
- Compartment syndrome.
- **Chronic Wound.**
- Necrotising Soft-Tissue Infections.
- Scar and Contracture.

CHRONIC WOUNDS

- Failure to heal in the expected time for a wound of that type, which is usually less than 3 weeks. Delays in healing can occur at any phase but most often occur in the inflammatory phase.
- Leg ulcers.
- Pressure sores .
- Marjolin's ulcer.

Leg ulcers

- A prolonged inflammatory phase leads to overgrowth of granulation tissue, and attempts to heal by scarring leave a fibrotic margin. Necrotic tissue, often at the ulcer centre, is called slough .
- should be biopsied to rule out neoplastic change, a squamous cell carcinoma known as a Marjolin's ulcer being the most common , also occurs .

Leg ulcers

- Arterial and venous circulation should be assessed, as should sensation throughout the lower limb.
- Treating the underlying cause .
- Surgical treatment is only indicated if nonoperative treatment has failed or if the patient suffers from intractable pain.
- Meshed skin grafts.
- The recurrence rate is high in venous ulceration, and patient compliance with a regime of hygiene, elevation and elastic compression is essential.

Aetiology of leg ulcers

- Venous disease leading to local venous hypertension (e.g. varicose veins)
- Arterial disease, either large vessel (atherosclerosis) or small vessel (diabetes)
- Arteritis associated with autoimmune disease (rheumatoid arthritis, lupus, etc.)
- Trauma – could be self-inflicted
- Chronic infection – tuberculosis/syphilis
- Neoplastic – squamous or basal cell carcinoma, sarcoma

Pressure Sore

- Tissue necrosis with ulceration due to prolonged pressure.
- Bed sores, pressure ulcers and decubitus ulcers.
- There is a higher incidence in paraplegic patients, in the elderly and in the severely ill patient.
- IF external pressure exceeds the capillary occlusive pressure
- (over 30 mmHg), blood flow to the skin ceases, leading to tissue anoxia, necrosis and ulceration.

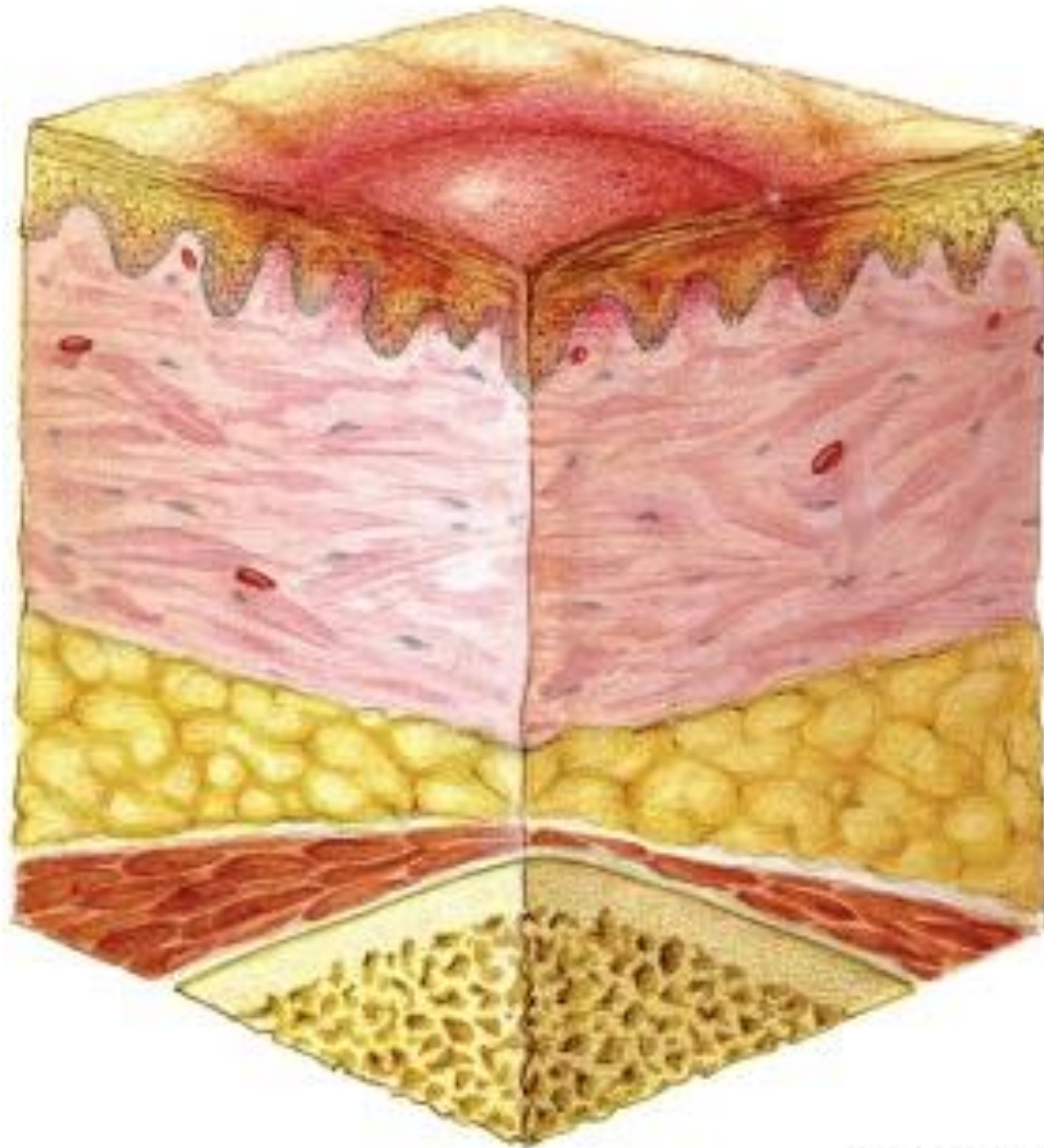
Pressure sore frequency in descending order

- Ischium
- Greater trochanter
- Sacrum
- Heel
- Malleolus (lateral then medial)
- Occiput

American National Pressure Ulcer Advisory Panel

TABLE 3.2 Staging of pressure sores.

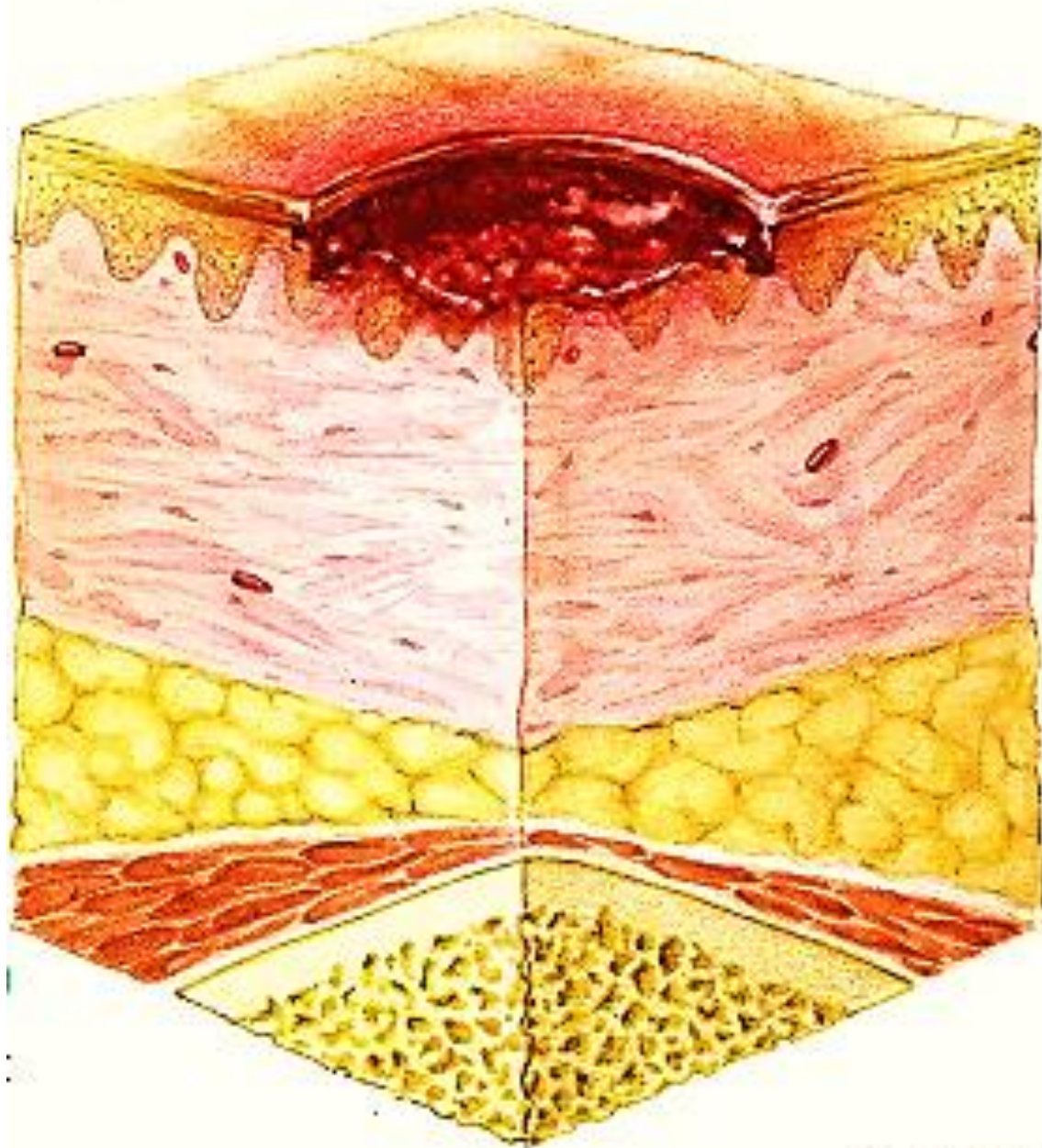
Stage	Description
1	Non-blanchable erythema without a breach in the epidermis
2	Partial-thickness skin loss involving the epidermis and dermis
3	Full-thickness skin loss extending into the subcutaneous tissue but not through underlying fascia
4	Full-thickness skin loss through fascia with extensive tissue destruction, maybe involving muscle, bone, tendon or joint





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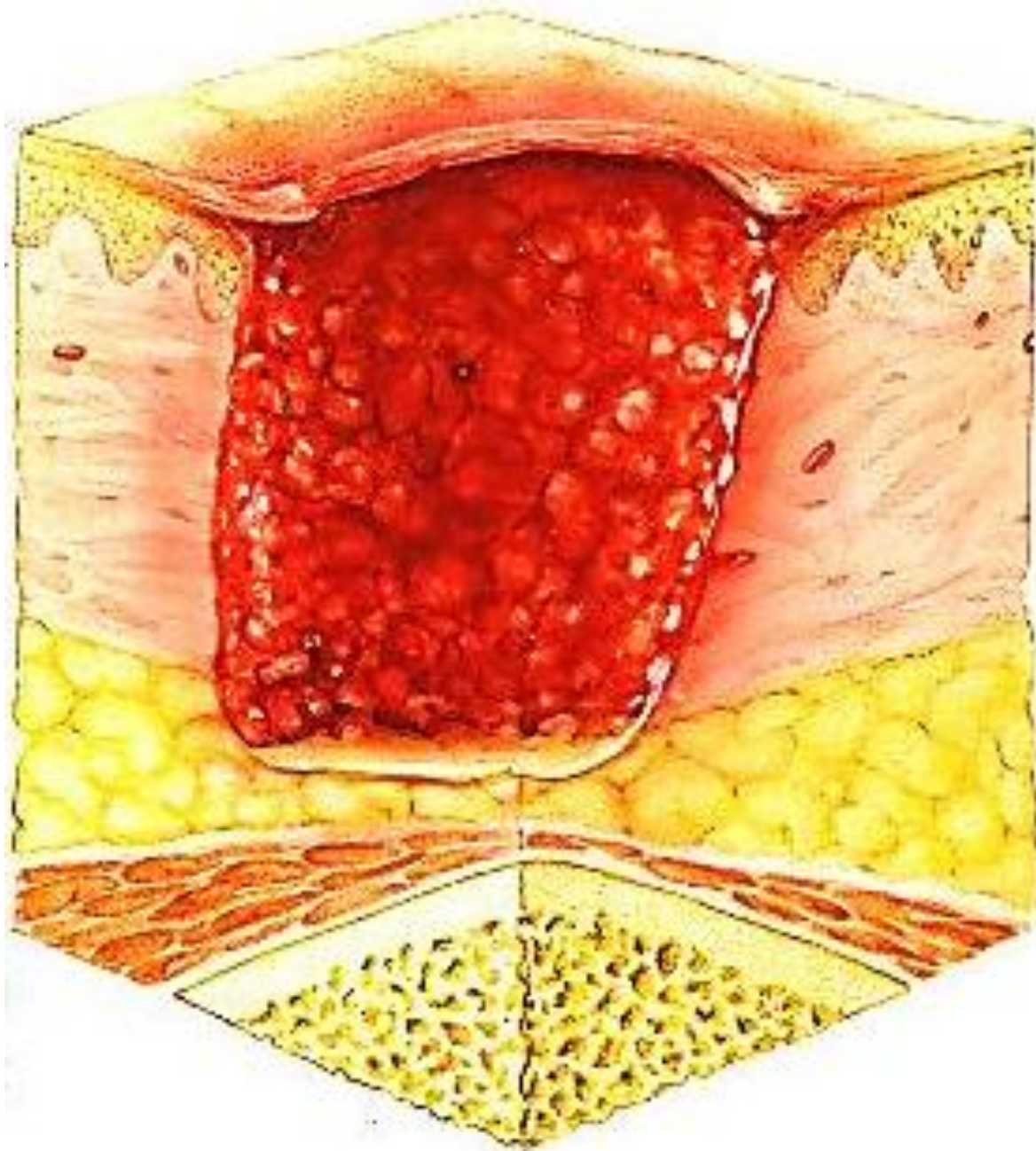


STAGE 2

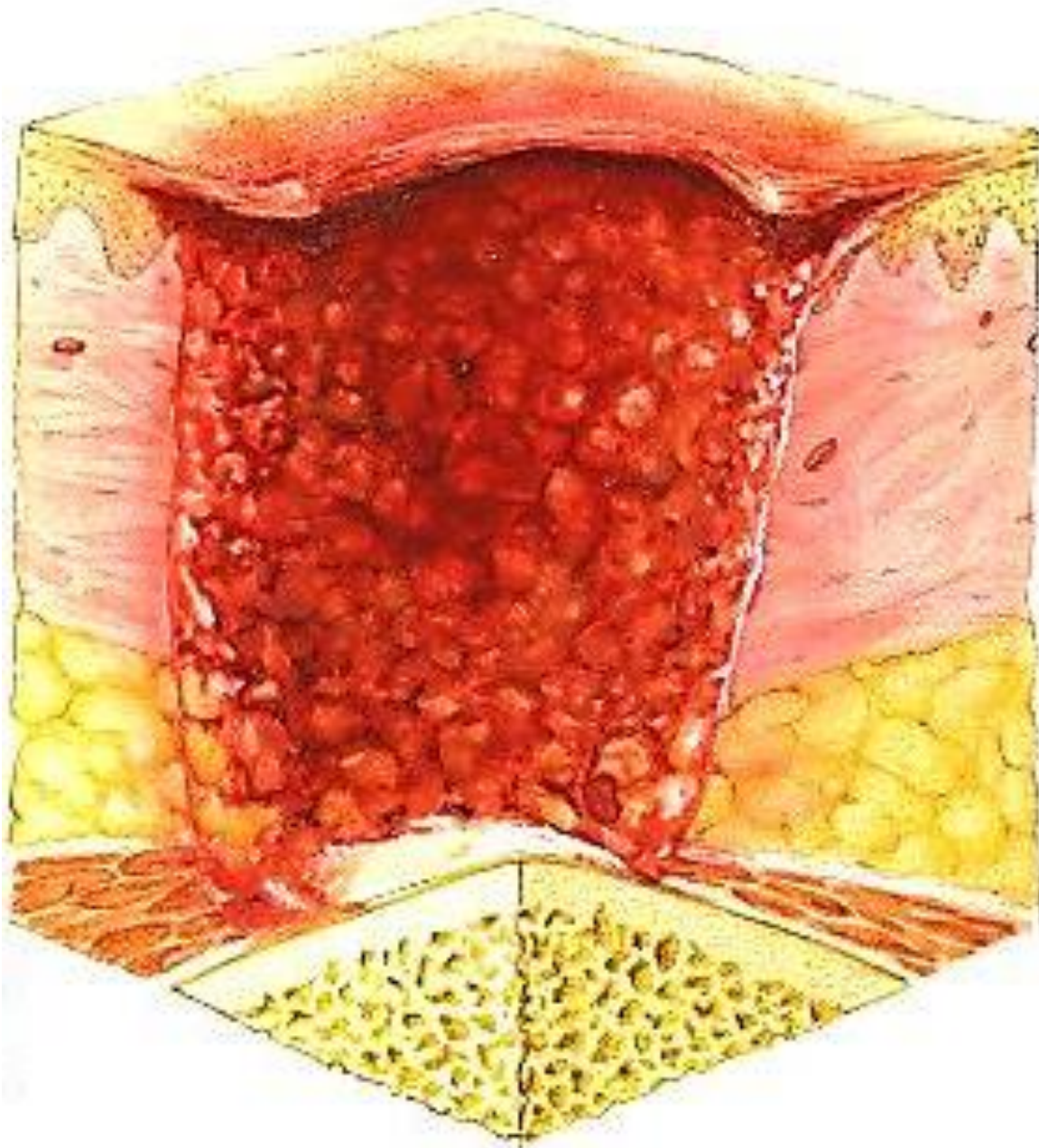


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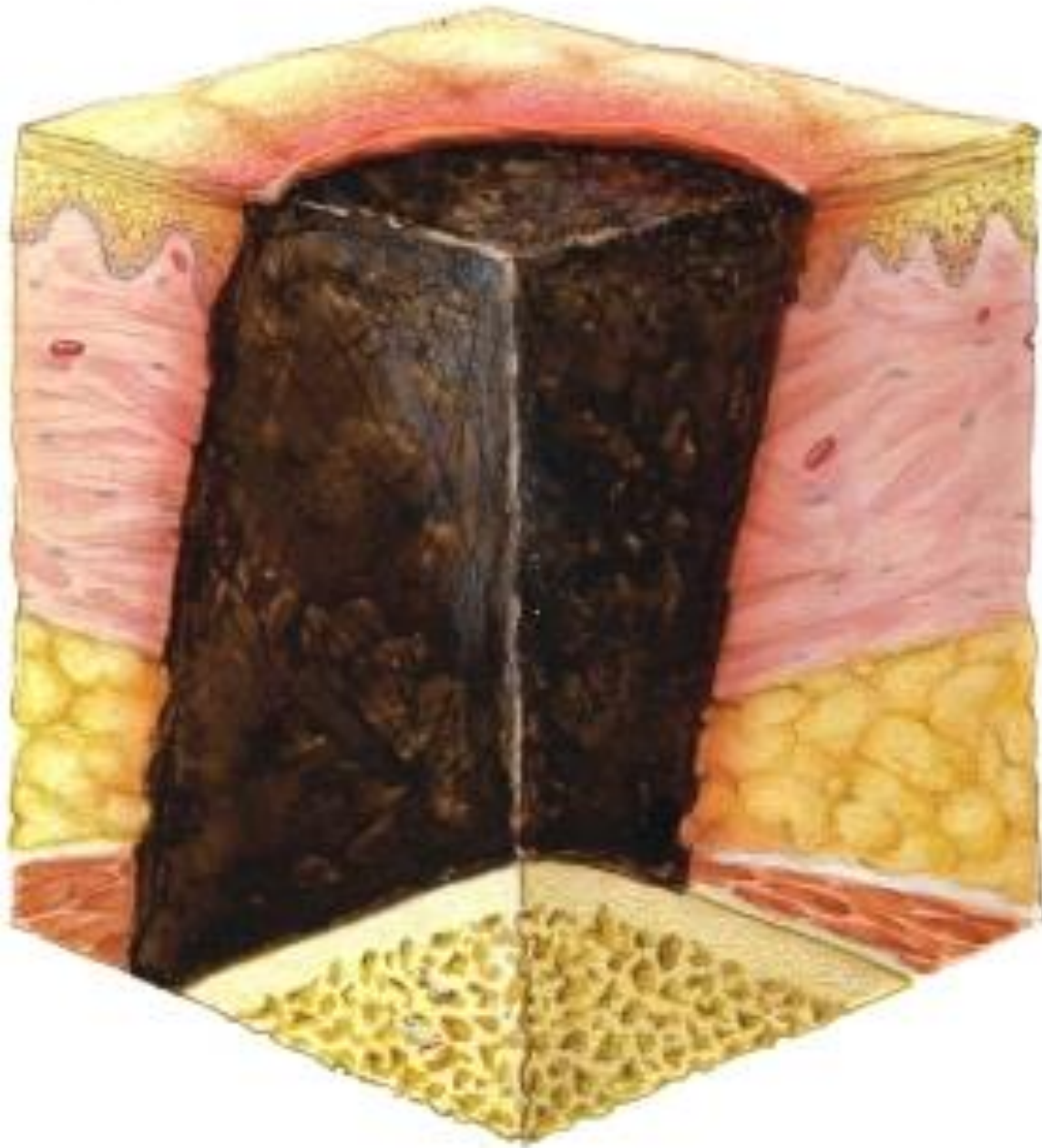






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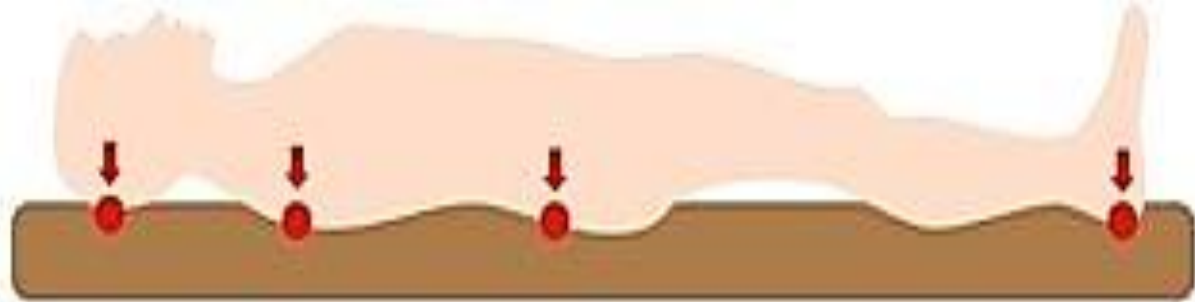
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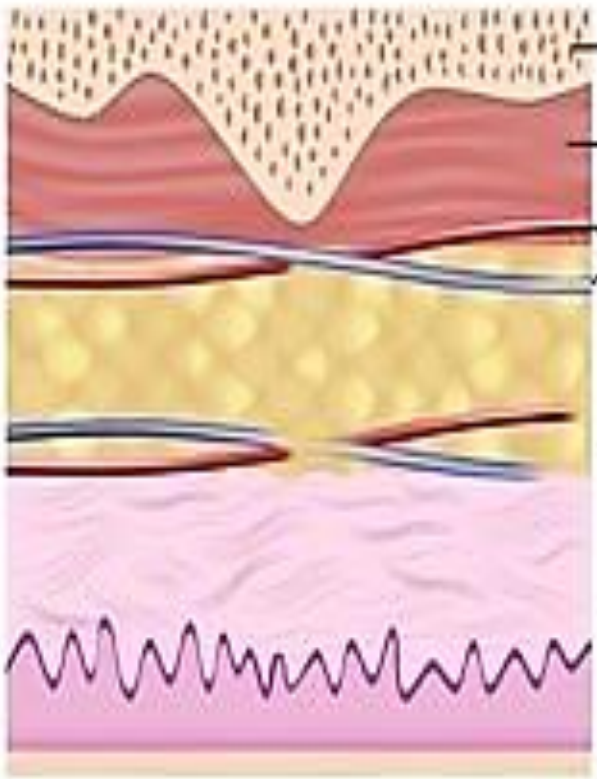


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Pressure of bone against hard surface

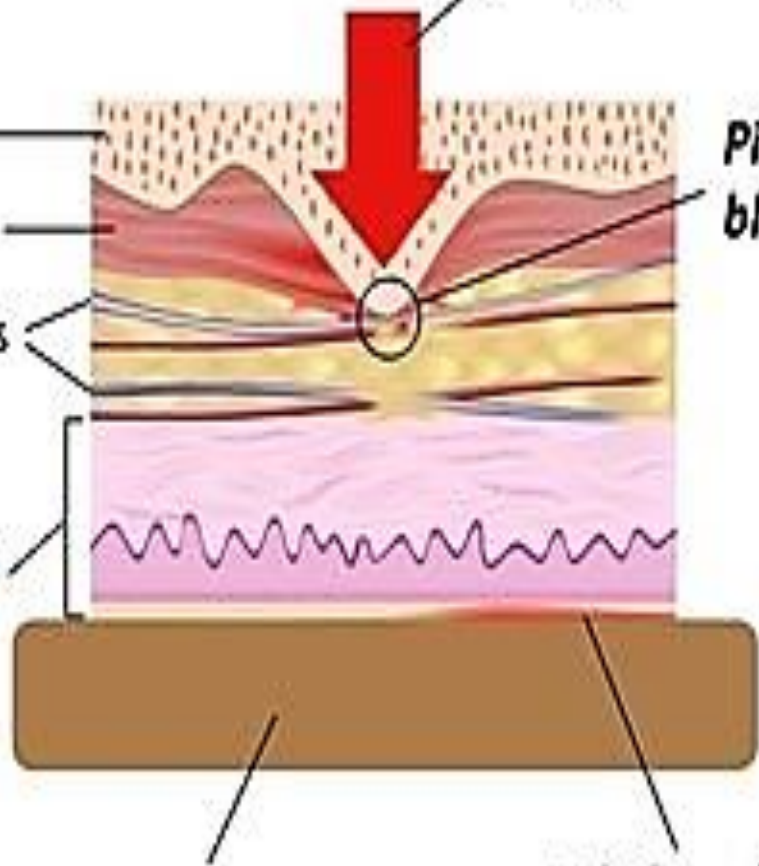


Bone

Soft tissue

Blood vessels

Skin layers



Pinching off of blood vessels

Hard surface (bed)

Friction of skin against the surface

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Normal

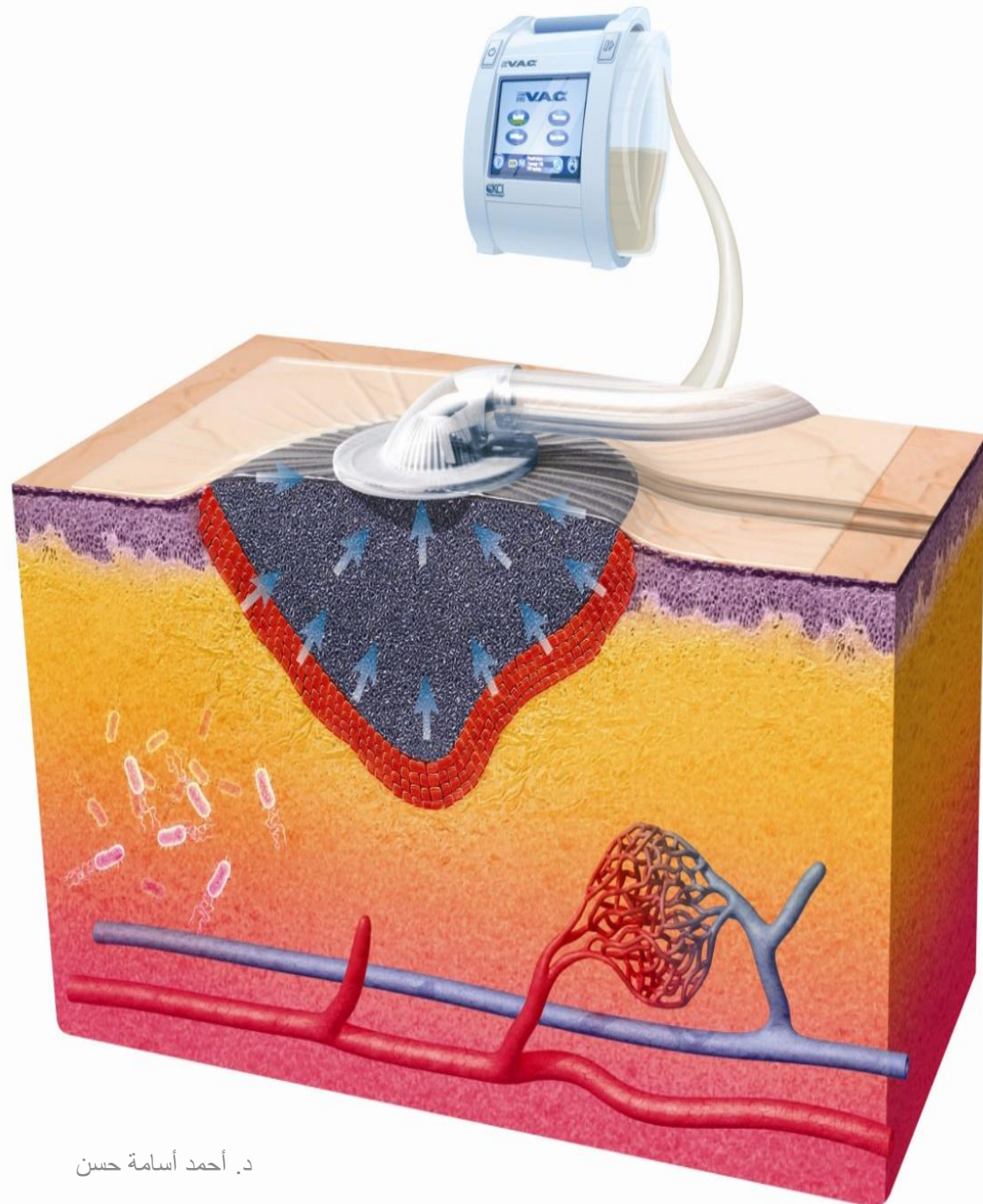
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Treatment of Bed Sore

- ❖ Swab for culture and sensitivity.
- ❖ Surgical debridement.
- ❖ Antibiotics (Broad spectrum).
- ❖ Continuous rolling the patient to each side every 2 hrs .
- ❖ ﴿وَنُقَلِّبُهُمْ ذَاتَ الْيَمِينِ وَذَاتَ الشِّمَالِ﴾ [الكهف: ١٨] (and We turned them on their right and on their left sides).
- ❖ Daily changing dressing and keeping the ulcer moist.
- ❖ Pneumatic Bed Sore Prevention.
- ❖ Topical tissue growth factor.
- ❖ Vacuum Assisted Closure (V.A.C.) (Negative Pressure Wound Therapy) Baily & Love 26th edition (P 29, 406, 584).
- ❖ Hyperbaric Oxygen Therapy.
- ❖ Rotational Flap.
- ❖ Urinary or faecal diversion in selected cases.
- ❖ Treatment underlying cause.



Hyperbaric Oxygen Therapy For Bed Sores



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Rotational Flap

Wound Complications

- Surgical Site Infection.
- Wound Dehiscence.
- Compartment syndrome.
- Chronic Wound.
- **Necrotising Soft-Tissue Infections.**
- Scar and Contracture.

NECROTISING SOFT-TISSUE INFECTIONS

Necrotising Fasciitis

- They are most commonly polymicrobial infections with Gram positive aerobes (Staphylococcus aureus, S. pyogenes), Gram negative anaerobes (Escherichia coli, Pseudomonas, Clostridium, Bacteroides) and beta-haemolytic Streptococcus.
- History of trauma or surgery with wound contamination.
- Sudden presentation and rapid progression.
- Deeper tissues are involved often leads to a late or missed diagnosis .



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- There are two main types of necrotising infections:
- Clostridial (gas gangrene) .
- Nonclostridial (streptococcal gangrene and necrotising Fasciitis).
- The variant of necrotising fasciitis with toxic shock syndrome results from *Streptococcus pyogenes* and is often called the 'flesh eating bug' in this situation.

Signs and Symptoms of Necrotising Infections

- Unusual pain
- Oedema beyond area of erythema.
- Crepitus.
- Skin blistering.
- Fever (often absent).
- Greyish drainage ('dishwater pus')
- Pink/orange skin staining.
- Focal skin gangrene (late sign).
- Shock, coagulopathy and multiorgan failure.



Fournier's gangrene

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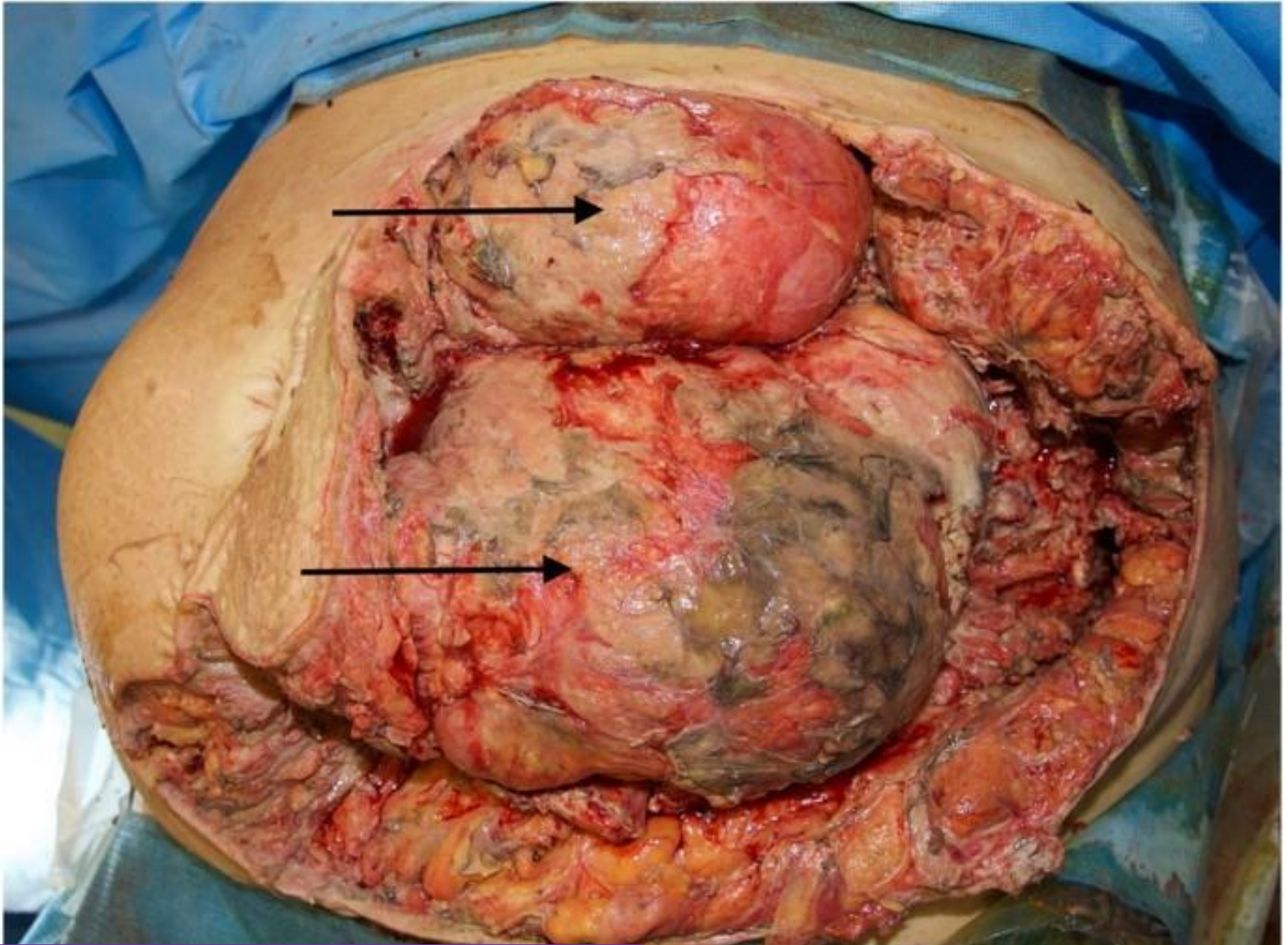
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Meleney's Synergic Gangrene



Meleney's Synergic Gangrene

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Treatment

- Appropriate antibiotics with wide surgical excision.
- Tissue irrigation and debridement session .
- Tissue biopsies are essential for histological diagnosis and culture.
- The raw areas resulting from excision often require skin grafting or flap.

Wound Complications

- Surgical Site Infection.
- Wound Dehiscence.
- Compartment syndrome.
- Chronic Wound.
- Necrotising Soft-Tissue Infections.
- Scar and Contracture.

SCARS

- **Hypertrophic scar (Skin) .**
- **Keloids (Skin) .**
- **Adhesions (Intestinal Obstruction) .**
- **Cirrhosis of the liver.**
- **Stricture (Common bile duct injury) .**
- **Stenosis (Injury to ureter) .**

SCARS (Skin)

- **Atrophic.**
- **Hypertrophic.**
- **Keloid.**

Atrophic scar

- An atrophic scar is pale, flat and stretched in appearance, often appearing on the back and in areas of tension. It is easily traumatised as the epidermis and dermis are thinned.
- Excision and re-suturing may only rarely improve such a scar.

Hypertrophic scar

- A hypertrophic scar is defined as excessive scar tissue that does not extend beyond the boundary of the original incision or wound. It results from a prolonged inflammatory phase of wound healing and from unfavourable scar siting (i.e. across the lines of skin tension). In the face, these are known as the lines of facial expression.

keloid scar

- A keloid scar is defined as excessive scar tissue that extends beyond the boundaries of the original incision or wound.
- Its aetiology is unknown, but it is associated with elevated levels of growth factor, deeply pigmented skin, an inherited tendency and certain areas of the body (e.g. a triangle whose points are the xiphisternum and each shoulder tip).

- The histology of both hypertrophic and keloid scars shows excess collagen with hypervascularity, but this is more marked in keloids where there is more type III collagen.
- Hypertrophic scars improve spontaneously with time, whereas keloid scars do not.

Summary box 3.7

Treatment of hypertrophic and keloid scars

- Pressure – local moulds or elasticated garments
- Silicone gel sheeting (mechanism unknown)
- Intralesional steroid injection (triamcinolone)
- Excision and steroid injections^a
- Excision and postoperative radiation (external beam or brachytherapy)^a
- Intralesional excision (keloids only)
- Laser – to reduce redness (which may resolve in any event)
- Vitamin E or palm oil massage (unproven)

^aAll excisions are associated with high rates of recurrence.



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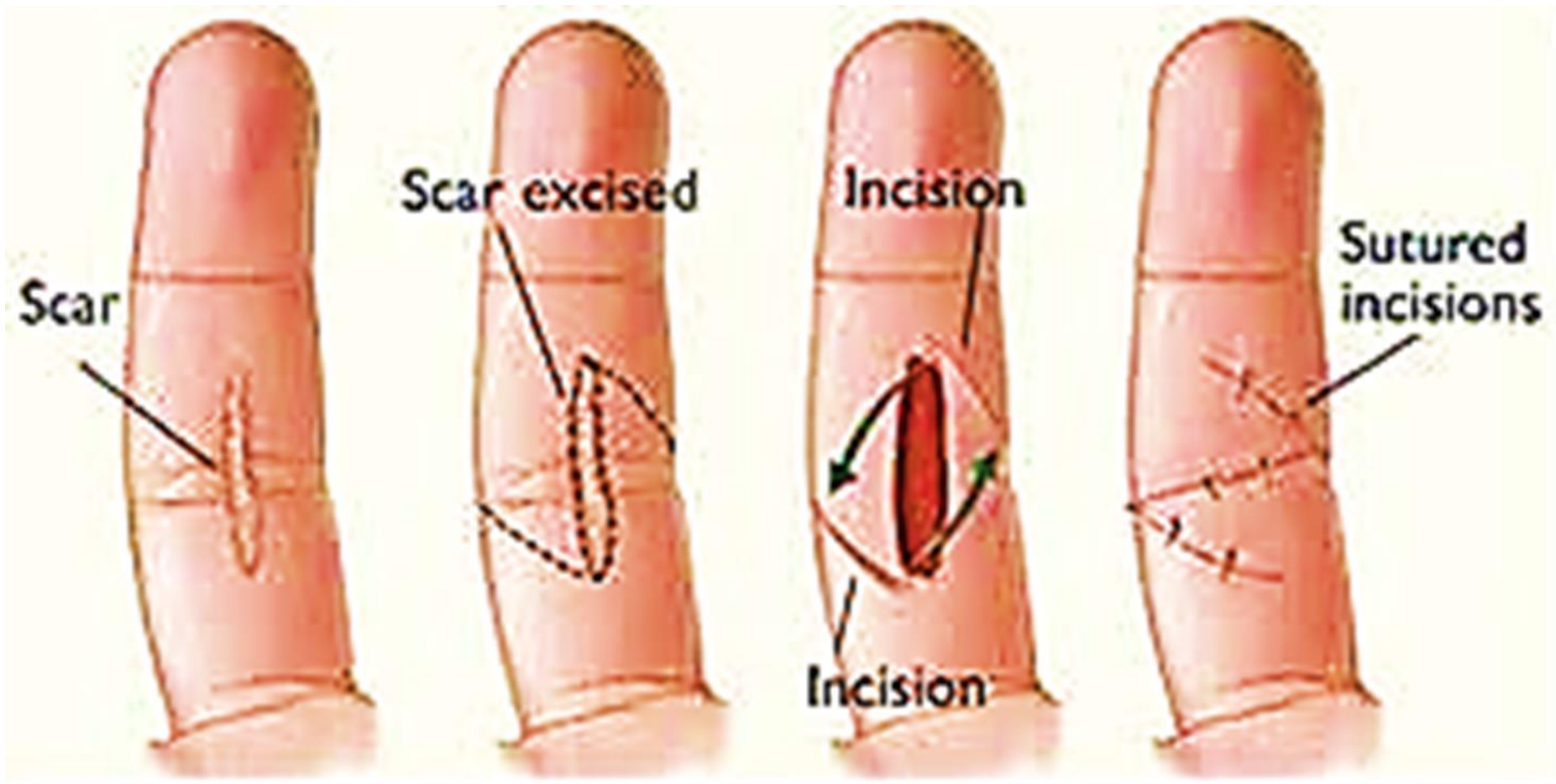
AVOIDABLE SCARRING

- Circumferential wound can be excised initially. Late treatment consists of scar excision and correct alignment of deeper structures or, as in the
- An excision of the scar margins and repair using W or Z plasty techniques.
- Suture marks may be minimised by using monofilament
- sutures that are removed early (3–5 days).
- Sutures inserted under tension will leave marks.
- Wounds can be strengthened post suture removal by the use of sticky strips.
- Fine sutures (6/0 or smaller) placed close to the wound margins tend to leave less scarring.
- Subcuticular suturing avoids suture marks either side of the wound or incision.
- Local herapy

CONTRACTURES

- A tight web may form restricting the range of movement at the joint and can cause hyperextension or hyperflexion deformity.
- Multiple Z- plasties.
- Requiring the inset of grafts or flaps.
- Splintage and intensive physiotherapy are often required postoperatively.

Z-plasty







**Post-traumatic
(chainsaw) midline
neck contracture**

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تم بتوفيق الله

لاتحسد أحداً بنعمة فأنت لاتعلم ماذا أخذ الله منه..
ولاتحزن بمصيبة فأنت لاتعلم ماذا سيعطيك الله عليها

{إنما يوفى الصابرون أجرهم بغير حساب}