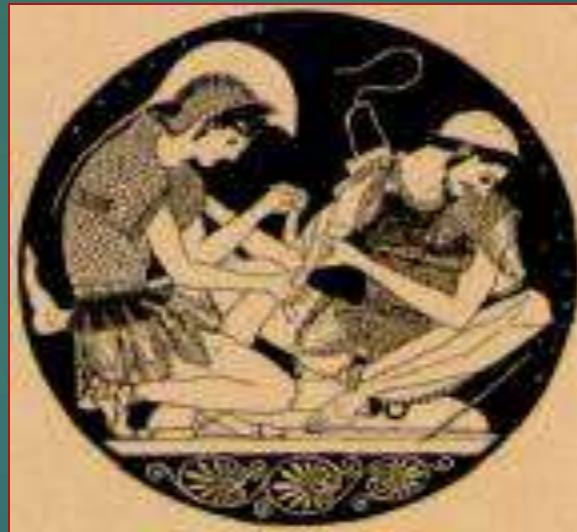


# Wounds. The processes of wound healing. Management of the wound



DR. KIRILL LOBASTOV

WOUND is an injury caused by physical exposures, with disruption of the normal continuity of the skin and underlying tissues.



The main clinical signs  
and symptoms of wounds are:

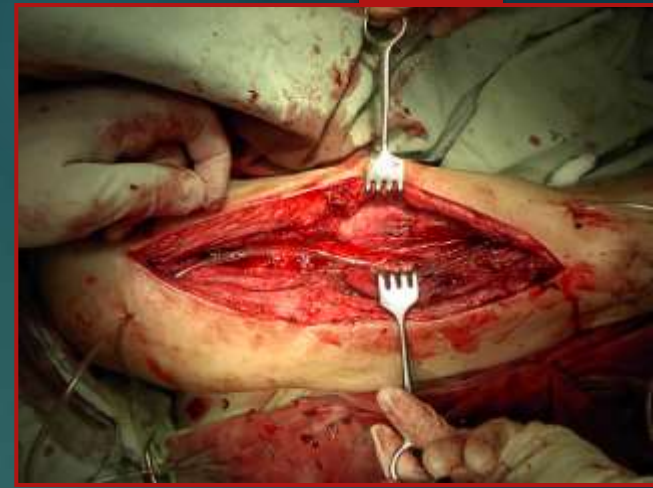
- ▶ pain
- ▶ bleeding
- ▶ gaping



# Classification of wounds:

Depending on the cause:

- 1). Surgical, or aseptic, i.e. resulting from aseptic surgery;
- 2). Accidental, or casual (these are always infected!);
- 3). Battle (wartime) wounds.



# Classification of wounds:

Depending on the presence  
of microorganisms in the wound:

- 1). Aseptic, or surgical;
- 2). Infected, or accidental;
- 3). Purulent, i.e. resulting from contamination with pyogenic flora.



# Classification of wounds:



In relation to the body cavities:

- 1). Penetrating, i.e. penetrate into the chest, abdominal cavity, the skull or joint cavities et cetera;
- 2). Non-penetrating, i.e. when the injury is confined to the cavity wall without penetrating into it.

# Classification of wounds:



Depending on the presence of complications:

- 1). Non-complicated, i.e. involving only mechanical tissue injury;
- 2). Complicated, i.e. in addition to mechanical damage , accompanied by other factors: poison, radioactivity, infection, burns and frostbite.

# Classification of wounds:

According to the character:

- 1). Incised;
- 2). Stab;
- 3). Chopped;
- 4). Contused;
- 5). Lacerated;
- 6). Bite;
- 7). Gunshot;
- 8). Poisoned;
- 9). Combined



# Types of wounds:



Incised (slashed) wounds tend to have smooth edges and, as a rule, be confined to soft tissues. When the incision is transverse to the elastic fibres of the skin compared to longitudinal incisions the wound gapes, bleeds more.

# Types of wounds:



Stab wounds caused by knives, awl, bayonets as well as other sharp piercing objects have smaller entry sites and are commonly accompanied by minimum damage to the adjacent tissues.

# Types of wounds:



Chopped wounds have even edges and are characterized by soft tissue damage and haemorrhage around the wound. Bleeding is usually profuse and there can be bone involvement.

# Types of wounds:



Contused wounds have an irregular shape. The adjacent tissue is crushed, there are marked haemorrhages with haematomas. The crushed adjacent tissue are normally not viable and are necrotised later on.

# Types of wounds:



Lacerated wounds can result from contact with a fast moving objects (e.g. a saw, shell-splinter). Tissue damage (the skin, muscle, tendon) in such injuries is marked. The wounds has an irregular shape, edges are jagged and there are massive haemorrhages into the skin, subcutaneous tissues and muscles. The wound cavity can also be filled with blood clots, bleeding mildly.

# Types of wounds:



Bite wounds occur from animal or human bites. They are similar to the lacerated and contused ones.

# Types of wounds:



Gunshot wounds result from the injuries by projectiles, firearms and grenades (e.g. missiles, bullets, pellets, bomb, mines etc.). These types of wounds are typically with extensive tissue damage because of the high speed of the wound inflicting and the resultant injury by bone fragments.

# Types of wounds:

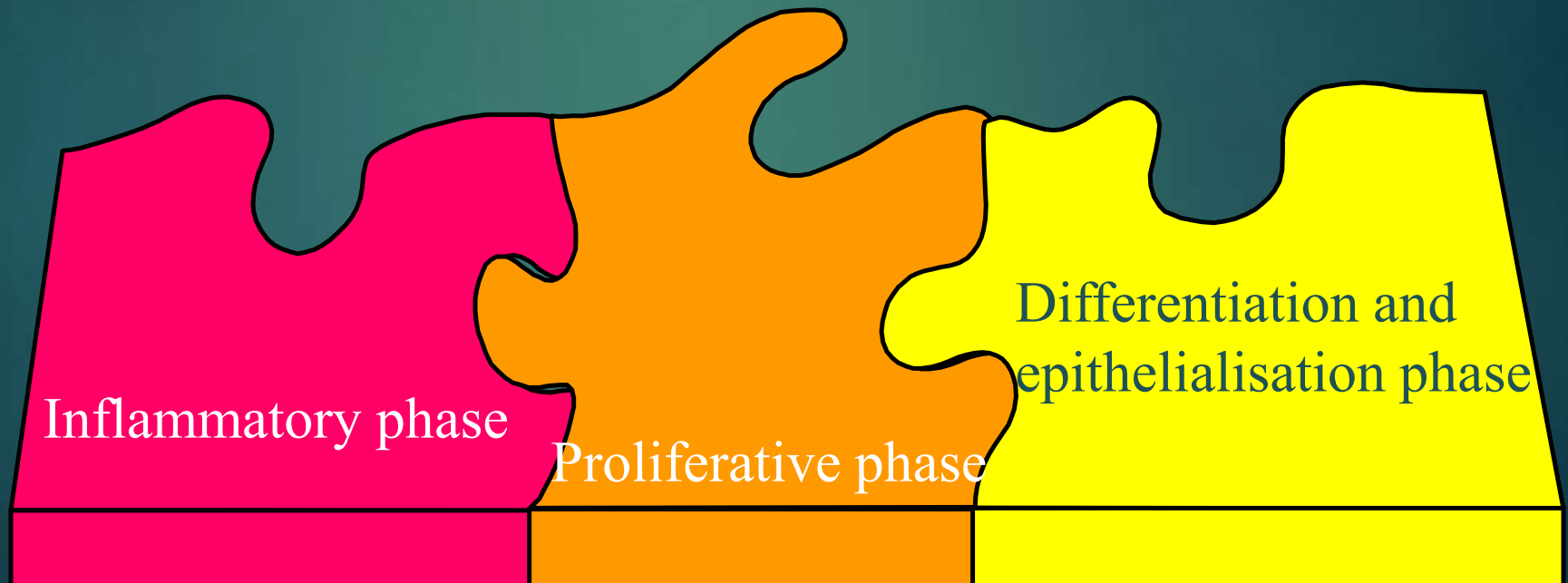
Gunshot wounds:

The three areas from a gunshot wound of damage are identified:

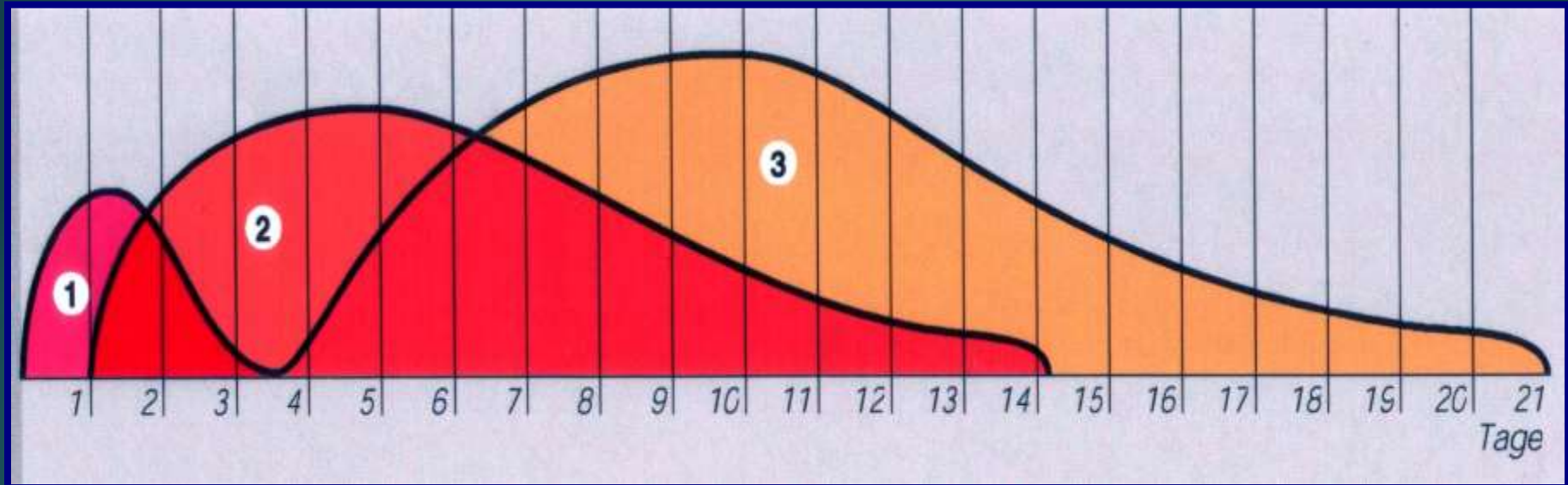
- ▶ the wound canal,
- ▶ the areas of primary traumatic necrosis
- ▶ and the area of concussion.

# The process of wound healing

Irrespective of the type of wound and the extent of tissue loss, the healing of every wounds takes place in phases which overlap in time and cannot be separated from one another.



# Schematic representation of the temporal course of the wound healing phases

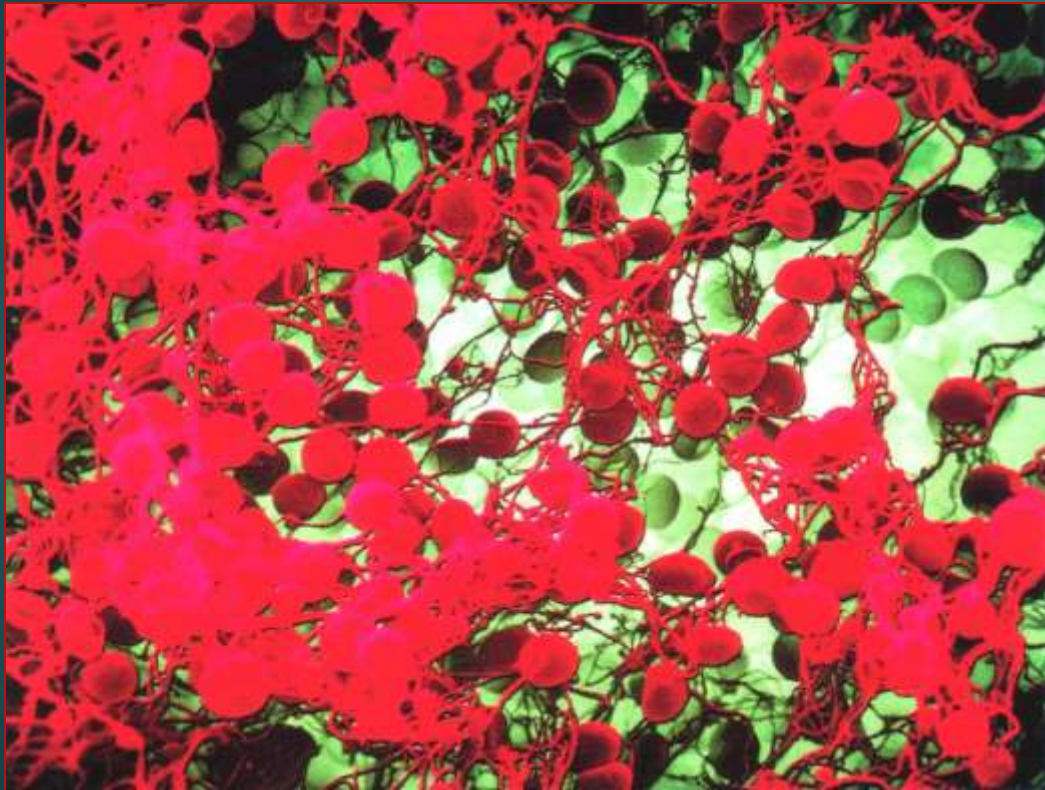


1. Inflammatory phase;

2. Proliferative phase;

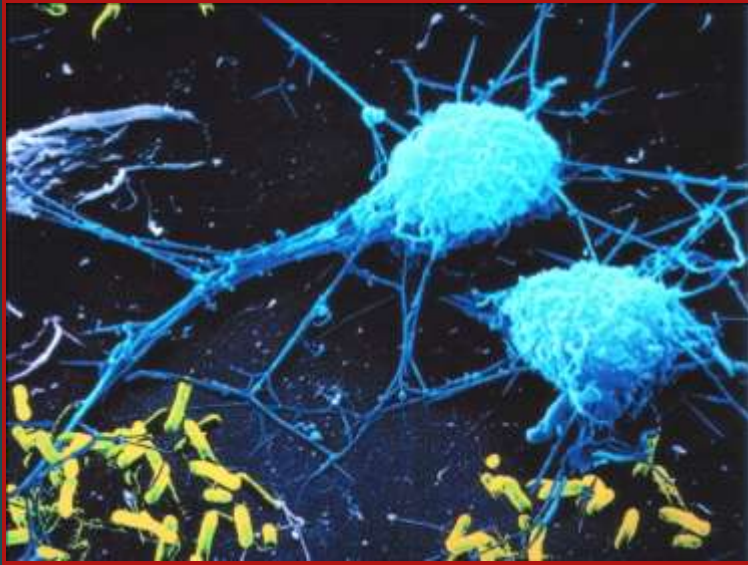
3. Differentiation and epithelialisation phase

# The inflammatory/exudative phase

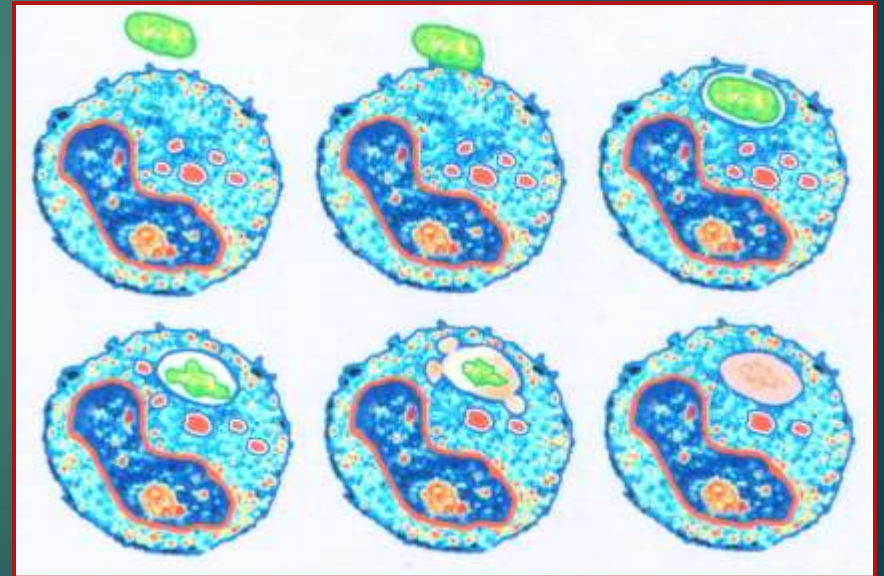
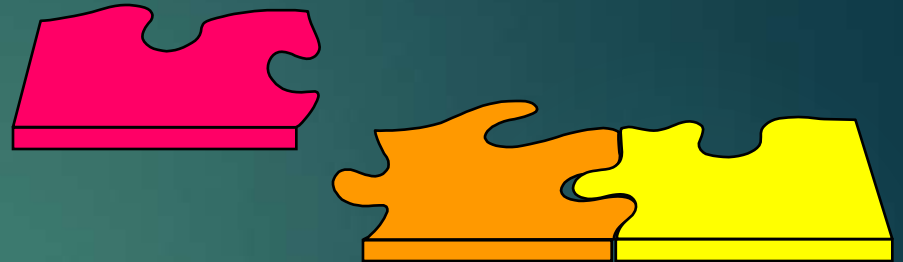


Blood clot of  
platelets, red blood cells  
and fibrin strands

# The inflammatory/exudative phase



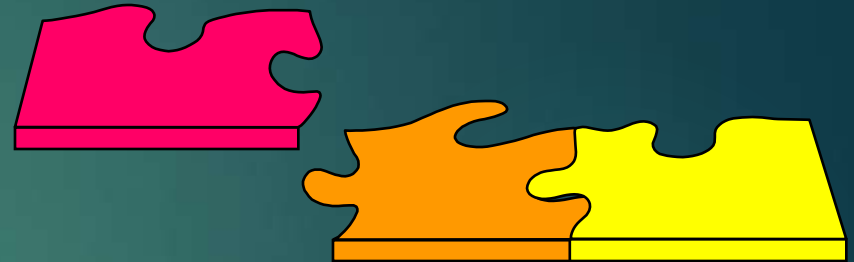
Macrophages during the  
Phagocytosis of  
E. coli bacteria



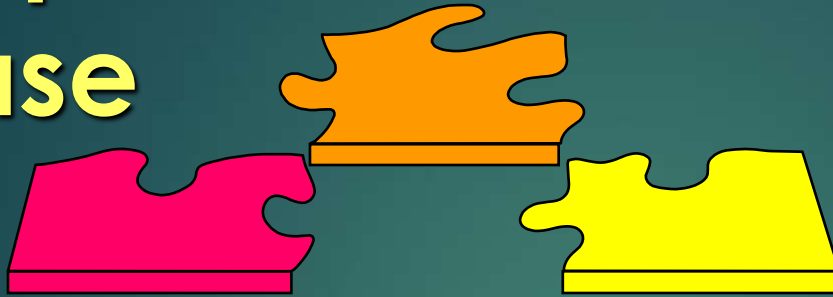
Course of phagocytosis

# The inflammatory/exudative phase

- ▶ erythema (rubor);
- ▶ warmth (calor);
- ▶ swelling (tumor);
- ▶ pain (dolor);
- ▶ limitation of function (functio laesa)

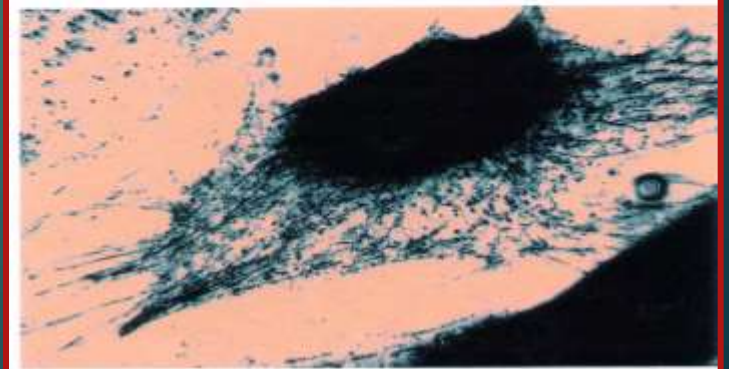
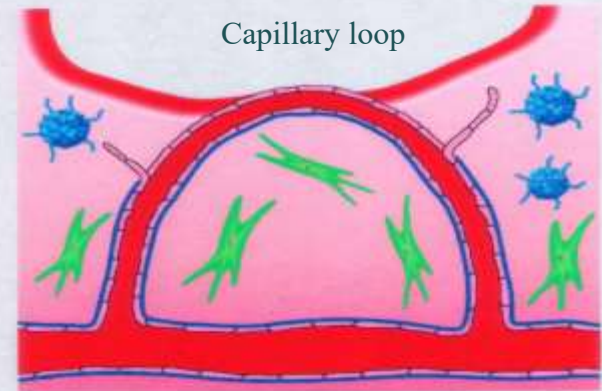


# The proliferative phase



During the second phase of wound healing, cell proliferation predominates aimed at new vessel formation and filling of the defect by granulation tissue.

1. The model of angiogenesis (above);
2. Dark field picture of a single skin fibroblast (below)



# The proliferative phase



So-called granulation tissue develops, the formation of which is initiated primarily by the fibroblasts.

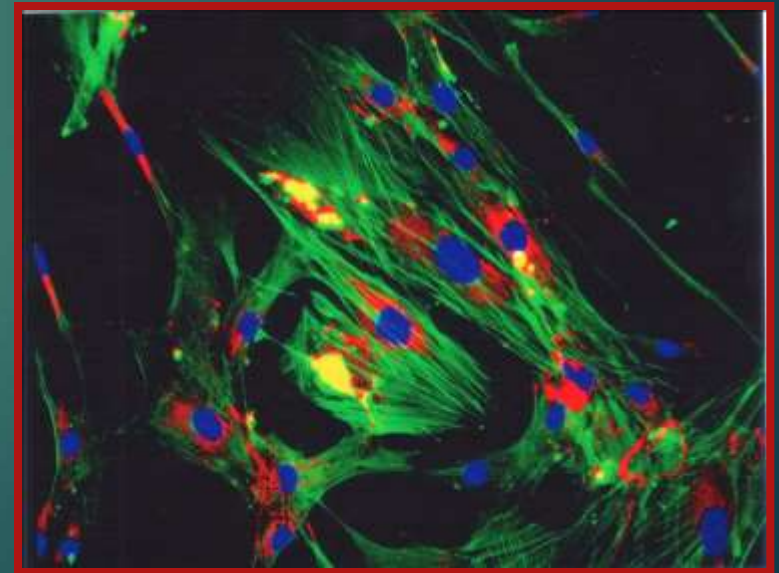


*Granulation tissue*

# The proliferative phase

The fibroblasts produces collagen which matures into fibres outside the cells and gives the tissue its strength. They also produce proteoglycans which form the gel-like ground substance of the extracellular space.

The fibroblasts are the most Important secretory cells in the production of skin connective tissue



# The differentiation and remodeling phase



Electron microscopic appearance of skin connective tissue with collagen bundles and elastic fibres

# The differentiation and remodeling phase



**Wound contraction**

# Quantitative classification of wound healing



Healing by primary intention usually occurs after surgical incisions or accidental wounds made by sharp-edged objects. Wounds capable of primary healing are closed with sutures, staples or wound closure strips.

# Quantitative classification of wound healing



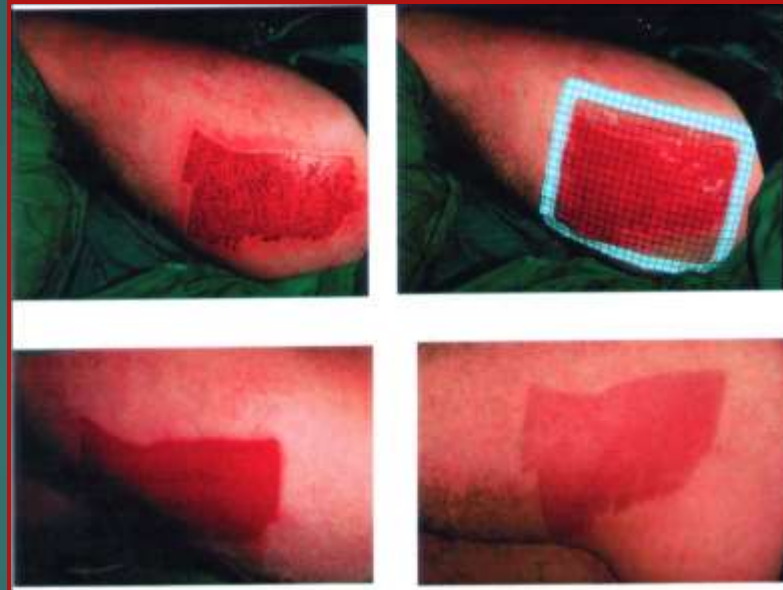
Delayed primary healing occurs when an infection is anticipated. In this case the wound should not be closed with sutures or wound closure strips.

# Quantitative classification of wound healing



Secondary wound healing always occurs when tissue gaps have to be filled or when a purulent infection prevents direct union of the wound edges.

# Quantitative classification of wound healing



Regenerative or epithelial healing  
for injuries of epidermidis only

The chronic wound is one undergoing secondary healing which has to be closed by formation of tissue. If this process requires more than eight weeks, the wound is classified as chronic.



# First aid and management of wounds



# Management of the contaminated wound



**Primary surgical debridement of the wound** is divided into:

- ▶ early – which is done within the first day of injury;
- ▶ delayed - within the second day after injury;
- ▶ late – more than 48 hours after injury.

# Primary surgical wound debridement

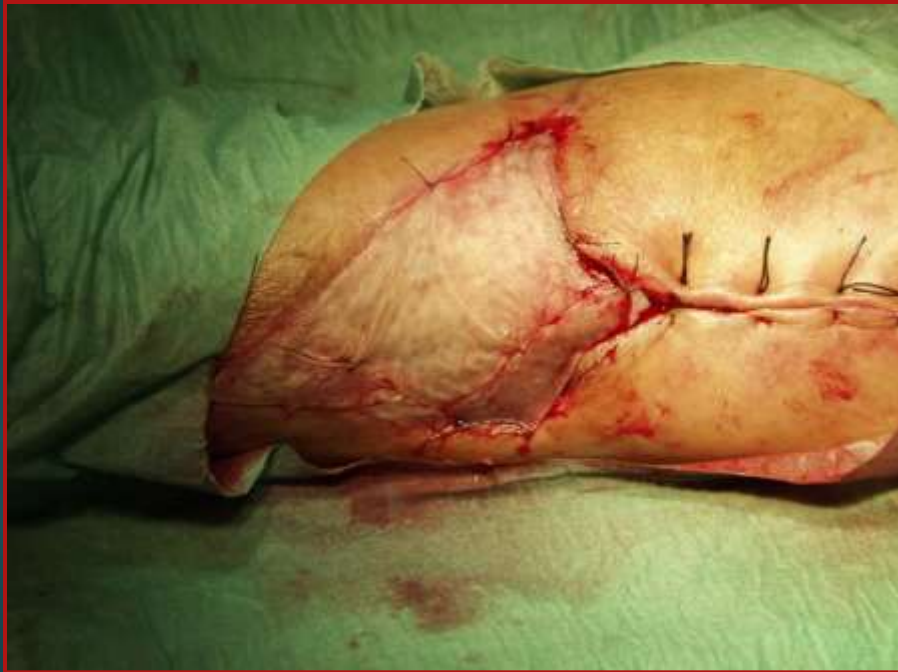


The aim: to transform the contaminated wound to aseptic surgical wound

# Primary surgical debridement

- ▶ Revision of the wound
- ▶ Remove foreign bodies, pollutions
- ▶ Incision of the edges, walls and bottom of the wound
- ▶ Arrest bleeding
- ▶ Drainage
- ▶ Sutures:
  - ▶ Primary – at the same time
  - ▶ Delayed – up to 5 days after debridement in the phase of inflammation
  - ▶ Secondary – 5 and more days after debridement, at the phase of proliferation

# Primary surgical wound debridement



Primary sutures – primary healing

# Indications for the use of delayed sutures:

- Delayed debridement
- Intensive pollution
- High risk of contamination
- Gunshot wound
- Low immunity





# Disorders of wound healing

- ▶ Seromas
- ▶ Wound haematomas
- ▶ Soft tissue necrosis
- ▶ Wound dehiscence (rupture)
- ▶ Hypertrophic scar formation
- ▶ Keloids



# Management of the infected (purulent) wound

- ▶ Secondary surgical debridement
- ▶ Additional methods of debridement
- ▶ Local treatment with dressings according to the phase of wound process



# Secondary surgical debridement

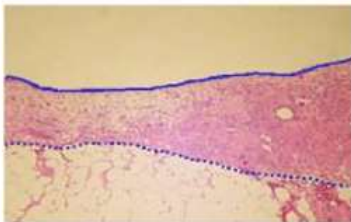
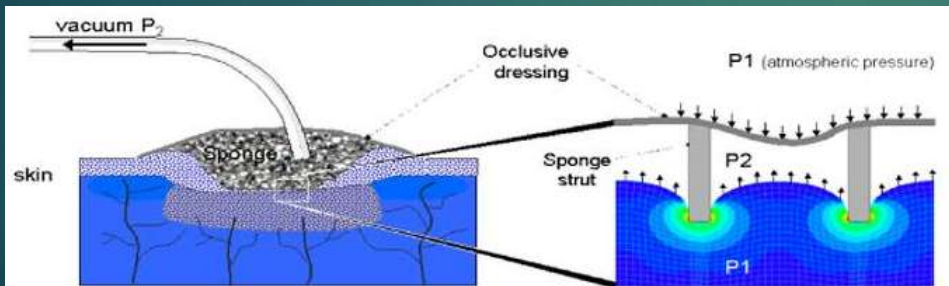
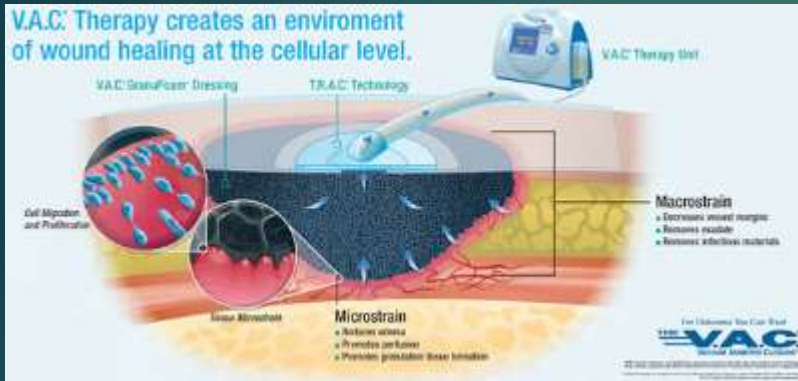
- ▶ Revision of the wound
- ▶ Removing fibrin films, pus, pollutions, necrotic tissues
- ▶ Careful incision of the infected tissues
- ▶ Washing of the wound with antiseptic solutions
- ▶ Drainage
- ▶ No primary or delayed sutures!
- ▶ Open treatment with dressings



# Additional methods of debridement (physical)

- ▶ Intensive washing with pressure
- ▶ Vacuum therapy
- ▶ Ultrasound therapy
- ▶ X-rays therapy
- ▶ Ultraviolet therapy
- ▶ Removing necrotic tissues, pus and pollutions
- ▶ Stimulation of microcirculation
- ▶ Stimulation of inflammatory cells
- ▶ Stimulations of fibroblasts

# Vacuum therapy of the wound



# Ultrasound therapy

- ▶ Microwaves in the fluid inside the wound cavity
- ▶ Hydrolysis
- ▶ Appearance of OH ions
- ▶ Antibacterial effect
- ▶ Stimulation of microcirculation and proliferation

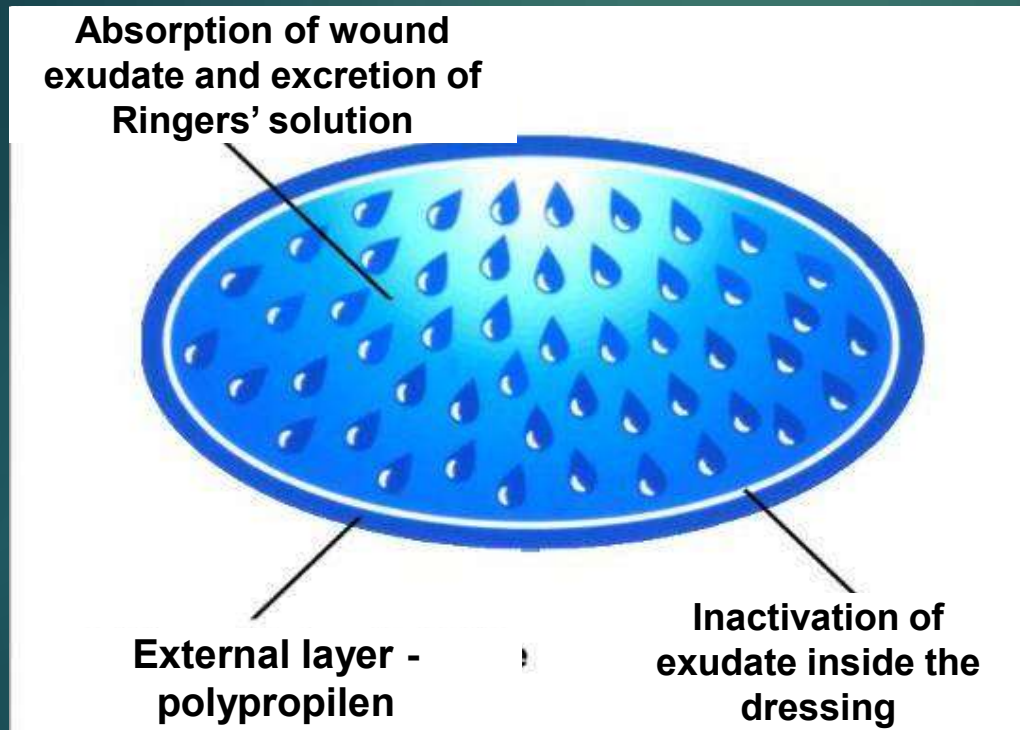


# Local treatment with dressings

- ▶ Gauze dressings: small absorption capacity, quick fixation to the wound, removing with extra traumatization
- ▶ Interactive dressings: active reciprocity with the wound
- ▶ Non-adhesive (atraumatic): good permeability for exudate, no fixation to the wound, additional therapeutic agents, no absorption
- ▶ Absorb: absorption and fixation of exudate

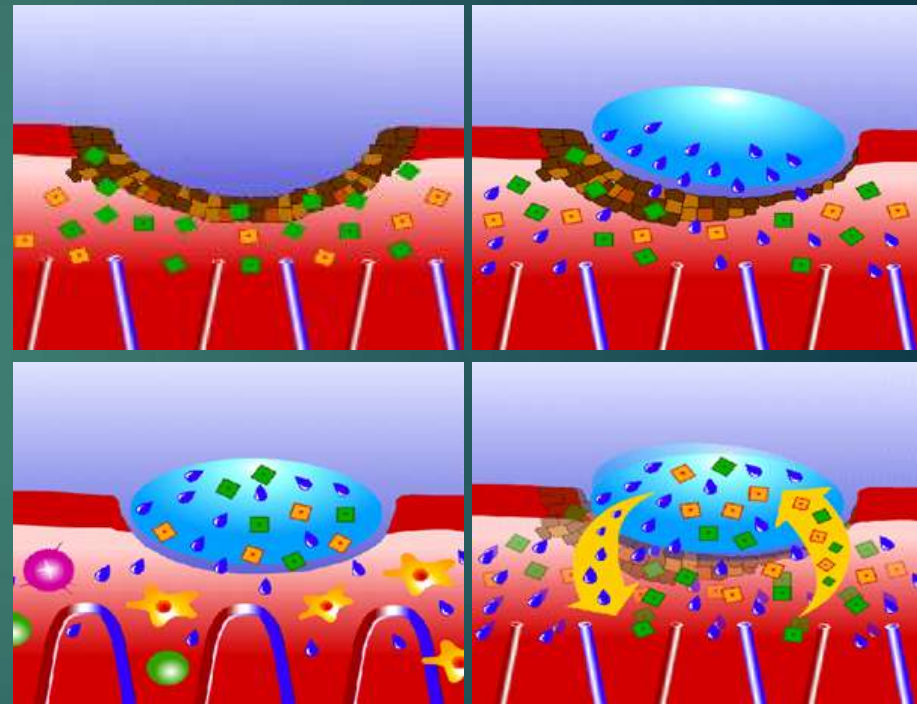


# Interactive dressings: Tender Wet 24



# Interactive dressings: Tender Wet 24

- ▶ Absorption and inactivation of exudate
- ▶ Inactivation of bacterial cells and their toxins
- ▶ Excretion of Ringers' solution for permanent washing of the wound
- ▶ Stimulation of endogen autolysis
- ▶ Making the wet environment



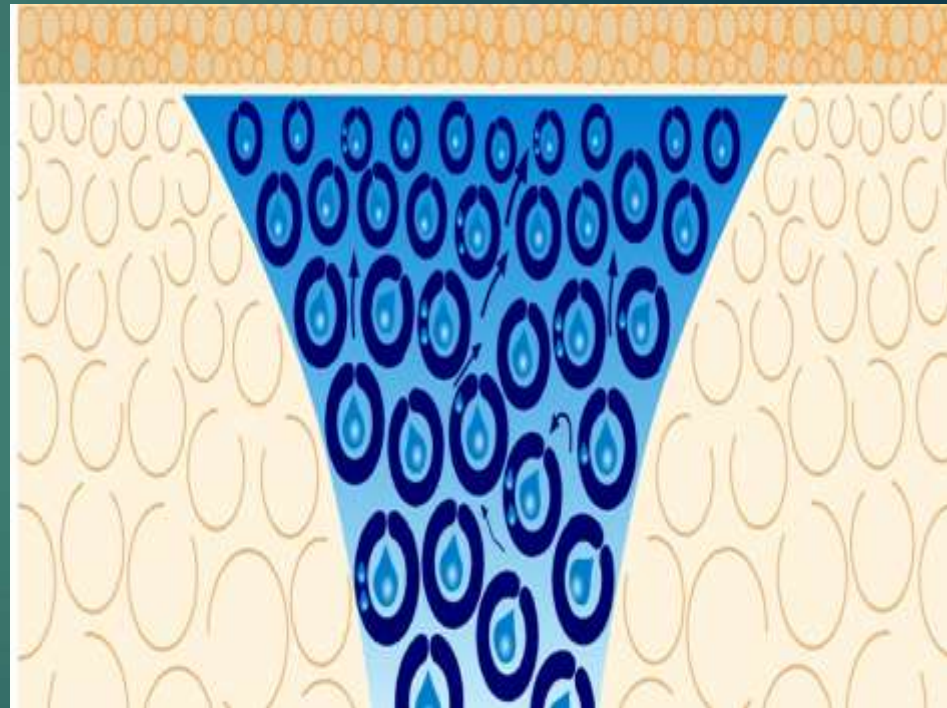
# Interactive dressings: Alginates

- ▶ Calcium alginate – fibers with highest absorption abilities
- ▶ Take out all exudate and transform to a morph non-adhesive gel
- ▶ Hemostatic capabilities



# Interactive dressings: Pema Foam

- ▶ Two-layer dressing made with polyurethane
- ▶ External layer is permeable for air but not for fluid, make wet environment
- ▶ Inner layer has high absorbability, take off, inactivate and transfer the exudate to the external layer for evaporation
- ▶ Protect from external exposures and contamination



# Hydrocolloid dressings

- ▶ External layer made with polyurethane and protect from external exposures and contamination
- ▶ Inner layer made with hydrogel with small absorbability
- ▶ Make wet environment that stimulate proliferation
- ▶ Stimulate autolysis



# Hydrogels

- ▶ No impermeable external layer
- ▶ Just hydrogel for wet healing



# Non-adhesive (atraumatic) dressings

- ▶ Hydrophobe basis made as a net: synthetic fibers with beeswax, paraffin, some balsams of other
- ▶ Porous structure of the net do not stop the exudation
- ▶ Consist of different additional drugs



# Non-adhesive (atraumatic) dressings

| Antibacterial               | Enzymes               | Painkiller              | Stimulator of proliferation      |
|-----------------------------|-----------------------|-------------------------|----------------------------------|
| Atrauman Ag                 | Parapran with enzymes | Parapran with lidocaine | Branolind H (Peru balsam)        |
| Voskopran with levomycetin  |                       |                         | Hydrotul (hydrogel)              |
| Voskopran with dioxidine    |                       |                         | Voskopran (beewax)               |
| Voskopran with Povidon-Iod  |                       |                         | Voskopran with methyluracil      |
| Parapran with chlorhexidine |                       |                         | Grassoilind, Atrauman, Branolind |
| Фаза воспаления             |                       |                         |                                  |
|                             |                       | Фаза пролиферации       |                                  |

# Absorb dressing

Zetuvit



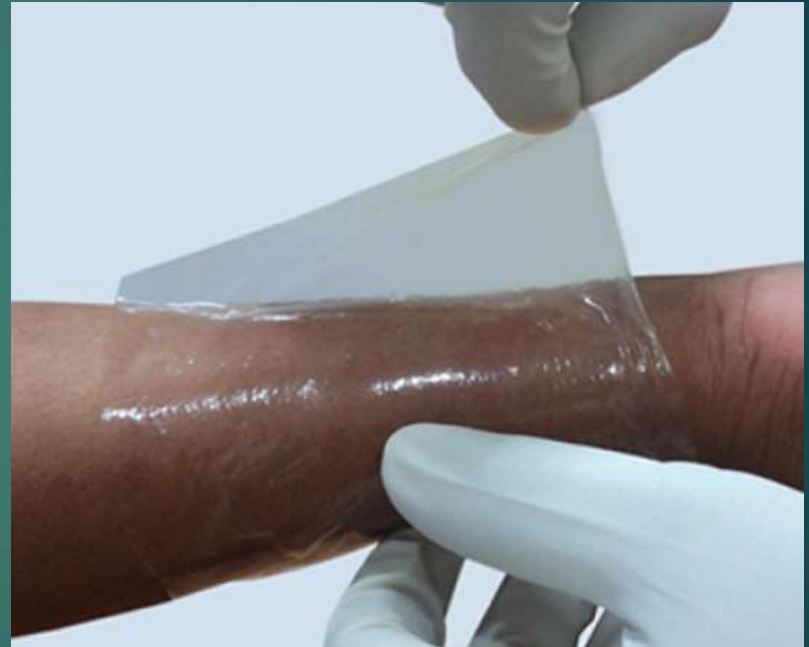
Voskosorb



For the non-adhesive dressing to absorb and inactivate exudate that come through the net pours

# Hydrofilms

- ▶ Permeable for air and non-permeable for fluid
- ▶ Protect from external exposure and contamination
- ▶ Wet environment

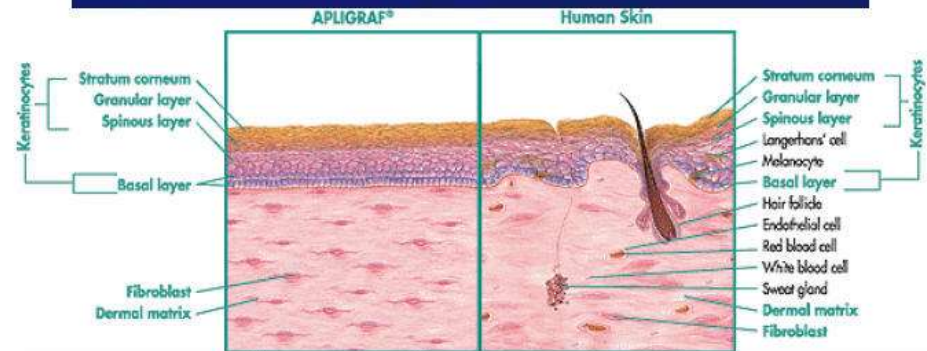
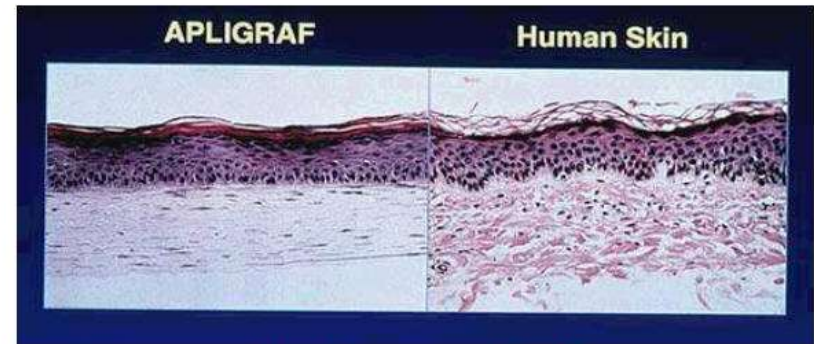
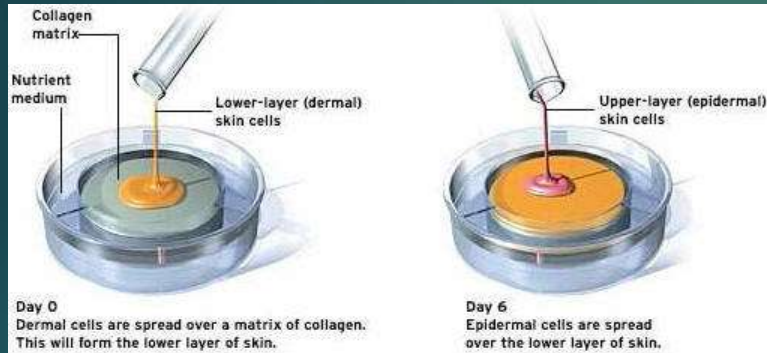


# Human Skin Equivalent (tissue engineering)

- ▶ One-layer consist of fibroblasts on the collagen matrix
- ▶ Two-layer consist of fibroblasts and epithelial cell based on the collagen matrix
- ▶ 40% of all cell migrate to the wound and stimulate healing



# HSE - APLIGRAF



# Inflammatory phase

- ▶ Aims:
  - ▶ Evacuate and absorb exudate
  - ▶ Reduce bacterial contamination
  - ▶ Acceleration of cleaning from necrotic tissues and other pollutions
- ▶ Gauze dressings with antiseptic solutions (chlorhexidine) or antibacterial soluble liniments (levomecol)
- ▶ Proteolytic enzymes (iruksol, travaza)
- ▶ Interactive dressings Tender Wet 24, pema Foam, Sorbalgon
- ▶ Atraumatic dressings with antibacterial drugs plus absorb dressings (Atrauman Ag + Zituvit)

# Proliferation phase

- ▶ Aims:
  - ▶ Protect the wound from external exposures
  - ▶ Protect the wound from dehydration
  - ▶ Make wet environment for good proliferation
- ▶ Gauze dressings with fat soluble liniments (vaselinum, lanolinum)
- ▶ Hydrocolloid dressings
- ▶ Atraumatic dressings with drugs stimulated proliferation plus absorb dressings (Branolid H + Zituvit)

# Epithelization phase

- ▶ Aims:
  - ▶ Protect the wound from external exposures
- ▶ Gauze without drugs
- ▶ Wet films