#### MINISTRY OF HEALTH OF UKRAINE **POLTAVA STATE MEDICAL UNIVERSITY** DEPARTMENT OF THE GENERAL SURGERY WITH PATIENT'S CARE

# WOUNDS. WOUND PROCESS

Lecture for general surgery Chorna I.A. Poltava

### Defenition

**Wound (vulnus)** is any mechanical damage of organism, accompanied with destroying integrity of covered tissues - skin or mucous membranes.

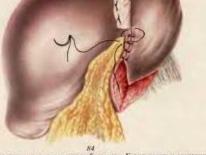


During this damage more deep tissues, inner organs (damage of brain liver, stomach, kidneys and others) can be destroyed.

 The injury of covered tissues is distinguished wound from other kinds of damages. For example, the injury of the liver is caused by the dull trauma of the abdomen without destroying the skin is named the rupture. Damage during the stroke by knife into the abdominal region is named wound of liver, because we observe the destroying of the skin.

#### wound of liver with destroying of the skin.

rupture of liver\_\_\_\_\_ without destroying of the skin



певосторенныя парамедианная добоктомия. Гепататация и закрыти раны салынком.

### The main features of wounds

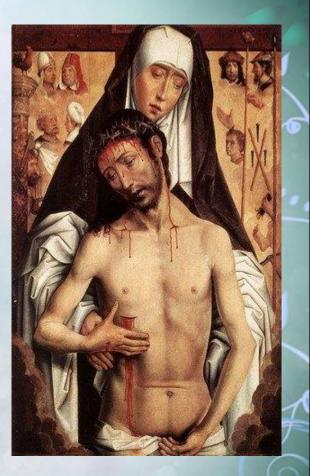


#### 1. Pain (dolor)

### 2. Bleeding (haemorrhagia)



3. <u>cleft</u> (hiatus)



## ACUTE WOUND





Traumatic wounds



Burns



Surgical Wounds



Skin abrasions



## **CHRONIC WOUND**





## 1. <u>Classification according</u>

## to the origin

All the wounds are divided into two groups:

 operative (caused with treatment or diagnostic purpose) and







 accidental (all other kinds of wounds, caused to spite (defianse) to the will of patient).

#### 2. Classification according to character of tissue injure

- 1. cut or incised wound (vulnus incisum);
- 2. stub or pierced wound (vulnus punctum);
- 3. contused wound (vulnus contusum);
- 4. lacerated wound (vulnus laceratum);



Muscle

5. crushed wound
(vulnus conqvassatum);
6. saber or slash wound
(vulnus caesum) (рубленная);





7. bite wound
 (vulnus morsum) - Bite wound
 is more infected than other wounds;



8. mixed wound
(vulnus mixtum);





9. **Gunshot** wound (vulnus sclopetarium). This wound has three zones of damaging, compound anatomical structure, high degree of contagious.

- Bullet causes injury by:
  - Laceration and crushing
    Shock waves and
    temporary cavitation

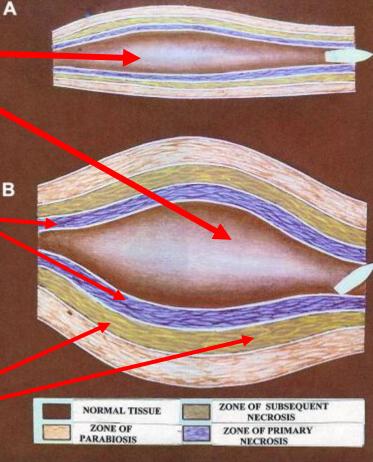


#### Three zones of damage for gunshot wound



1) - wound canal. In some cases there can be bullet, parts of necrotic tissue, blood and bacteria.

- 2) direct traumatic necrosis. It appears under the influence of kinetic energy. It consists of viable or unviable tissues, which are ooze by blood.
  - 3) zone of molecular contusion. It consists of tissues, which have malfunction of metabolism and damage of cellular structures. This zone is called "stockpile of the following necrosis".



# Additional classification of gunshot wound.

According to the character of wound canal:

- 1. Through (сквозное) damage -Perforating entry and exit wound - it has entrance and exit apertures (bullet is out of the organism)
- 2. Blind injury Penetrating entry only -in has only entrance aperture (bullet is at the end of wound canal).
  - 3. Tangential damage of superficial tissues, without the penetration to cavities of organism.



No rubber bullets =OaklandPD ? Really?..... pic twitter com/SiK7mLLq







#### According to the factor of damage:

- 1. Small speed damage gunshot. Speed of the bullet is 600 m/s. The wound canal more often may be direct and blind. Such wound has, as a rule, small entrance aperture and not big tissue damage.
- 2. High-speed damage. Speed of the bullet is 900 m/s and more. These wounds have small entrance aperture and wide, with defect of tissues, exit aperture. Wound canal winding, that's why we may observe the injury of many organs and tissues. More destroying effect may be caused by explosive shells (разрывные снаряды).
  - 3. Fraction (Shot) wounds. These wounds have many separate apertures, bleeding, contusion of organs and tissues.

## **Gunshot** inlet

## Gunshot outlet

## Inlet



## Outlet

#### Loops of intestinum

## Shotgun in the abdomen



## Wound Ballistics (Kinematics): Medium and High velocity wounds

- Factors that contribute to tissue damage include:
  - <u>Bullet size</u>: The larger the bullet, the more resistance and the larger the permanent tract
  - <u>Bullet deformity</u>: Hollow point and soft nose flatten out on impact, resulting in a larger surface area involved.

## Wound Ballistics: Medium and High velocity wounds

- tissue damage continued:
  - Semijacket: The jacket expands and adds to the surface area
  - Tumbling: Tumbling of the bullet causes a wider path of destruction
  - Yaw: The bullet can oscillate vertically and horizontally (wobble) about its axis, resulting in a larger surface area presenting to the tissue.

## **Gunshot Wounds: Cavitation**



To what is cavitation (shock wave) related?

### **Gunshot Wounds**

Tearing

Splitting

Exit

Arrest

#### Entrance and Exit Wounds

#### Entrance

Abrasion -----7 Burn -----Tatooing -----

#### Entra ce and exit wour

Sources

Service of the

## Wound Ballistics: Medium and High velocity wounds

- The wound consists of three parts:
  - Entry wound: Usually smaller than the exit wound
  - Exit wound: Not all gunshot wounds will have exit wounds and on occasion there be multiple exit wounds due to fragmentation of bone or the bullet.
     Generally the exit wound is larger and has ragged edges.

#### **Entrance and Exit Wounds**



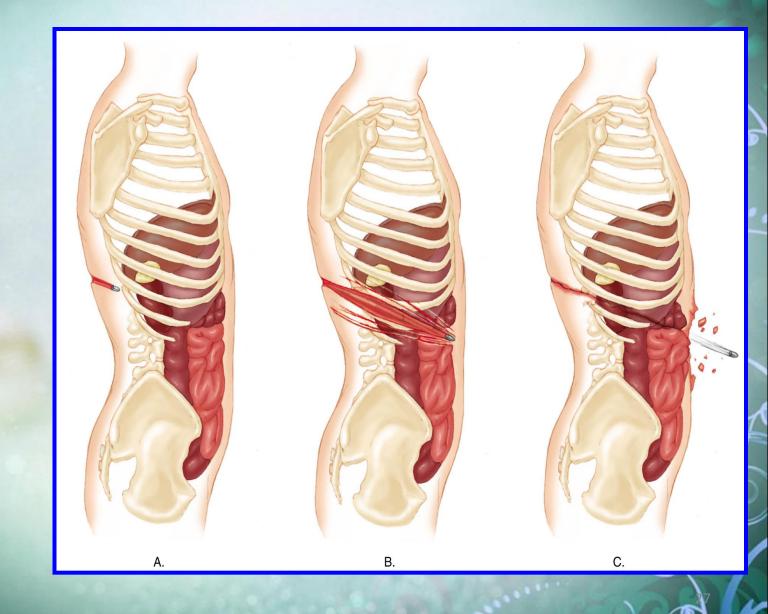


## Wound Ballistics: Medium and High velocity wounds

#### The wound consists of three parts:

Internal wound: Medium-velocity bullets inflict damage primarily by damaging tissue that the bullet contacts; Highvelocity bullets inflict damage by tissue contact and transfer of kinetic energy (the shock wave producing a temporary cavity) to surrounding tissues

#### **Mechanism of Injury: Penetrating Trauma**



# **Penetrating Trauma Injuries**

Head: The skull is a closed space, thus presenting some unique situations:

The shock wave has no place to go therefore the brain tissue can be compressed.

If the forces are strong enough the skull may explode from the inside out.

\* A medium velocity bullet may follow the curvature of the interior of the skull. This path can produce significant damage

### **Punctures/Penetrations (Gunshot wounds)**



#### **Punctures/Penetrations (Gunshot wounds)**

Comminuted Fracture

**Penetrating Trauma Injuries** Thorax: Three major groups of structures inside the thoracic cavity must be considered in evaluating a penetrating injury to the chest: Lungs: Less dense tissue so injuries are generally from the bullet tract and less so from a shock wave. Serious injuries include a pneumothroax or hemothorax Vasular: Blood and muscle is more dense than lung tissue, therefore it is more susceptible to shock waves in addition to the bullet track. Injuries include damage to the aorta and the superior vena cava as well as injury to the heart uscle

#### **Penetrating Trauma Injuries** Thorax:

 Gastrointestinal: The esophagus is located in the thorax and may be injured by the bullet track
 Injuries include damage to the esophagus as well as spilling any contents into the thoracic cavity which can lead to infection.



**Penetrating Trauma Injuries** Abdomen: The abdomen contains structures of three types: Air filled, solid and bony. **Gastrointestinal:** The majority of the GI system is located in the abdomen. Most of the GI tract structures are considered to be air filled. Injuries include damage to the GI system structures as well as spilling any contents into the abdominal cavity which can lead to infection. **Solid organs:** The solid organ of the abdomen are very susceptible to direct injury as well as injury from the shock wave.

Injuries include direct and shock wave damage to all of the solid organs such as the liver, spleen, pancreas, and the kidneys in the retroperitoneal space. Let's not forget about the bladder, uterus, ovaries, gall bladder, and major blood vessels such as the vena cava and the aorta.

## **Penetrating Trauma Injuries**

#### Abdomen:

Bones: The pelvis is a very vascular organ. Fracture of the pelvic due to a gunshot wound can lead to major blood loss

Injuries are generally limited to direct bullet track damage. The bone fragments may become secondary missiles and cause additional damage.

### **Shotgun Wounds**



# The ultimate in fragmentation is created by shotgun wounds

# **Penetrating Trauma Injuries**

 Muscles, peripheral nerves and blood vessels, connective tissue, skin and bones:

All of these tissues may suffer direct injury or shock wave injuries.

Injuries may include: tissue loss, bleeding, and loss of function,

#### **Open Wound**

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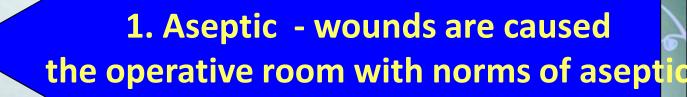
#### **3. According to the zone of damage:**

#### Wounds with small zone of damage.

#### Wounds with large zone of damage.



### **4. Classification according to the level of infection**



 2. Fresh infected - wounds made to 3 days from the moment of damage.
 Fresh-infected wound have amount (quantity)
 •of microorganisms not more than 105 per 1 g of tissue

3. Suppurative - wounds have of presence of infective process. .

#### **Surgical Wound Classification**

- **Clean**: (1-5% risk of infection) uninfected operative wounds in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed, and if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.
- Clean-contaminated: (3-11% risk) operative wounds in which the respiratory, alimentary, genital, or urinary tract is 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 technique is encountered.



Surgical Wound Classification (cont..) <u>Contaminated</u>: (10-17% risk) open, fresh, accidental wounds, operations with major breaks in sterile technique or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered.

 Dirty or infected: (>27% risk) 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.

#### 4. Classification according to the serious:

There are <u>simplex</u> and <u>complex</u> wounds.
 *Simplex* wound is the damage of skin, subskin and muscle. *Complex* wound is the damage if inner organs, bones, magisterial vessels and nerves trunks.





5. Classification in dependence of the relation of wound's defect to the cavities of the body:







There are

- Superficial wounds
- Not penetrated wounds and
- Penetrated wounds

   (pneumothorax,
   hemothorax,
   intraabdominal wounds).

# 6. Classification according to the region of saturation









There are wounds of

- neck, head ,
- trunks,
- upper and lower
   extremities.

When wounds connect two parts of the body, they are called complex wounds.

# <u>7. According to the number of injuries</u> they determine single and plural.





### 7. According to the ethyology

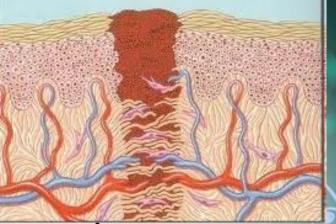
#### 1. Mecanical:

- Ttraumatic (accidental), home accident, factorial trauma, road trauma, wartime trauma
- Surgical
- 2. Thermal (Hager or low temperature)
- 3. Chemical (chemical compounds acids. alkalis, etc.)
- 4. Radiation damages
- 5. Impairment of tissues nutrition (throphic ulser, bedsores et s.)

#### **Wound process**

- Wound process is complex of successive changes in wound and connective with him reactions of all organism.
- Conditionally, we may divide this into general reactions (catabolic and anabolic process) of the organism and heal of the wound.

#### **Healing of wound**



- Reparation of wound is the reparative process of damage tissue with reconstruction its integrity and functions.
- For closing of tissue defect 3 main processes are exist: formation of the collagen by fibroblasts, epithelization of the wounds, effect of tissue tension (the contraction by miofibroblasts).

#### **Phases of wound reparation**

**Rufanov** determined 2 phases: hydration and dehydration.

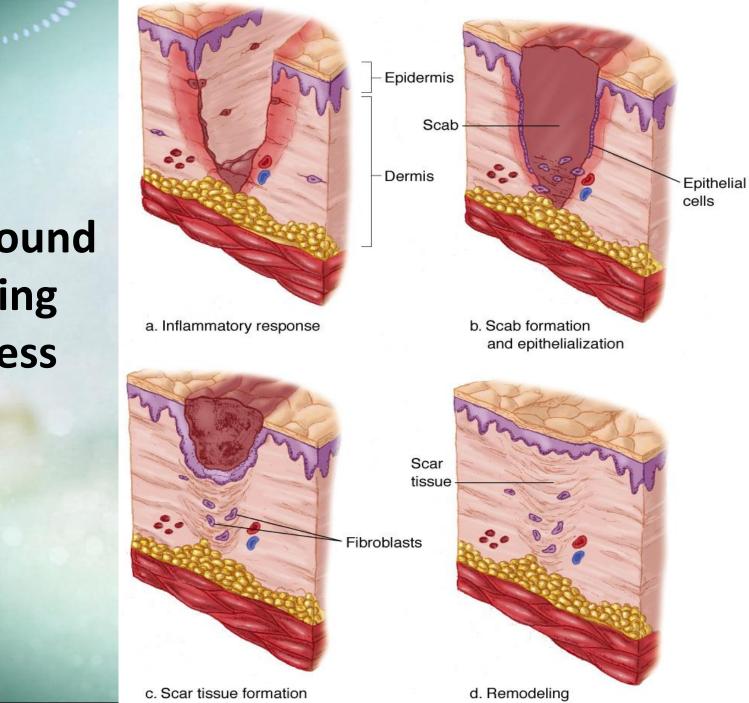
Girgolav determined 3 period of wounds reparation:

- 1. preparing period.
- 2. period of regeneration.
- 3. period of stitch formation (remodeling).

Kusin determined 3 period of wound process:

- I phase of inflammation (1-5 days).
- 2 phase of regeneration (6-14 days).
- 3 the phase of formation and stitch reorganization (begin from 15-th day

#### The Wound Healing Process



 Dacenko determined 3 period of wound process
 1 phase – purulentnecrotic change

2 phase – granulation



Most widely we use clinical classification by Dacenko:





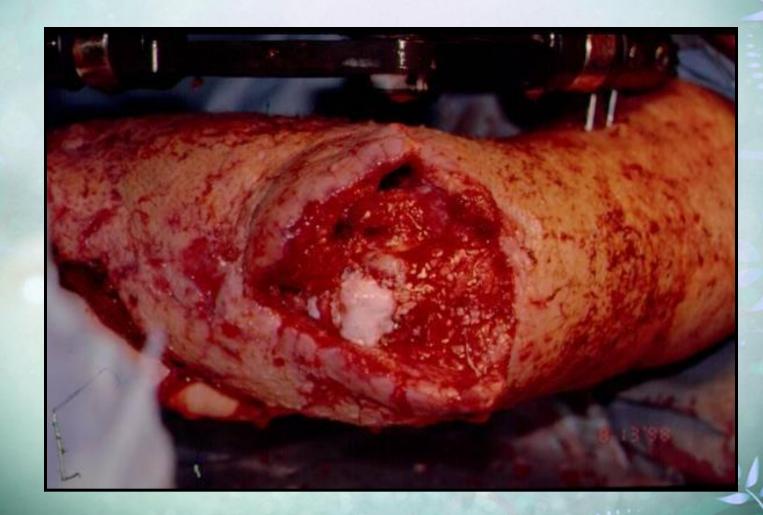
#### 1 phase

1 phase – purulent-necrotic change
 (inflammation phase, period of vessel's changes, preparing period, hydratation).
 Clinically, this phase is characterized by presence of necrotic tissues and purulent content in wound. Margins this wound have edema and infiltrate

## 1 phase – purulent-necrotic



## 1 phase – purulent-necrotic



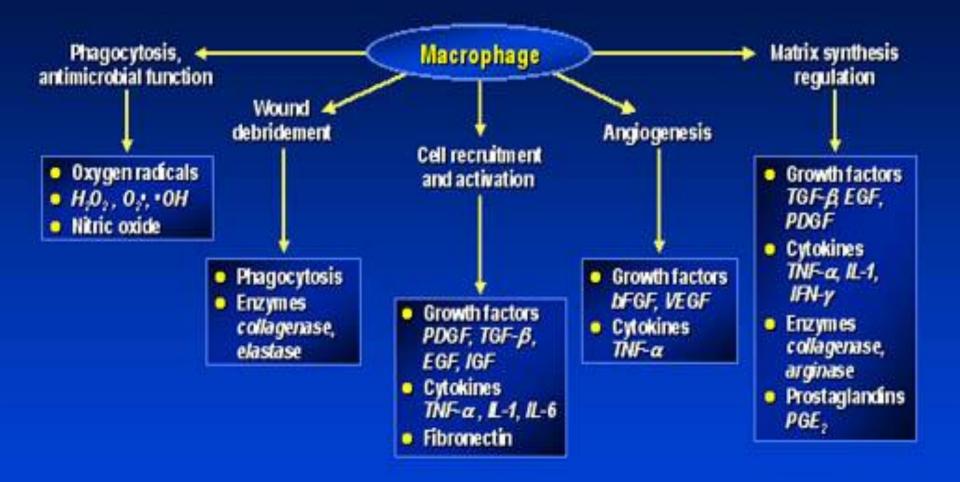
#### inflammation phase



Edema and leucocytes infiltration of tissues prepare the condition for clean of he wound. The most important components in the wound clean period are blood elements and enzymes. At first days leucocytes appear surround the wound. At 2-3 days lymphocytes and macrophages appear. Neutrophilic leucocytes make fagocytation of the microorganisms, necrotic mass, make the extracellular proteolysis, and excrete the mediators of inflammation.

 The main functions of macrophages - are excreting proteolytic ferments and phagocitosis.
 Also immune reactions take place.

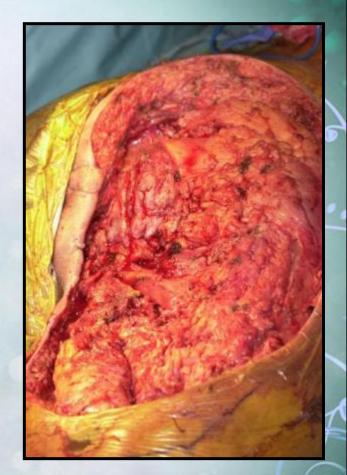
#### ROLE OF MACROPHAGES IN WOUND HEALING



Adapted with permission from Witte MB and Barbul A. Surg Clin North Am. 1997;77:513.

# 2 phase

2 phase – granulation (regeneration) manifesteted by cleaning wound from purulent-necrotic tissues and formation of granulation tissues. Granulation tissue gradually fills wound's cavity.



# **Proliferative Phase**



During this period (2 phase) wound's collagenisation, intensive growth of blood and lymphatic vessels occur. In wound the number of neutrophils decrease, and number of fibroblasts increase. The main role of fibroblasts is synthesis of connective tissues components and formation of collagens and elastic fibers. The proliferation of capillaries performs. Inflammatory process becomes less.

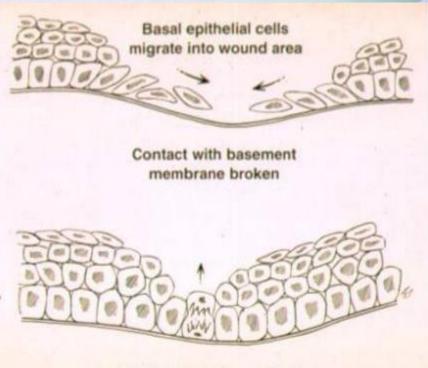
### 3 phase

**3 phase – epithelization** characterized by epithelization of wound surfaces and reorganization (sclerosation) of scar (stitch) (formation and reorganization of the stitch or Remodeling Phase ).



## **Epithelialization**

**Basal epithelial cells** at the wound margin flatten (mobilize) and migrate into the open wound Basal cells at margin multiply (mitosis) in horizontal direction Basal cells behind margin undergo vertical growth (differentiation)



Vertical growth by mitosis

# **Epithelialization/Contraction**



# Epithelialization



# **Maturation Phase**



Term 3th phase is 15day - 6 month. In this phase the synthetic activity of fibroblasts and other cells stop. Main process is to strengthen (consolidate) of new scar. Forming stitch cannot do the same function.

 The best reparative process the child organism has. It caused by presence in period of development anabolic processes. In such condition the reparation is shorter and is not so dangerous.

### Factors influence on healing of the wound:

- age of the patient;
- state of nutrition and body mass;
- presence of secondary infection of the wound;
- state of blood circulation in zone of damage and organism in general;
- presence of destroys of water-electrolytic balance;
- immune status of the organism;
- chronic accompanies diseases;
- using anti-inflammatory medications.

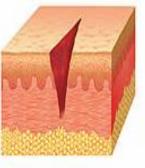
- The term of course each phase (exudation, proliferation, cleaning the wound, reparation) is determined before (in advance) impossible practically.
- But, the succession of change this process reserves (retain) stable.

# **Classical types of reparation:**

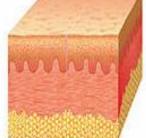
- reparation by primary tension;
- reparation by secondary tension;
- reparation under the crust.

#### 1. <u>Reparation</u> by primary tension.

"Sanatio per primam intentionem" is the most economic and favorable type of wound healing. In such case stitch is thin and strong. **Operation wounds heal by primary tension** when the border of wound connected. Between border and wall of wound any cavity absents. The amount of necrotic mass is small and small inflammation.





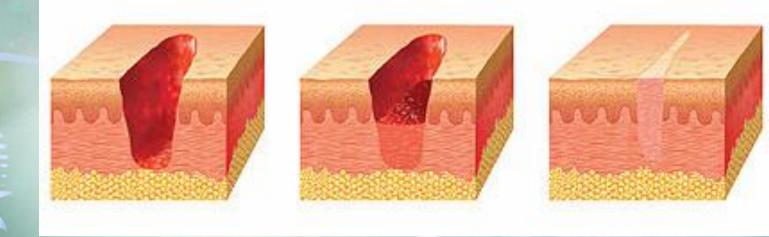


Primary tension has only uninfected wounds, or wounds with small infection. According to this there is some aspects for primary tension:

- No infection in wound;
- Connection the borders of wound;
- Absence of the hematoma and other objects in wound;
- Absence of the necrotic mass;
- Good state of the patient.

#### 2. Reparation by secondary tension.

"Sanatio per secundam intentionem" - heals by suppuration by with development of granulate tissue. In this type inflammation or big defect of skin are observed.



## **Secondary Wound Healing**



#### Conditions to heal by secondary tension:

- big quantity of microbes in wound;
- big defect of the skin;
- the presence of some objects or hematoma;
- the presence of necrotic mass;
- • unfavorable state of the patient.





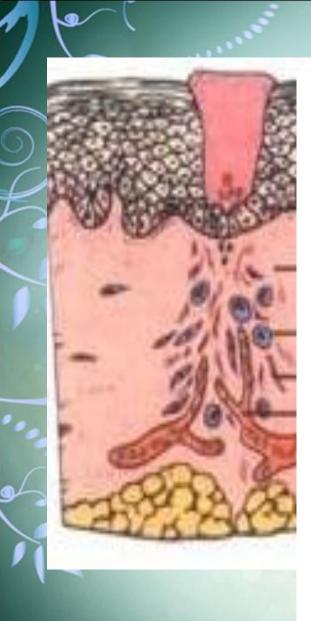


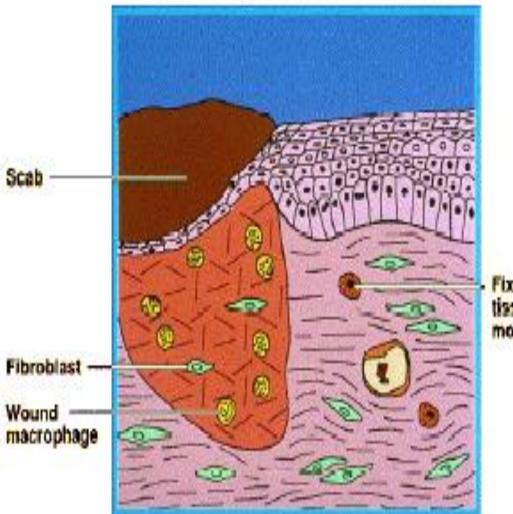
 Granulative tissue - this is the special kind of connective tissue, which forms only during heal of the wound by second tension. In normal, granulative tissue does not develop without damage. The main component of granulative tissue is the growth of the vessels. The granulative tissue may form after cleaning of wounds.

#### **Components of the granulative tissue**

The main components are 6 layers:

- Superficial leukocytic-necrotic layer. It consists of leucocytes, detritus and skinned cells. This layer is the whole period of reparation.
- Layer of the band vessels. Besides the vessels it consists of polyblasts. In this layer collagen fibers may be formed.
- Layer of the vertical vessels. It is constructed from perivascular elements.
- Ripen (Developing созревающий) layer. This is the deepest part of the previous layer; this layer is characterized by polymorphism of the cells formation.
- Layer of the horizontal fibroblasts. It consists of monomorphic cellular elements, collagen fibers.
- Fibrous layer. It shows the process of granulative growing.





Fixed tissue monocyte

## **Function of granulative tissue**

- Change the wound defect it is main plastic component.
  - Protection of the wound from microorganisms and some objects.
  - Sequestration and excretion of necrotic

mass.

### **Pathological granulation**

 During the influence of the "bad" factors, the process of granulation destroys. The granulation becomes pathological, may be its absent, may be hypogranulation or hypertrophied granulations..

## **3. Reparation under the crust Tertiary**/ delayed primary intention

This reparation takes place after small damage of skin.



**Reparation under the crust** starts from the blood clotting, lymph clotting. They becomes dry and perform crosr. Crust is the "biological bandage". Under the crust starts regeneration of the tissue (3-7 days). It's not necessary to cut crust if inflammation is absent.

- But if under the crust necrotic mass, pus are observed, the operation is necessary.
- Crust is medium stage between primary and secondary tension.

#### Regeneration Exact Replacement

Tissue

Injury

Normal Repair - Reestablished

Equilibrium

# - Chronic Ulcers

### - Fibrosis and Contractures

## **Complication of wound healing**.

- Development of infection.
- Bleeding (primary, secondary)
- Insufficiency of wound borders. May be eventration.
- Form hypertrophied or kelloid scars.



#### Bacterial biofilm is a major barrier to wound healing

Bacteria protected from topical agents

> Low oxygen in biofilm niches

Impaired migration and proliferation of keratinocytes

Bacteria protected from systemic antibiotics Host defenses unable to clear infection

## **Eventration.**



## **Excess Healing**

#### Hypertrophic Scars

- Within confines of original wound
- Often regress over time
- Develop 4 weeks after wound
- Tension and flexor areas

#### • <u>Keloids</u>

- Extend beyond original wound
- Rarely regress spontaneously
- Autosomal dominant predisposition
- Can result from any trauma
- Develop 3mos to years after initial insult
- Need multimodal approach to treat
  - Surgical excision, steroids, silicone sheets, XRT, pressure

## Hypertropic Scar











# **Keloid Scar**





# Keloid Scar



## Collagen

Normal Skin

-collagen ratio 4 : 1 Type I/III

Hypertrophic Scar
 –collagen ratio 2 : 1 Type I/III

#### Thank You

