МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
Федеральное государственное бюджетное образовательное учреждение высшего образования
«ПЕНЗЕНСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ»

О. В. Богонина

УЧЕНИЕ О РАНАХ

Учебно-методическое пособие

O. V. Bogonina

DOCTRINE OF WOUNDS

Teaching manual

ПЕНЗА 2026

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Представлены современные подходы к диагностике и лечению ран, включая первичную и вторичную хирургическую обработку, терапию гнойных ран и типы заживления.

Издание подготовлено на кафедре «Челюстно-лицевая хирургия» Медицинского института ПГУ и предназначено для обучающихся по специальности 31.05.03 «Стоматология», а также рекомендуется студентам стоматологических факультетов медицинских вузов, клиническим ординаторам.

The teaching manual presents modern approaches to the diagnosis and treatment of wounds, including primary and secondary surgical debridement, therapy of purulent wounds, and types of wound healing.

The publication was prepared at the Department of “Maxillofacial Surgery” of the Medical Institute of PSU and is addressed to students of the specialty 31.05.03 “Dentistry”, and is also recommended to students of dental faculties of medical universities, clinical residents

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INTRODUCTION

Most surgical patients have wounds. Environmental changes (usually negative), population growth, and the ongoing introduction of technology into people's everyday lives have led to the emergence of more complex types of wounds, both in anatomical structure and microbiological composition.

In recent decades, the specifics of the wound clinic includes infection with a variety of pathogenic microflora, which are resistant to conventional antibiotics and can influence the course of the wound process.

Our main task will be to understand how to distinguish a wound from similar pathological processes and at what stage of the wound process it is located, since the surgeon's subsequent tactics change radically with the smallest changes in the wound clinic.

On that basis the authors came up with the idea of creating this educational guide.

The goal of this educational guide is to provide assistance to dental students in preparing for practical classes in general surgery, as well as for passing the exam in the discipline "General Surgery, Surgical Diseases".

The authors set two main tasks for the intended teaching guide: first, to give students basic, fundamental knowledge about wounds; secondly, to convey to students the information that the doctor's actions are based on regulatory documents.

The proposed educational manual presents basic information about wounds and wound infections in an accessible language and in a structured form.

The content of the educational guide is in accordance with the work program "General Surgery, Surgical Diseases", and meets the requirements of the Federal State Educational Standard of Higher Education in the areas of training for the specialty 31.05.03 "Dentistry".

This educational guide is not the only source for preparing students for practical classes and exams; and it solves the issues of students' general orientation in the mass of the material being studied.

CHAPTER 1

BASIC DEFINITIONS, INDICATIONS, CLASSIFICATIONS OF WOUNDS

1.1. Main indications of a wound

A wound (*vulnus*) is called mechanical damage to tissues or organs, accompanied by a violation of the integrity of their integument or mucous membrane.

The elements of any wound are the wound cavity, the walls and the bottom of the wound. **The wound cavity (*cavum vulnerale*)** is a space limited by the walls and bottom of the wound. If the depth of the wound cavity significantly exceeds its transverse dimensions, then it is called **the wound canal (*canalis vulneralis*)**.

It is the violation of the integrity of the covering tissues (skin, mucous membrane) that distinguishes wounds from other types of damage (bruise, rupture, sprain). For example, a rupture of lung tissue that occurs as a result of blunt trauma to the chest is considered a rupture, and in the case of damage caused by a knife blow, it is considered a lung wound, because there is a violation of the integrity of the skin.

It is necessary to distinguish between the concepts of "wound" and "injury". In essence, a wound is the end result of tissue damage. The concept of wounding (*vulneratio*) is understood as the process of injury itself, the entire complex and multifaceted set of pathological changes that inevitably arise during the interaction of tissues and a wounding projectile both in the area of injury and in the entire body.

Main signs of a wound

The main classic signs of wounds are pain, bleeding and gaping. The severity of each symptom is determined by the nature of the injury, the volume of damaged tissue, the characteristics of the innervation and blood supply to the wound canal area, and the possibility of injury to vital organs.

Pain (*dolor*) occurs due to direct damage to the nerve endings in the wound area, as well as as a result of their compression due to developing edema. If part or all of the nerve trunk is damaged, pain can not only be localized at the site of injury, but also spread to the entire area of innervation.

Pain factors:

1. Localization of the wound. Wounds are especially painful in places where there are a large number of pain receptors (skin in the area of

the fingertips, periosteum, parietal peritoneum, pleura). Damage to fiber, muscles and fascia has a lesser effect on the intensity of pain.

2. The presence of damage to large nerve trunks.

3. The nature of the wounding weapon and the speed of inflicting the wound. The sharper the weapon, the less damage to the receptors and the less pain. The faster the impact occurs, the less pronounced the pain syndrome is.

4. Neuropsychic state of the patient. Pain sensations can be reduced when the victim is in a state of passion, shock, alcohol or drug intoxication. Pain is completely absent when the operation is performed under anesthesia, as well as with a disease such as syringomyelia (the gray matter of the spinal cord is affected).

Pain is a protective reaction of the body, but prolonged intense pain causes depletion of the central nervous system (CNS), which adversely affects the functions of vital organs.

Bleeding (*haemorrhagia*) is an obligatory sign of a wound, since damage to any tissue, starting with the skin and mucous membrane. It is accompanied by a violation of the integrity of blood vessels. The severity of bleeding can vary – from minor capillary to profuse arterial.

Bleeding intensity factors:

1. The presence of damage to large (or medium-sized) vessels: arteries or veins.

2. Localization of the wound. Bleeding is most pronounced when the face, head, neck and hand are wounded, where the tissues have the best blood supply.

3. The nature of the wounding weapon: the sharper it is, the more pronounced the bleeding. With crushed and bruised wounds, bleeding is minimal.

4. State of systemic and local hemodynamics. For example, with low blood pressure (BP) or compression of a great vessel, the intensity of bleeding decreases.

5. Condition of the coagulation system. With its disorders (for example, with hemophilia), damage to even small vessels can lead to significant blood loss and even death.

Gaping (*hiatus*) is caused by contraction of the elastic fibers of the skin. The severity of the divergence of the skin edges of the wound is primarily determined by the relationship of its axis to the Langer`s lines, showing the main directions of the location of the coarse fibrous structures of the skin.

So, to reduce gaping during surgical interventions on the upper and lower extremities, the longitudinal direction of the incisions is preferably

chosen, rather than transverse. The direction of the incision is of particular importance in cosmetic and plastic surgery, when closing skin defects and excision of scars.

For greater wound gaping (opening of ulcers), the incision is made perpendicular to the Langer's lines.

1.2. Classification of wounds by origin

Based on their origin, wounds are divided into surgical (intentional) and accidental.

Surgical wounds are inflicted deliberately for therapeutic or diagnostic purposes. A characteristic feature of these wounds is that they are not infected because they are applied under special aseptic conditions. Surgery is always performed under anesthesia, the wound is applied taking into account the anatomical structure, with minimal trauma, with careful hemostasis, followed by maximum restoration of the anatomical structures. Thus, with surgical wounds there is no pain, the possibility of bleeding is minimized, and the gaping is usually eliminated at the end of the operation by suturing, i.e. the main signs of the wound are artificially eliminated. Thanks to this, the most favorable conditions are created for wound healing by primary intention.

All other wounds are accidental. The term is not entirely appropriate, since military or "criminal" wounds are not inflicted by accident, but deliberately. A common feature of accidental wounds is the obligatory infection and such wounds are inflicted against the will of the wounded person, which can cause harm or lead to death.

Classification of wounds depending on the nature of tissue damage Depending on the type of wounding weapon and the nature of tissue damage, the following types of wounds are distinguished:

– cut;
– chopped;
– bruised;
– torn;
– crushed;
– chopped;
– bitten;
– mixed;
– firearms.

Incised wounds (vulnusincisum) – occur as a result of the impact of a sharp object on the surface of the skin (knife, razor, shards of glass, metal).

When a wound is inflicted, the force is concentrated on a narrow area, where high pressure develops, easily separating the tissue in the direction of action of the wounding object. They are characterized by minimal tissue destruction along the wound channel and surrounding tissues. The edges of the wound are even, smooth, and gape depending on the elasticity of the tissue and the direction of the cut line (the relationship between the wound axis and Langer's lines).

The pain syndrome is moderate, bleeding is significant. In most cases, there are good conditions for the evacuation of discharge from the wound cavity. With this type of wound, large blood vessels, nerves, muscles, and tendons can be damaged. If the above damage is absent and infection does not develop in the wound, then due to the small volume of damage, the wounds heal without complications, more often by primary intention.

Puncture wounds (vulnus punctum) – occur as a result of deep penetration of a sharp long thin instrument (awl, bayonet, knife, knitting needle, sharpening).

The anatomical feature is significant depth with little damage to the skin. The wound has a small entrance hole and is accompanied by minor damage to surrounding tissue. Due to the small diameter of the wound channel, the edges of the wound quickly stick together, making the outflow of wound fluid difficult, creating favorable conditions for the development of infection, including anaerobic infection. With this type of wound, pain is not expressed, there is no gaping, there is no external bleeding, but hematomas can develop in deep-lying tissues.

Puncture wounds are very insidious: they either cause virtually no harm or cause serious damage to blood vessels, nerves and internal organs. Thus, with a puncture wound, a small defect on the skin of the anterior abdominal wall is possible both with a non-penetrating wound and with serious damage to the liver, stomach, intestines – conditions that pose a threat to the patient's life.

Contused wounds (vulnus contusum) – occur when a blunt, hard object with a wide damaging surface is exposed to tissue in areas where there is solid support in the form of bones. In order to overcome the resistance of the skin, the wounding object must damage less durable but fragile deep formations (muscles, bones) (fig. 1).

Characterized by the presence of a large number of crushed, bruised, blood-soaked tissues. The wound has an irregular shape, uneven edges, and gapes widely. The pain syndrome is pronounced due to the large area of damage, the bleeding is often small, since the vessels quickly thrombose

due to damage to the vessel wall. Due to the large volume of necrotic tissue, contused wounds are prone to healing by secondary intention.



Fig. 1. Bruised wound

Lacerated wounds (vulnus laceratum) – occur when an object is exposed at an angle to the surface of the skin, when the force of the wounding object exceeds the permissible strength of the tissue. More often they occur when exposed to moving parts of mechanisms (transmissions, saws). Characterized by a significant amount of damage, skin detachment throughout. When a flap of skin is completely or almost completely separated, the wound is called scalped (fig. 2).



Fig. 2. Laceration

The shape of the wound is usually irregular, gapes widely, its edges are uneven, and there are massive hemorrhages in the skin, subcutaneous tissue, and muscles. There is a pronounced pain syndrome, there may be massive bleeding, but more often the bleeding is moderate, the wound is filled with blood clots. Wounds of this nature can also occur with shrapnel gunshot wounds.

Crushed, crushed wounds (vulnus convassatum) – are formed when exposed to a blunt object with a wide surface when opposed to a solid support (bones, other objects).

Characterized by crushing and extensive tissue necrosis. Soft tissue and muscle are crushed on the underlying bones, and sometimes the bones are damaged. The edges are uneven, the wounds gape widely. The surrounding tissues are saturated with blood, and there are non-viable areas. The pain syndrome is pronounced. Bleeding is often small. Damage to large vessels and nerves is rare. Often complicated by the development of infection.

Chopped wounds (vulnus caesum) – occur as a result of exposure to a sharp object (axe, checker, saber) with greater force perpendicular or at an angle to the tissue.

They are characterized by deep damage, wide gaping, bruising and concussion of surrounding tissues. They occupy an intermediate position between cut and bruised. The edges are smooth with hemorrhages around. The pain is significant and severe bleeding may occur. Internal organs, bones, blood vessels and nerves are often damaged.

Bite wounds (vulnus morsum) – result from the bite of an animal or person, which are the most infected, since the oral cavity is rich in virulent microflora. Such wounds are often complicated by the development of infection, despite the fact that the area of damage is not particularly large.

The saliva of some animals can carry certain toxins or poisons (venomous snake bite). In addition, bite wounds can become infected with the rabies virus, which requires preventive measures.

Mixed wounds (vulnus mixtum) combine the properties of different wounds: laceration, bruise, stab wound.

Gunshot wounds (vulnus clopetarium) – occur when hit by firearm projectiles (bullets, shrapnel, arrow-shaped elements).

A gunshot wound has serious differences from all others:

• presence of three damage zones;

• complex anatomical nature of the damage;

• high degree of infection;

• additional classifications.

All types of wounds are characterized by the presence of two zones of damage: the wound channel and traumatic necrosis. Observation of gunshot wounds soon after the introduction of firearms into practice revealed that they are more severe and heal much worse than wounds inflicted by knives. Also N. I. Pirogov was clear that the severity of a gunshot wound is determined by the large amount of mechanical damage

to tissue around the wound canal. However, the mechanism of this damage was clarified only over the past decades, when, on the basis of modern technology and experiments using ultra-high-speed filming, the science of the mechanism of tissue damage in a gunshot wound was created – wound ballistics.

The main difference between a gunshot wound is the high speed of the wounding object (bullet, shell, fragment). It is known that the energy of any freely moving body (bullet) is equal to $mV^2/2$. In case of a gunshot wound, all the kinetic energy of the bullet (if it stops in the tissues) or part of it (if there is a through wound and the flight continues) turns into energy of destruction of body tissues.

Considering the high speed of the bullet (projectile), tissue damage is also very high. Pointed bullets pass through tissue more easily, and if the bullet loses stability, starting to "tumble", it gives off maximum energy to the tissue. This is the basis for the action of modern bullets, which are lightweight and therefore tend to lose stability at high initial speeds (the so-called "bullets with a displaced center of gravity").

When a projectile penetrates tissue, an area of increased pressure is created, in which tissue compression occurs, spreading to the sides of the projectile in the form of a shock wave. The phenomenon of "side impact" occurs, as a result of which a temporary cavity is formed in the tissues, which seems to pulsate, and the tissues are compressed, separated, and mutually displaced at high speed. The pressure inside the cavity can reach 1000 atm, and the load on the walls of the pulsating cavity can be 120 kg/cm^2.

A similar mechanism of action on tissue leads to the development of not two, but three zones of damage, which was noted by Borst in 1917. In modern surgery for gunshot wounds, the following damage zones are distinguished.

• *1st zone* – wound channel. In some cases, it contains a bullet and other foreign bodies, scraps of necrotic tissue, spilled blood, and bacteria.

• *2nd zone* – zone of direct traumatic necrosis. Occurs under the influence of kinetic energy transferred from the bullet to tissues. Contains non-viable and partially non-viable tissues soaked in blood.

• *3rd zone* – zone of molecular concussion. Consists of tissues with metabolic disorders and damage to cellular structures. Under unfavorable conditions, for example, a decrease in perfusion, oxygenation, or the development of infection, the tissues devitalize (die). The zone of molecular shock is also called the «storehouse of subsequent necrosis». It is the presence of this zone that determines the complexity and features of the treatment of gunshot wounds.

Complex anatomical nature of the injuries

The high kinetic energy of the bullet causes not only three zones, but also the complex anatomical nature of tissue damage. What does it mean?

Gunshot wounds often involve damage to multiple body cavities (for example, the chest and abdominal cavities). Splintered bone fractures often occur; if internal organs are damaged, their ruptures and massive crushing of the walls can occur. The wound channel is not always a straight line from the inlet to the outlet; it can look like a broken curve and be accompanied by damage to a variety of organs.

High degree of infection

Gunshot wounds are very often complicated by the development of infection. This is due not only to the presence of an extensive zone of necrosis, but also to abundant contamination of the wound: the bullet (projectile) carries oil and soot from the weapon, pieces of clothing are drawn into the wound canal, in case of a shrapnel wound – the earth, when fired at close range, development of skin burn. High infection along with an abundance of necrotic masses significantly increases the risk of suppuration, and massive muscle damage and the small diameter of the inlet make it difficult for oxygen to reach and increase the possibility of developing an anaerobic infection.

1.3. Additional classifications

Classification according to the nature of the wound channel:

1. Through wound – there are entrance and exit holes, and the bullet, accordingly, does not remain in the body.

2. Blind wound – there is only an entrance hole, the bullet remains in the victim's body at the end of the wound channel.

3. Tangential wound – damage to superficial tissues without penetration deep into the body.

Classification by damaging factor:

1. Low-velocity gunshot wounds. The bullet speed does not exceed 600 m/s (small-caliber weapons: pistol, rifle or shots from a long distance; the bullet is on the downward part of its trajectory and loses speed). The wound channel is often straight and often blind. Such wounds usually have a small entry hole and a moderate amount of tissue damage.

2. High-velocity gunshot wounds. The bullet's flight speed reaches 900 m/s and higher (modern automatic weapons). As a rule, the wounds have a small entrance hole and a wide exit hole with a soft tissue defect. The wound channel is tortuous due to the "tumbling" of the bullet, many tissues and organs are damaged. An even greater destructive effect is produced by explosive shells and fragments, the trajectory of which is unpredictable.

3. Shot wounds. They are distinguished by the multiplicity of individual wounds, significant blood loss and, when fired at close range, by the impact of a shock wave, causing contusion of organs and tissues.

Classification by damage zones:

• ***Wounds with a small area of damage*** – wounds in which the damage to the edges is invisible (surgical, incised) or barely noticeable (stabbed, chopped), and the zone of necrosis is extremely insignificant. Wounds with a small area of damage have little gaping, heal quickly, and are less prone to complications.

• ***Wounds with a large area of damage*** – wounds in which the edges visually appear damaged: hemorrhages, crushing, crushing of tissues are visible (bruised, lacerated, crushed, gunshot wounds). Wounds with a large area of damage bleed little, hurt more, take a long time to heal, and are prone to complications.

Classification by degree of infection:

Microorganisms entering the wound are extremely important and sometimes decisive for the course of the healing process and the final outcome.

Depending on the degree of infection, three types of wounds are distinguished:

• aseptic;
• freshly infected;
• purulent.

This division is of fundamental importance for the treatment of wounds.

Aseptic wounds are wounds inflicted in the operating room (surgical wounds) in full compliance with aseptic standards. Such wounds heal quickly and are not prone to complications.

However, surgical wounds are also different: one thing is an operation on blood vessels (removal of varicose veins, for example), in which the risk of developing postoperative complications is minimal, and quite another thing is an operation for acute phlegmonous appendicitis, in which, despite the strictest adherence to norms, asepsis, there is a fairly high risk of purulent complications due to the inflammatory nature of the disease itself and the opening of the colon lumen during surgery.

Depending on the degree of microbial contamination, all operations are divided into four types:

• clean, or aseptic, operations (planned primary interventions without opening the lumen of internal organs);

• operations with possible infection – conditionally aseptic (interventions involving opening the lumen of organs in which the presence of microorganisms may be present);

• operations with a high risk of infection – conditionally infected (interventions during which contact with microflora is more significant);

• operations with a very high risk of infection – infected (emergency interventions for various purulent processes).

Any wound inflicted outside the operating room within 3 days from the moment of injury is considered ***freshly infected***. Microorganisms enter the wound with the wounding object, as well as from the surface of the skin. The degree of infection of such wounds varies and depends both on the type of wounding weapon and on the conditions in which the wound was received. It is important to note that the number of microorganisms in a freshly infected wound does not exceed 10^5 per 1 g tissue. Gunshot wounds and wounds contaminated with soil (for example, a wound caused by a metal rod protruding from the ground injuring the foot) are particularly susceptible to infection.

Purulent wounds are also infected. But they are fundamentally different from freshly infected ones in that the infectious process is already developing in them. The microorganisms that have entered the wound have multiplied (the number significantly exceeds 10^5 on 1 g the tissue), and their effect on the tissue causes a pronounced inflammatory process, necrosis, the formation of purulent exudate and the phenomenon of general intoxication.

Classification by difficulty:

Based on complexity, it is customary to distinguish between simple and complex wounds.

If only the skin, subcutaneous tissue and muscles are damaged, they speak of ***simple*** wounds.

Complex wounds are those with damage to internal organs, bone structures, great vessels and nerve trunks.

Damage to internal organs (brain and spinal cord, thoracic or abdominal organs, etc.) is diagnosed using special symptoms. Damage to the arterial vessels on the limb is indicated by the absence of their pulsation in the peripheral parts, pallor and a decrease in skin temperature in the area of the blood supply. In cases of isolated damage to the main venous trunks, phenomena of venous stagnation occur – the distal parts of the limb become edematous and acquire a bluish (cyanotic) tint. When the nerve trunk is crossed, loss of sensitivity and/or motor function of the limb occurs, and with a tangential wound and contusion, their partial impairment occurs.

Classification depending on the relationship of the wound defect to body cavities:

In relation to body cavities, wounds can be ***penetrating*** or ***non-penetrating.***

Penetrating wound is one that causes communication between any cavity (skull, pleura, peritoneum, joint) and the external environment. This requires a violation of the integrity of the corresponding membrane (dura mater, parietal pleura, parietal peritoneum, joint capsule). If these membranes are damaged, the wound is penetrating; if not, it is non-penetrating.

Penetrating injuries are the most serious and dangerous. When the chest is injured, pneumothorax and hemothorax may occur, which is reliably established using x-ray examination. If the abdominal cavity is injured, damage to hollow and parenchymal organs, intra-abdominal bleeding, etc. are possible. In the diagnosis of these disorders, along with clinical examination, special diagnostic methods (X-ray examination, ultrasound, endoscopy) are of great importance.

Classification by area of damage:

The classification of wounds by location is very simple. There are wounds of the neck, head, torso, upper and lower extremities, etc. In cases where the wound affects various organs of different anatomical regions, it is called combined (thoraco-abdominal wounds – damage to the thoracic and abdominal cavities).

Depending on the number of simultaneously inflicted injuries, single and multiple wounds are distinguished.

Combined wounds

When the wound is exposed to damaging factors other than mechanical ones (high or low temperature, chemical or radioactive substances), they speak of combined lesions.

CHAPTER 2

WOUND HEALING

2.1. Phases of wound healing

The wound process is a set of consecutive changes occurring in the wound and the associated reactions of the whole organism.

Conventionally, the wound process can be divided into general reactions of the body and direct wound healing.

First phase

Within 1–4 days from the moment of injury, excitation of the sympathetic nervous system is noted, the release of hormones of the adrenal medulla, insulin, ACTH and glucocorticoids into the blood. As a result, vital processes intensify: body temperature and basal metabolism increase, body weight decreases, the breakdown of proteins, fats and glycogen increases, the permeability of cell membranes decreases, protein synthesis is suppressed, etc. The significance of these reactions is to prepare the whole organism for life in conditions of alteration.

In the cavity of any wound there is one or another number of microorganisms and damaged tissues that undergo phagocytosis and resorption. At the same time, due to metabolic disorders, a large amount of waste products are formed in the tissues surrounding the wound, which enter the blood and cause general reactions in the body. As a result, in the first period a moderate increase in body temperature, weakness, and decreased performance are observed.

Blood tests reveal an increase in the number of leukocytes, sometimes a slight shift in the leukocyte formula to the left; protein may appear in urine tests. With heavy blood loss, a decrease in the number of red blood cells, hemoglobin, and hematocrit occurs.

Second phase

Starting from the 4–5th day, the nature of general reactions is determined by the predominant influence of the parasympathetic nervous system.

Somatotropic hormone, aldosterone, and acetylcholine are of primary importance. In this phase, body weight increases, protein metabolism normalizes, and the body’s reparative capabilities are mobilized. In an uncomplicated course, by the 4–5th day the symptoms of inflammation and intoxication are stopped, the pain subsides, the fever stops, and laboratory

parameters of blood and urine normalize. It should be noted that such a pattern of general reactions during wound healing is possible only in the absence of complications.

Wound healing

The second component of the wound process is a complex of changes occurring directly in the wound itself and the surrounding tissues. It has a name – wound healing.

Wound healing is the process of repair ***(reparare*** – restore, correct) damaged tissues with restoration of their integrity and functions.

To close the defect formed due to damage, three main processes occur in the wound:

• ***Formation of collagen by fibroblasts***. During wound healing, fibroblasts are activated by macrophages. They proliferate and migrate to the site of injury, binding to fibrillar structures through fibronectin. At the same time, fibroblasts intensively synthesize extracellular matrix substances, including collagens. Collagens ensure the elimination of tissue defects and the strength of the formed scar.

• ***Epithelization of the wound*** occurs as epithelial cells migrate from the edges of the wound to its surface. Completed epithelization of the wound defect creates a barrier to microorganisms. However, migration from the edges cannot close a large defect, which makes it necessary in some cases to perform skin grafting.

• ***The effect of tissue contraction***, to a certain extent due to the contraction of myofibroblasts, ensures the reduction of wound surfaces and wound closure.

These processes occur in a certain sequence, which is determined by the phases of wound healing (phases of the wound process).

Phases of wound healing

Historically, there have been several classifications of wound healing phases.

I. G. Rufanov (1954) distinguished two phases: hydration and dehydration. S. S. Girgolav (1956) identified three periods of wound healing:

I – preparatory period;

II – regeneration period (filling the wound cavity with newly formed tissue);

III – the period of scar formation.

Currently, the most popular classification of wound healing phases according to M. I. Kuzina (1977):

Phase I – inflammation phase (days 1–5);

Phase II – regeneration phase (6–14 days);

Phase III – the phase of scar formation and reorganization (from the 15th day from the moment of injury).

Inflammatory phase

Phase I of wound healing – the inflammation phase, occurs in the first 5 days and combines two successive periods: vascular changes and cleansing of the wound from necrotic tissue. Vascular reactions and extravascular changes occurring in the wound are closely related.

Period of vascular changes . In response to injury, a number of disorders affecting the microvasculature develop. In addition to the direct destruction of blood and lymphatic vessels, which contributes to the disruption of the outflow of blood and lymph, a short-term spasm occurs, and then a persistent paretic dilatation of microvessels. Participation in the inflammatory reaction of biogenic amines (bradykinin, histamine, serotonin), as well as the complement system, leads to persistent vasodilation and increased permeability of the vascular wall. This creates additional conditions for slowing blood flow, which is aggravated by thickening of the blood due to the release of its liquid part through the vascular wall, adhesion and aggregation of platelets. As a result, thrombosis of capillaries and venules occurs.

Reduced perfusion leads to deterioration of tissue oxygenation in the wound area. Acidosis develops, carbohydrate and protein metabolism is disrupted. During the breakdown of cellular proteins (proteolysis), K^+ and H^+ ions are released from the destroyed cells, increasing the osmotic pressure in the tissues, water retention occurs, and tissue edema (hydration) develops, which is the main external manifestation of inflammation.

Prostaglandins, metabolites of arachidonic acid released from destroyed cell membranes, take an active part in this phase. In addition to the vasodilating effect, they, like interleukins, contribute to the appearance of a pyrogenic reaction and, together with bradykinin, determine the development of pain.

The described changes in the microvasculature lead to the appearance of extravascular changes, the main ones of which are the exudation of plasma and lymph, the release and migration of leukocytes to the wound area, and the degranulation of mast cells.

As a result, edema and leukocyte infiltration of tissues develop, and conditions are prepared for cleansing the wound.

The period of cleansing the wound from necrotic tissue. In cleansing the wound, the most significant role is played by blood cells and enzymes. From the first day, neutrophils appear in the tissues and exudate surrounding the wound, and on the 2–3rd day – lymphocytes and macrophages.

Neutrophilic leukocytes phagocytose microorganisms and necrotic masses, carry out extracellular proteolysis, lyse non-viable tissue and secrete inflammatory mediators.

The main functions of macrophages are the release of proteolytic enzymes and phagocytosis of necrotic tissues partially destroyed by leukocytes, decaying neutrophilic leukocytes, bacterial decay products, as well as participation in immune reactions. Lymphocytes contribute to the immune response.

In an uncomplicated course, by the 5–6th day most of the inflammatory reactions are stopped and the next phase of wound healing begins.

Features of the inflammation phase

In the first phase, inflammation is much more pronounced, and wound cleansing takes much longer. Phagocytosis and lysis of cells devitalized as a result of trauma or the action of microorganisms cause a significant concentration of toxins in the surrounding tissues, increasing inflammation and impairing microcirculation. A wound with a developed infection is characterized not only by the presence of a large number of microbes in it, but also by their invasion into the surrounding tissues. At the border of penetration of microorganisms, a pronounced leukocyte shaft is formed. It helps to separate infected tissues from healthy ones; demarcation, lysis, sequestration and rejection of non-viable tissues occur. The wound is gradually clearing. As areas of necrosis melt and decay products are absorbed, intoxication of the body increases. This is evidenced by all common manifestations characteristic of the development of wound infection. The duration of the first phase of healing depends on the amount of damage, the characteristics of the microflora, the condition of the body and its resistance. At the end of the first phase, after lysis and rejection of necrotic tissue, a wound cavity is formed and the second phase begins – the regeneration phase, the peculiarity of which is the emergence and development of granulation tissue (fig. 3).



Fig. 3. Local signs of inflammation: hyperemia,
edema, areas of tissue necrosis

Regeneration phase

Phase II of wound healing – the regeneration phase, occurs in the period from 6 to 14 days from the moment of injury.

Two main processes occur in the wound: collagenization and intensive growth of blood and lymphatic vessels. The number of neutrophils decreases and fibroblasts, connective tissue cells with the ability to synthesize and secrete macromolecules of the extracellular matrix, migrate to the wound area.

An important role of fibroblasts in wound healing is the synthesis of connective tissue components (granulation tissue) and the construction of collagen and elastic fibers (fig. 4). The main bulk of collagen is formed precisely in the regeneration phase.



Fig. 4. Regeneration phase: the wound is clean,
granulation tissue is visible

At the same time, recanalization and growth of blood and lymphatic vessels begin in the wound area, which improves tissue perfusion and nutrition of fibroblasts that need oxygen. Mast cells are concentrated around the capillaries, which promote capillary proliferation.

Biochemical processes in this phase are characterized by a decrease in acidity, an increase in the concentration of Ca^{2+} ions and a decrease in the concentration of K^{+} ions and a decrease in metabolism.

The inflammatory process subsides, there is less discharge, swelling decreases or completely disappears (dehydration).

Scar formation and reorganization phase

Phase III of wound healing – the formation and reorganization of a scar, begins approximately on the 15th day and can last up to 6 months.

In this phase, the synthetic activity of fibroblasts and other cells decreases and the main processes are reduced to strengthening the resulting scar. The amount of collagen practically does not increase. Its restructuring and the formation of cross-links between collagen fibers occur, due to which the strength of the scar increases. The listed processes lead not only to an increase in the strength of the scar, but also to a reduction in its size, which is called retraction. As collagen density increases, the formation of new blood vessels slows down and the scar tissue gradually fades.

There is no clear boundary between the regeneration phase and scarring. The maturation of connective tissue begins in parallel with epithelization of the wound.

Forming scars rarely reach the resistance of healthy tissue to damage. Skin wounds restore only 70–90 % of their original strength, but this also takes time.

The strength of scars in the absence of complications by the end of the 1st month is 50 % of the original, by the end of the 2nd – 75 %, and the 4th – 90 %.

Tissues with a complex structure (nervous, parenchymal, muscle) are less capable of regeneration. At the site of the wound, a scar develops that does not fully perform the necessary functions (fig. 5). Tissues of simple structure (connective epithelium) are more capable of regeneration.

This is the basic scheme of wound healing, which is the same for wounds of any origin and location. However, the course of the wound process is influenced by a number of factors.



Fig. 5. Scar formation

2.2. Factors influencing wound healing

The following factors influence wound healing:

• age of the patient;

• nutritional status and body weight;

• presence of secondary wound infection;

• immune status of the body;

• the state of blood circulation in the affected area and the body as a whole;

• chronic concomitant diseases (diseases of the cardiovascular and respiratory systems, diabetes mellitus, malignant tumors, etc.);

• some types of therapy (taking anti-inflammatory drugs, radiation therapy, etc.).

The child's body has the greatest reparative capabilities, which is associated with the predominance of anabolic processes during development. Under these conditions, healing of various injuries occurs in a shorter time and with a more favorable outcome. In old age, on the contrary, wounds tend to last a long time with the formation of fragile scars.

Loss of body weight and cachexia lead to disruption of metabolic processes and complicate the normal healing of wounds, since the body urgently needs sources of energy and plastic material. It has been noted that patients with excess subcutaneous fat are more likely to experience wound complications. This is due to the fact that adipose tissue has a significantly worse blood supply than other tissues and is less resistant to the development of infection.

The occurrence of wound suppuration significantly prolongs the healing time and worsens the healing result. Patients with a weakened immune background after infectious diseases and those with congenital or acquired immune defects, including AIDS patients, are at increased risk of developing infectious complications.

The intensity of blood circulation in the damaged area is important. A decrease in tissue perfusion as a result of disturbances in systemic hemodynamics or due to damage to the main vessels in the area of damage (atherosclerotic narrowing or blockage of an artery, venous thrombosis, etc.) significantly slows down the course of all phases of the wound process and contributes to the development of complications.

Chronic diseases of the cardiovascular and respiratory systems affect oxygenation and nutrient supply to local tissues and the entire body.

If these systems are insufficient (for example, with bronchial asthma, pulmonary fibrosis, silicosis, emphysema and other chronic lung diseases; arterial hypertension, widespread atherosclerosis and other diseases of the heart and blood vessels), the synthesis of essential proteins and carbohydrates, energy metabolism are disrupted, and repair processes are slowed down.

In diabetes mellitus, in addition to the development of micro- and macroangiopathy, carbohydrate metabolism in tissues suffers and immunity disorders occur. This disrupts the course of the wound process.

In cancer patients, the growth of a malignant tumor requires significant expenditure of energy and nutrients, all types of metabolism are disrupted, and cachexia develops. All this negatively affects wound healing in such patients, which is confirmed by the higher incidence of wound complications after surgery in cancer patients.

Some types of therapy also slow down the wound process. In the early stages, glucocorticoids and non-steroidal anti-inflammatory drugs can slow down the healing process. Radiation therapy causes obliteration of small vessels in the dermis, which leads to local tissue ischemia and also slows down wound healing.

2.3. Types of healing

With a possible variety of options for the course of the wound process, depending on the nature of the wound, the degree of development of the microflora, and the characteristics of the immune response, they can always be reduced to three classical types of healing:

- healing by primary intention;
- healing by secondary intention;
- healing under the scab.

Healing by primary intention

Healing by primary intention ***(sanatioperprimamintentionem)*** is the most economical and functionally beneficial, it occurs in a shorter time with the formation of a thin, relatively durable scar.

Surgical wounds heal by primary intention when the edges of the wound come into contact with each other (connected with sutures). The amount of necrotic tissue in the wound is small, and inflammation is insignificant.

After the inflammation subsides and the wound is cleansed of non-viable cells in the regeneration phase, connective tissue adhesions are formed between the walls of the wound due to the collagen formed by fibroblasts and sprouting blood vessels. At the same time, epithelium grows from the edges of the wound, which serves as a barrier to the penetration of microorganisms.

Occasional small superficial wounds with dehiscence 1 cm can also heal by primary intention without suturing. This occurs due to the convergence of the edges under the influence of edema of the surrounding tissues, and subsequently they are held in place by the resulting “primary fibrin adhesive”.

Thus, with this healing method, there is no cavity between the edges and walls of the wound; the resulting tissue serves only to fix and strengthen the fused surfaces.

Only wounds in which there is no infectious process heal by primary intention: aseptic surgical wounds or accidental wounds with minor infection if the microorganisms die within the first hours after injury.

The development of an infectious complication in a wound is facilitated by the presence of a substrate for the vital activity of microbial agents. These may include a hematoma, an abundance of necrotic masses, or the presence of a foreign body. A hematoma, in addition to being a breeding ground for microorganisms, is also a factor that prevents close contact of the wound walls. A foreign body in a wound can serve as a source of infection and cause a rejection reaction, accompanied by severe, long-term inflammation and necrosis of surrounding tissues.

For healing by primary intention, there must be no factors that disturb the general condition of the patient and negatively affect the course of the wound process.

Thus, in order for the wound to heal by primary intention, the following conditions must be met:

- absence of infection in the wound;
- tight contact of the wound edges;

• absence of hematomas, foreign bodies and necrotic tissue in the wound;

• satisfactory general condition of the patient (absence of general adverse factors).

Healing by primary intention occurs in the shortest possible time, practically does not lead to the development of complications and causes minor functional changes. This is the best type of wound healing, which you should always strive for and create the necessary conditions for it.

Healing by secondary intention

Healing by secondary intention ***(sanatiopersecundamintentionem)*** – healing through suppuration, through the development of granulation tissue. In this case, healing occurs after a pronounced inflammatory process, as a result of which the wound is cleared of necrosis.

Conditions for healing by secondary intention

For wound healing by secondary intention, conditions are necessary that are opposite to those that promote primary intention:

• significant microbial contamination of the wound;

• significant size defect of the skin;

• the presence of foreign bodies, hematomas and necrotic tissue in the wound;

• unfavorable condition of the patient's body.

When healing by secondary intention, there are also three phases, but they have some differences.

Healing under the scab

Healing of a wound under a scab occurs with minor superficial injuries such as abrasions, damage to the epidermis, abrasions, burns, etc.

The healing process begins with the coagulation of spilled blood, lymph and tissue fluid on the surface of the injury, which dry out to form a scab.

The scab performs a protective function and is a kind of "biological bandage". Rapid regeneration of the epidermis occurs under the scab, and the scab is rejected. The whole process usually takes 3–7 days. In healing under a scab, the biological characteristics of the epithelium are mainly manifested – its ability to line living tissue, delimiting it from the external environment.

The scab should not be removed if there are no signs of inflammation. If inflammation develops and purulent exudate accumulates under the scab, surgical treatment of the wound with removal of the scab is indicated.

CHAPTER 3

TREATMENT OF WOUNDS

Despite the many specific features of various wounds, the basic principles of their healing are the same. In this regard, we can highlight the general tasks facing the surgeon when treating any wound:

1. Combating early complications.
2. Prevention and treatment of infection in the wound.
3. Achieving healing in the shortest possible time.
4. Complete restoration of the functions of damaged organs and tissues. These tasks begin at the very first stages of treatment when providing first aid.

3.1. First aid at the prehospital stage

When providing first aid to a victim, you should:

• eliminate early life-threatening wound complications;

• prevent further wound infection.

Coping with life-threatening complications

The most severe early complications of a wound are bleeding, the development of traumatic shock and damage to vital internal organs.

The intensity of bleeding depends on the type of damaged vessel and its caliber. Massive blood loss is caused by injury to the main arteries and veins, which can lead to the development of hemorrhagic shock with severe disorders of general hemodynamics. Therefore, in case of heavy bleeding, the first task is to stop it by applying a tourniquet (if an artery is injured) or clamping the veins distal to the injury while treating the wound, followed by applying a pressure bandage or other temporary methods of stopping the bleeding.

If there is a threat of developing traumatic shock, the administration of analgesics (including narcotics) and antishock drugs is used at the prehospital stage.

In cases of penetrating chest wounds and the occurrence of pneumothorax, it is necessary to apply an occlusive dressing using a special sterile rubberized fabric. Thus, the pleural cavity is sealed, and pneumothorax does not increase during transportation. When a large penetrating wound of the anterior abdominal wall occurs, internal organs sometimes prolapse into the wound. To prevent further prolapse and infection, a wide aseptic dressing should be applied.

Preventing further infection

Regardless of the nature and location, all accidental wounds are bacterially contaminated. However, in addition to the initial entry of microorganisms into the wound, their further penetration from the patient's skin, from the surrounding air, and from various objects is also possible. Therefore, to prevent additional penetration of bacteria into the wound, when providing first aid, remove contaminants from the surrounding skin with a cotton or gauze swab moistened with alcohol, diethyl ether or another solution that has antiseptic and cleansing effects. Then you should lubricate the edges of the wound with a 5 % alcohol solution of iodine (or alcohol, an alcohol solution of chlorhexidine, brilliant green, etc.) and apply an aseptic bandage, and, if necessary, a pressure bandage.

There is no need to wash the wound itself or remove foreign bodies from it when providing first aid.

In addition to wound treatment, for extensive injuries to the soft tissues of the extremities, as well as for bone fractures, transport immobilization is used to avoid aggravation of damage.

Further measures to treat the wound are primarily determined by its type and degree of infection. Therefore, treatment of operating (aseptic), freshly infected and purulent wounds is distinguished.

Treatment of surgical wounds

Treatment of a surgical wound essentially begins on the operating table, when the surgeon tries to create the best conditions for its healing.

Creating conditions for wound healing by primary intention during surgery

Surgical wounds are conditionally aseptic and incised. When applied, all conditions are created for healing by primary intention: infection prevention, reliable hemostasis are ensured, and there are no foreign bodies or necrotic tissue in the wound. At the end of the operation, the edges of the wound are brought together and carefully compared by suturing.

If there is a possibility of exudate accumulating in the wound, drainage is left in it.

The operation is finished by applying an aseptic dressing.

After suturing a deep wound of the limb with damage to muscles, tendons, blood vessels and nerve trunks, immobilization using a plaster splint is advisable. This technique provides functional rest, accelerated healing and reduced pain in the postoperative period.

It is important to carry out antibiotic prophylaxis, the general principle of which is the administration of an antibiotic before surgery

(or on the operating table) and within 6–48 hours after it. More often, cephalosporins of the second and third generations are used for this purpose.

It should be emphasized that the main conditions for wound healing by primary intention are created precisely during the operation.

Treatment of wounds in the postoperative period

After the operation, four additional tasks must be solved:

• pain relief;
• prevention of secondary infection;
• acceleration of wound healing processes;
• correction of the patient's general condition.

Anesthesia

Pain relief in the postoperative period can be carried out using various methods, depending on the traumatic nature of the intervention and the severity of the pain syndrome.

Prevention of secondary infection

After surgery, an aseptic dressing is applied to the wound. It must be changed one day after the operation, and then as needed.

To prevent infectious complications, it is important to monitor the condition and functioning of drains and remove them in a timely manner (non-functioning drains are a possible source of infection).

Acceleration of healing processes

To prevent hematoma, an ice pack is applied to the wound on the first day after surgery. Starting from the 3rd day, thermal procedures and physiotherapy (UHF, quartz treatment) are used.

To improve blood circulation and metabolic processes, early activation of patients is necessary.

Correction of general condition

In the postoperative period, you should carefully monitor the patient’s general condition for timely identification and correction of factors that adversely affect the course of the wound process (anemia, hypoproteinemia, circulatory failure, disturbances of carbohydrate metabolism, water-electrolyte balance, etc.).

Wound healing and suture removal

The use of these methods for the prevention of complications and treatment of surgical wounds in the vast majority of cases ensures their healing by primary intention. The end of this process is the formation of a postoperative scar.

Formally, the wound becomes a scar after the stitches are removed. The timing of suture removal (respectively, the timing of wound healing) is determined by the location of the wound and the patient's condition. Different healing times for wounds of different locations are primarily explained by the characteristics of blood circulation. On the face and front surface of the neck, the blood supply is very good, wounds heal quickly. On the lower limb, especially on the foot, the blood supply is worse – wounds take longer to heal.

The presence in the general condition of the patient of factors that adversely affect the course of the wound process (old age, anemia, concomitant diseases, etc.) increases the healing time.

Treatment of newly infected wounds

Considering that all accidental wounds are initially bacterially contaminated, treatment tactics depend on the nature and location of the wound, the extent and duration of the damage.

Fresh superficial wounds, scratches, abrasions require only treatment with antiseptics and an aseptic dressing. Such wounds heal on their own without suturing by primary intention or under a scab. However, even with such wounds, we must not forget about the possibility of penetration of pathogens of tetanus (usually when a wound or tool comes into contact with the ground) and rabies (from bites of various animals). In such cases, anti-tetanus serum and anti-rabic vaccine are administered.

With the majority of freshly infected wounds, the surgeon is faced with the task of preventing the development of infection (suppuration) in it and creating conditions for its rapid healing. In this regard, the main measure in the treatment of freshly infected wounds is primary surgical treatment (PST) of the wound.

3.2. Primary surgical treatment

Primary surgical treatment of a wound is the first surgical operation performed on a patient with a wound in compliance with the rules of asepsis, with anesthesia and consisting of the sequential implementation of the following steps:

- wound dissection;
- revision of the wound channel;
- excision of the edges, walls and bottom of the wound;
- hemostasis;
- restoration of the integrity of damaged organs and structures;
- suturing the wound with leaving drainage (if indicated).

Thus, thanks to PST, a random infected wound becomes incised and aseptic, which creates the possibility of its rapid healing by primary intention.

Dissection of the wound is necessary for a complete (under visual control) inspection of the area of the wound channel and the nature of the damage (fig. 6).

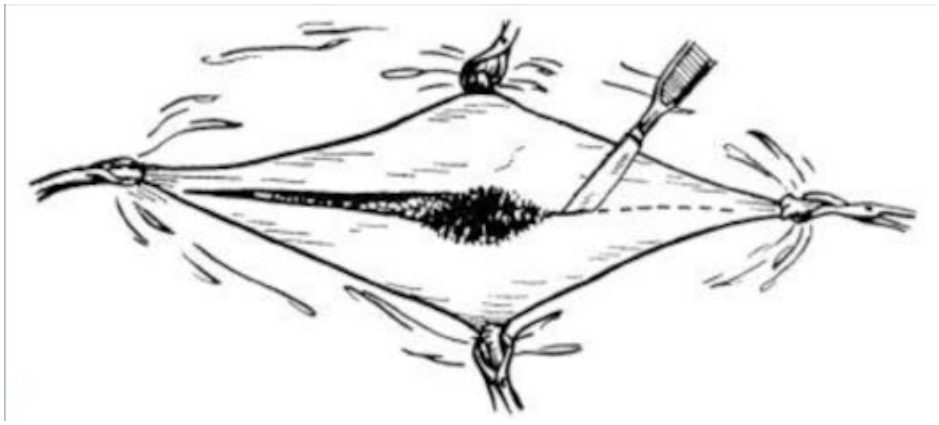


Fig. 6. Wound dissection

Excision of the edges, walls and bottom of the wound is carried out to remove necrotic tissue, foreign bodies, as well as the entire wound surface infected during injury. After completing this stage, the wound becomes cut and sterile. Further manipulations should be carried out only after changing tools and processing or changing gloves (fig. 7).

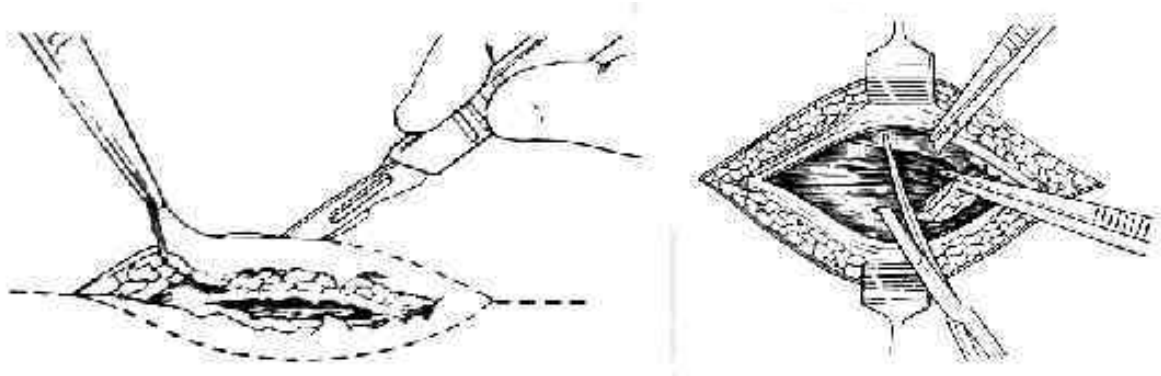


Fig. 7. Excision of the walls, edges and bottom of the wound

It is usually recommended to excise the edges, walls and bottom of the wound in a single block by approximately 0.5–2.0 cm. In this case, it is necessary to take into account the location of the wound, its depth and the type of damaged tissue. For contaminated, crushed wounds, and wounds on the lower extremities, the excision should be wide enough. For wounds on the face, only necrotic tissue is removed, and for an incised wound,

excision of the edges is not performed at all. It is impossible to excise the viable walls and bottom of the wound if they are represented by tissues of internal organs (brain, heart, intestines).

After excision, careful **hemostasis** is carried out to prevent hematoma formation and possible infectious complications.

The restorative stage (suturing nerves, tendons, blood vessels, connecting bones, etc.) immediately during PST, if the surgeon's qualifications allow it. If not, you can subsequently perform a repeat operation with a delayed suture of the tendon or nerve, or perform delayed osteosynthesis. Restoration measures should not be carried out in full during PST in wartime.

Suturing the wound is the final stage of PST. The following options are available for completing this operation.

1. Layer-by-layer suturing of the wound is tightly performed for small wounds with a small area of damage (cuts, punctures, etc.), lightly contaminated wounds, localization of wounds on the face, neck, torso or upper extremities with a short period from the moment of injury.

2. Suturing the wound with leaving drainage(s) is performed in cases where either there is a risk of developing an infection, but it is very small, or the wound is localized on the foot or lower leg, or the damaged area is large, or PST is performed 6–12 hours after damage, or the patient has a concomitant pathology that adversely affects the wound process, etc., i.e. at risk of developing infection.

3. The wound is not sutured if there is a high risk of infectious complications:

– late PST;

– excessive contamination of the wound with soil;

– massive tissue damage (crushed, bruised wound);

– concomitant diseases (anemia, immunodeficiency, diabetes mellitus);

– localization on the foot or lower leg;

– elderly age of the patient.

Gunshot wounds, as well as any wounds when providing assistance in wartime, should not be sutured.

Suturing a wound tightly under unfavorable factors is a completely unjustified risk and an obvious tactical mistake by the surgeon!

Main types

The sooner PST of the wound is performed from the moment of injury, the lower the risk of infectious complications.

Depending on the age of the wound, three types of PST are used: early, delayed and late.

• ***Early PST*** is carried out within 24 hours from the moment of wound infliction, it includes all the main stages, it is usually completed with the application of primary sutures. If there is extensive damage to the subcutaneous tissue and it is impossible to completely stop capillary bleeding in the wound, drainage is left for 1–2 days. Subsequently, treatment is carried out as for a "clean" postoperative wound.

• ***Delayed PST*** is performed from 24 to 48 hours after the wound is inflicted. During this period, inflammation develops, edema and exudate appear. The difference from early PST is that the operation is performed while antibiotics are administered and the intervention is completed by leaving the wound open (unsutured) with the subsequent application of primary delayed sutures.

• ***Late PST*** is performed after 48 hours, when inflammation is close to maximum and the development of the infectious process begins. Even after PST, the likelihood of suppuration remains high. In this situation, it is necessary to leave the wound open (do not stitch it up) and administer a course of antibiotic therapy. It is possible to apply early secondary sutures on days 7–20, when the wound is completely covered with granulations and becomes relatively resistant to the development of infection.

Indications

The indication for performing PST of a wound is the presence of any deep accidental wound within 48–72 hours from the moment of application. The following types of wounds are not subject to PST:

• superficial wounds, scratches and abrasions;

• small wounds with less dehiscence 1 cm;

• multiple small wounds without damage to deeper tissues (for example, a shot wound);

• puncture wounds without damage to internal organs, blood vessels and nerves;

• in some cases, through bullet wounds of soft tissues.

Contraindications

There are only two contraindications to performing PST of a wound.

• Signs of development of a purulent process in the wound.

• Critical condition of the patient (terminal condition, third degree shock).

Types of seams

The long-term existence of a wound defect does not contribute to rapid, functionally beneficial healing. This is especially true in cases of extensive damage, when there are significant losses of fluid, proteins, electrolytes through the wound surface and there is a high risk of suppuration. In addition, making the wound granulate and covering it with epithelium takes quite a long time. Therefore, you should strive to close the edges of the wound as early as possible using various types of sutures.

Advantages of suturing:

• acceleration of healing;

• reduction of losses through the wound surface;

• reducing the likelihood of repeated wound suppuration;

• increasing functional and cosmetic effects;

• facilitating wound treatment. There are primary and secondary sutures.

Primary sutures

Primary sutures are placed on the wound before granulation begins to develop, and the wound heals by primary intention.

Most often, primary sutures are applied immediately after completion of the operation or PST of the wound in the absence of the risk of developing purulent complications. Primary sutures are not advisable to use in late PST, PST in wartime, or PST of a gunshot wound.

Removal of sutures is carried out after the formation of a dense connective tissue adhesion and epithelization within a certain time frame.

Primary delayed sutures are also placed on the wound before granulation tissue develops (the wound heals by primary intention). They are used in cases where there is a certain risk of infection.

Technique: the wound after surgery (PST) is not sutured, the inflammatory process is controlled, and when it subsides, primary delayed sutures are applied on days 1–5.

A type of primary delayed sutures are provisional: at the end of the operation, sutures are placed, but the threads are not tied, and the edges of the wound are not brought together. The threads are tied on days 1–5 when the inflammatory process subsides.

The difference from conventional primary delayed sutures is that there is no need for repeated anesthesia and suturing of the wound edges.

3.3. Secondary surgical treatment

The indication for SST of a wound is the presence of a purulent wound in the absence of adequate outflow from it (retention of pus) or the formation of extensive areas of necrosis and purulent leaks. A contraindication is only when the patient is in an extremely serious condition, and is limited to opening and draining the purulent focus.

The tasks facing the surgeon performing wound surgical treatment:

• opening of a purulent focus and leaks;

• excision of non-viable tissue;

• implementation of adequate wound drainage.

Before starting SST, it is necessary to determine the visible boundaries of inflammation, the localization of purulent melting, the shortest access to it, taking into account the location of the wound, as well as possible ways of spreading the infection (along the neurovascular bundles, muscle-fascial sheaths). In addition to palpation examination, various types of instrumental diagnostics are used: ultrasound, thermographic, X-ray (for osteomyelitis) methods, CT.

Like primary surgical treatment, SST is an independent surgical intervention. It is performed in the operating room by a team of surgeons using anesthesia. Only adequate anesthesia allows you to solve all the problems of SST. After opening the purulent focus, a thorough instrumental and digital inspection is carried out along the wound itself and possible leaks are found, which are subsequently also opened through the main wound or counter-aperture and drained. After performing an inspection and determining the volume of necrosis, pus is evacuated and non-viable tissue is excised (necrectomy). At the same time, we must not forget that there may be large vessels and nerves near or in the wound itself that need to be preserved. Before the end of the operation, the wound cavity is washed abundantly with antiseptic solutions (hydrogen peroxide, boric acid, etc.), loosely tamponed with gauze swabs with antiseptics and drained. The most advantageous method of treatment for extensive purulent wounds is flow-through drainage. If the injury is localized to a limb, immobilization is necessary. Most often a plaster splint is used.

Secondary seams

Secondary sutures are applied to granulating wounds that heal by secondary intention. The purpose of using secondary sutures is to reduce (or eliminate) the wound cavity. A decrease in the volume of a wound defect leads to a decrease in the number of granulations required to fill it. As a result, healing time is reduced, and the content of connective tissue in a healed wound, compared to wounds treated openly, is much less. This has a beneficial effect on the appearance and functional characteristics of

the scar, its size, strength and elasticity. Bringing the edges of the wound closer together reduces the potential entry point for infection.

The indication for the application of secondary sutures is a granulating wound after the elimination of the inflammatory process, without purulent streaks and purulent discharge, without areas of necrotic tissue. To objectify the subsidence of inflammation, seeding of wound discharge can be used – if there is no growth of pathological microflora, secondary sutures can be applied.

There are ***early secondary sutures*** (they are applied on days 6–21) and ***late secondary sutures*** (they are applied after 21 days). The fundamental difference between them is that by the 3rd week after surgery, scar tissue forms at the edges of the wound, preventing both the rapprochement of the edges and the process of their fusion. Therefore, when applying early secondary sutures (before the edges become scarred), it is enough to simply stitch the edges of the wound and bring them together by tying the threads. When applying late secondary sutures, it is necessary to excise the scarred edges of the wound under aseptic conditions ("refresh the edges"), and after that apply sutures and tie the threads.

To speed up the healing of a granulating wound, in addition to suturing, you can use tightening the edges of the wound with strips of adhesive tape. The method does not completely and reliably eliminate the wound cavity, but it can be used even before the inflammation has completely subsided. Tightening the edges of a wound with an adhesive plaster is widely used to speed up the healing of purulent wounds.

3.4. Treatment of purulent wounds by phases of the wound process

Treatment of purulent wounds consists of local and general treatment. The nature of treatment, in addition, is determined by the phase of the wound process (table 1).

Treatment goals in the inflammation phase

In the first phase of the wound process (inflammation phase), the surgeon faces the following main tasks:

- fight against microorganisms in the wound;
- ensuring adequate drainage of exudate;
- assistance in prompt cleansing of the wound from necrotic tissue;
- reduction of manifestations of the inflammatory reaction.

When treating a purulent wound locally, methods of mechanical, physical, chemical, biological and mixed antiseptics are used.

When a postoperative wound becomes suppurated, it is usually sufficient to remove the sutures and spread its edges wide apart. In case of severe inflammation and extensive necrosis in a purulent wound, it is necessary to perform secondary surgical debridement (SST) of the wound.

Table 1

Principles of treatment of purulent wounds

Wound process phase	Goal of treatment	Method of treatment
First phase (alteration, exudation)	Evacuation of contents from the wound cavity	Drainage, Hypertonic solutions
	Removal of necrotic tissue	Mechanical treatment of the wound
	Infection suppression	Multicomponent ointments on a water-soluble basis; Chemotherapy, antiseptics
	Rejection of dead tissue	Hypertonic solutions ; Water-soluble ointments; Proteolytic enzymes
Second phase (regeneration)	Infection suppression	Ointments with chemotherapy drugs and antiseptics
	Granulation growth	Kombutek, algipor; Indifferent ointments
Third phase (remodeling)	Scar organization and epithelization	Indifferent ointments; Solcoseryl; Surgical treatment of the wound with suturing; Skin grafting

Treatment of a purulent wound after surgery

After performing SST or simply opening (opening) the wound at each dressing, the doctor examines the wound and assesses its condition, noting the dynamics of the process. The edges are treated with alcohol and an iodine-containing solution. The wound cavity is cleaned with a gauze ball or napkin from pus and loose sequestration, and necrotic tissue is sharply excised. This is followed by rinsing with antiseptics (3 % hydrogen peroxide solution, 3 % boric acid solution, nitrofural, etc.), drainage (as indicated) and loose tamponing using various antiseptics.

The main measures for treating a purulent wound in the inflammation phase are associated with the need to drain exudate and fight infection (table 1). Therefore, hygroscopic dressings are used, and it is possible to use a hypertonic solution (10 % sodium chloride solution). The main antiseptic agents are 3 % boric acid solution, 0.02 % aqueous solution of chlorhexidine, 1 % solution of hydroxymethylquinoxylin dioxide, nitrofural (1:5000 solution).

In the first phase of healing, when there is heavy exudation, ointment preparations cannot be used, as they create an obstacle to the outflow of discharge, which contains a large number of bacteria, proteolysis products, and necrotic tissue. Only on the 2nd – 3rd day is it possible to use water-soluble ointments based on polyethylene oxide (table 2). They contain various antimicrobial drugs: chloramphenicol, metronidazole + chloramphenicol, nitrofural, mafenide (10 % mafenide ointment). In addition, the ointments contain drugs such as trimecaine, for an analgesic effect, and methyluracil, which has anabolic and anti-catabolic activity, to stimulate cellular regeneration processes.

Table 2

Drugs for treating wounds in the inflammatory phase

Water-soluble ointments	**Sorbents**	**Enzymes**	**Antiseptic solutions**	**Aerosols**
Levomikol Levosin Dioxicol Sulfamekol Furagel Hinifurin Nitacid Iodine ointment Streptonitol	Gelevin Celosorb Immosgent Diotevin Collasorb Colladiasorb Diovin Anilovin Anilodiovin	*Proteases of animal origin* (Chymopsin, Collagenase) *Plant derived protease* (Karipazim) *Proteases of microbial origin* (Protease C, Lysoamidase) *Enzyme-containing products* (Trypsin, Chymotrypsin, Profezim, Lyzosorb)	Iodopyrone solution 0.2 % solution of furagin potassium Sulyodopyrone Dioxidine	Nitazol Dioxysol Gentazol

“Chemical necrectomy” with the help of proteolytic enzymes that have necrolytic and anti-inflammatory effects has a certain significance in the treatment of purulent wounds. For this purpose trypsin and chymotrypsin are used. The drugs are poured into the wound in dry form or injected in an antiseptic solution. To actively remove purulent exudate, sorbents are placed directly into the wound, the most common of which is hydrolytic lignin.

In order to increase the effectiveness of SST and further treatment of purulent wounds, a variety of physical methods of influence are used in modern conditions. Ultrasonic cavitation of wounds, vacuum treatment of a purulent cavity, treatment with a pulsating jet, and various methods of using lasers are widely used. All these methods are aimed at accelerating the cleansing of necrotic tissue and the detrimental effect on microbial cells.

Treatment in the regeneration phase

In the regeneration phase, when the wound has been cleared of non-viable tissue and inflammation has subsided, the next stage of treatment begins, the main objectives of which are to stimulate reparative processes and suppress infection.

In the second phase of healing, the formation of granulation tissue plays a leading role. During this period, in the absence of complications, exudation is sharply reduced and the need for a hygroscopic dressing, the use of hypertonic solutions and drainage disappears. Granulations are very delicate and vulnerable, so it becomes necessary to use ointment-based preparations that prevent mechanical trauma. The most effective are ointments containing stimulating substances (5 % and 10 % methyluracil ointment). However, despite the fact that granulation tissue also performs a protective function, the possibility of re-development of the infectious process cannot be completely excluded. Therefore, during dressings, wounds continue to be washed with antiseptic solutions, ointments, emulsions and liniments are used, including antibiotics (chloramphenicol, tetracycline, gentamicin ointments). Multicomponent ointments containing anti-inflammatory, antiseptic, substances that stimulate regeneration and improve regional blood circulation (hydrocortisone + oxytetracycline, balsamic liniment according to A. V. Vishnevsky) are widely used.

To speed up wound healing, the technique of applying secondary sutures (early and late) is used, as well as tightening the edges of the wound with an adhesive plaster.

Treatment of wounds in the phase of scar formation and reorganization

In the third phase of healing, the main tasks are to accelerate the epithelization of the wound and protect it from unnecessary trauma. For this purpose, bandages with indifferent and stimulating ointments, as well as physiotherapeutic procedures, are used.

Physiotherapy

Physiotherapeutic procedures occupy a significant place in the treatment of purulent wounds. In the first phase, to relieve acute inflammation, reduce swelling, pain, and accelerate the rejection of necrotic tissue, an electric field of UHF and UV in an erythemal dose is used, which also stimulates the phagocytic activity of leukocytes and has an antimicrobial effect. Electro- and phonophoresis are used for local administration of antibiotics, enzymes, anti-inflammatory and analgesic drugs. It should be remembered that if there is insufficient outflow of purulent contents, physiotherapeutic procedures lead to aggravation of the purulent-inflammatory process.

In the second and third phases of the wound process, in order to activate reparative processes and epithelization, UV irradiation and laser irradiation with a defocused beam are used. The magnetic field has a vasodilating and stimulating effect: when exposed to a pulsating magnetic field, the size of the scar decreases.

During the entire period of the wound process, it is possible to use hyperbaric oxygenation, which improves tissue oxygen saturation.

Treatment in an abacterial environment

For extensive wound defects and burns, treatment in a controlled abacterial environment is successfully used. There are general and local isolators; isolation of the entire patient is necessary when treating patients with reduced resistance to infection: after oncological operations accompanied by massive chemotherapy or radiation treatment; during organ transplantation associated with the constant use of immunosuppressants that inhibit the rejection reaction; various blood diseases that cause disruption and inhibition of lymphopoiesis.

Treatment in an abacterial environment is carried out without applying a bandage, which promotes drying of the wound, which adversely affects microorganisms. The following parameters are maintained in the isolator: temperature 26–32 °C, excess pressure 10–15 mmHg. st, relative humidity 50–65 %. Parameters may vary depending on the nature of the wound process.

Treatment with special bandages

In modern practice of local treatment of both clean and purulent wounds, a technique using ready-made dressings of domestic and foreign production containing multicomponent fillers is increasingly used. The composition of dressings for use in phase I includes drugs that can absorb wound exudate, adsorb bacterial cells and toxins, and promote the lysis of necrotic masses. Bandages for phases II and III contain fillers that protect granulations and “young” scars and stimulate reparative processes. This technique is also used for temporary closure of extensive wound surfaces in order to reduce the loss of protein, electrolytes, and fluid. The most common dressings currently are Vaskopran, Algipor, Sorbalgon, Suspurderm, Hydrocoll, etc.

General treatment

General treatment of wound infection has several areas:

• antibacterial therapy;

• detoxification;

• immunocorrective therapy;
• anti-inflammatory therapy;
• symptomatic therapy.

Antibacterial therapy

Antibacterial therapy is one of the components of complex therapy for purulent diseases and, in particular, purulent wounds. It is used mainly in phases I, as well as phases II and III of the wound process.

If the patient has no signs of intoxication, the wound is small, the integrity of the bone structures and great vessels is preserved, and there are no concomitant diseases, only local treatment is usually sufficient. In other situations, antibacterial therapy should be started as early as possible.

One of the main principles of therapy is the use of a drug to which the wound microflora is sensitive. But from the moment the material is collected to the receipt of the research results, sometimes more than one day passes. Then it is advisable to administer an antibiotic, to which the suspected infection is usually most sensitive. In this case, determining the characteristic features of pus inherent in any microorganism can help.

Staphylococci most often form thick pus of a yellowish tint, streptococci – liquid pus of a yellow-green color or ichor type, E. coli – brown pus with a characteristic odor, Pseudomonas aeruginosa gives a corresponding coloring of bandages and a sweetish odor (pus formed by Proteus has similar symptoms, but usually not green). We must not forget that mixed infection is more common in a purulent wound, so it is preferable to prescribe broad-spectrum antibacterial drugs at the initial stages. After determining sensitivity, you can change the antibiotic.

Detoxification

A large amount of necrosis and developing infection cause the body to become saturated with toxins. A patient with a purulent wound in the first phase of the wound process exhibits all signs of intoxication (chills, fever, sweating, weakness, headache, lack of appetite), and inflammatory changes in blood and urine tests increase. All this serves as an indication for detoxification therapy, which includes the following methods (in increasing complexity and effectiveness):

• infusion of saline solutions;
• method of forced diuresis;
• use of detoxification blood replacement solutions;
• extracorporeal methods of detoxification.

The choice of method depends primarily on the severity of intoxication and the severity of the patient’s condition.

During the regeneration and scar formation phase, there is usually no need for detoxification therapy.

Immunocorrective therapy

When a purulent process occurs in a wound and intoxication develops, a decrease in the body's resistance often occurs with a drop in the level of antibody production, phagocytic activity, a deficiency of subpopulations of lymphoid cells and a slowdown in their differentiation. Long-term use of powerful antibacterial drugs also leads to this. These changes contribute to the further development of infection, an increase in the area of secondary necrosis and a progressive deterioration of the patient’s condition.

To correct this temporary deficiency, immunomodulators are used. The most widely used are interferons, levamisole, and thymus preparations. However, when administered over a long period of time and in large doses, these drugs suppress the production of one's own immune cells. Recently, increasing attention has been paid to cytokines created by genetic engineering, in particular interleukins, which have broad indications for use in immunodeficiency states. Human recombinant interleukin-1 and interleukin-2 have been created and used in treatment.

Active immunization with toxoids and vaccines is used for prophylactic purposes in order to prepare the patient to fight the infection on his own. Typically, staphylococcal toxoid, polyvalent Pseudomonas aeruginosa vaccine, etc. are used.

Anti-inflammatory therapy

Anti-inflammatory therapy is not the leading method of treating wounds; it is used quite rarely and is limited to the administration of glucocorticoids and non-steroidal anti-inflammatory drugs. In addition to the analgesic effect, these drugs help reduce the manifestation of inflammation, reduce edema, increase perfusion and oxygenation of the tissues surrounding the wound, and improve their metabolism. This leads to accelerated formation of the demarcation line and rapid clearing of necrosis.

Symptomatic therapy

In the inflammation phase, pain syndrome develops due to tissue edema. Therefore, if necessary, analgesics (usually non-narcotic) are administered. For fever, antipyretics are used. In case of significant blood loss, transfusion of blood components and blood-substituting solutions is performed.

For extensive wound defects with loss of fluid, proteins and electrolytes through their surface, infusion replacement therapy includes protein hydrolysates, native plasma, mixtures of amino acids and polyionic solutions. General strengthening therapy includes vitamins of various groups (C, B, E, A) and regeneration stimulants (methyluracil, orotic acid, anabolic hormones). In patients with severe disturbances in the functioning of various organs and systems due to injury or complications of a purulent wound, their correction is necessary.

CHAPTER 4

COMPLICATIONS OF WOUND AND SCARS HEALING

An essential element of wound healing is the formation of granulation tissue. Its condition determines the nature of the wound process and the speed of wound healing. But normal granulation tissue does not always form in the wound. When exposed to a number of unfavorable factors, the development of granulations can be pathological. Wound healing can be complicated by various processes, the main ones being the following.

Development of infection. It is possible to develop a nonspecific purulent infection, as well as anaerobic infection, tetanus, rabies, and diphtheria.

Bleeding. There may be both primary and secondary bleeding. They are often observed when blood clotting is weakened due to anticoagulation therapy or in pathological defects of the coagulation system. Clinical symptoms of secondary bleeding include increased heart rate, decreased blood pressure, and increased volume (neck or extremity). For diagnosis, it is necessary to conduct a blood test, check clotting status, monitor pulse and blood pressure

Wound dehiscence (wound failure) are wound healing disorders in which parts of the wound surfaces, despite the application of a tightening suture, do not stick together and are not held together by connective tissue, but move away from each other due to mechanical stresses in the tissue. Examples of predisposing factors include ischemic sutures, sutures removed too early, malnutrition, factor XII deficiency, obesity, debilitating cancers, postoperative cough or diabetes mellitus. In addition, therapy with cytostatics, corticoids or antibiotics increases the risk of ruptures. It is especially dangerous with a penetrating wound of the abdominal cavity, as it can lead to the release of internal organs (intestines, stomach, omentum) – eventration (fig. 8).

Occurs in the early postoperative period (up to 7–10 days), when the strength of the developing scar is low and tissue tension occurs (flatulence, increased intra-abdominal pressure). Eventration requires urgent re-surgical intervention.



Fig. 8. Eventration

Scarring

The result of the wound process is wound healing with the formation of a scar. The scar remains for life, and it can not only cause cosmetic inconvenience to the patient, but also be a substrate for the development of a pathological process. These circumstances dictate the need in the process of treating wounds to foresee what kind of scar will form and take actions aimed at forming the most cosmetically and functionally beneficial scars.

The type, nature and properties of the scar depend primarily on the type of wound healing. When healing by primary intention, the scar is usually linear, thin, mobile, even, and is at the same level with the entire surface of the skin. Its consistency is similar to the surrounding tissues. When healing by secondary intention, the scar usually has an irregular shape. Its consistency is dense, inactive, and its color differs from the surrounding skin. The surface of the scar is located below the surface of the skin, so it is retracted.

All scars are divided into regular and hypertrophic.

• ***Regular scar*** consists of normal connective tissue and has elasticity. The strength of scar tissue and resistance to damage are acquired gradually.

• ***Hypertrophic scars*** consist of dense fibrous tissue and are formed by excessive collagen synthesis. They are in the nature of rough, tight, ugly scars, raised above the surface of the skin, have a reddish tint, are sensitive and painful, and often cause itching. Among them are common hypertrophic scars and keloids.

Conventional hypertrophic scar never extends beyond the area of damage, corresponds to the boundaries of the previous wound. In the development of such a scar, two factors play a leading role: the large size of the wound defect and constant trauma to the scar.

Keloid – a scar that penetrates into the surrounding normal tissues that were not previously involved in the wound process. Unlike ordinary hypertrophic scars, keloids often form on functionally inactive areas of the body. Its growth usually begins 1–3 months after epithelization of the wound. The scar continues to enlarge even after 6 months and usually does not shrink or soften. Keloid scars occur after any, even minor, wound (needle prick, insect bite), or superficial burn. Stabilization of the scar occurs on average 2 years after its appearance.

The morphological structure of a keloid is composed of excessively growing immature connective tissue with a large number of atypical giant fibroblasts. The pathogenesis of keloid formation remains unclear. Mechanisms of autoaggression against one's own immature connective tissue play a certain role. Impaired collagen synthesis may be determined by genetic abnormalities. Treating keloid scars is a difficult task. In the initial stages, electrophoresis with hyaluronidase is used. The formed keloid scar is excised and a cosmetic intradermal suture is applied. In the postoperative period, during the entire healing process, the wound is treated with enzymes, steroid hormones, and radiation therapy is performed. However, it should be recognized that at present there are no adequate methods for the prevention and treatment of keloid scars.

The main complications of scars:

• scar contractures;

• ulceration of the scar;

• ruminal papillomatosis;

• tumor degeneration of scar tissue (malignization). It should be noted that most often all types of complications occur with scars after healing by secondary intention.

Scar contractures are the contraction of surrounding tissues by scars with limitation and disruption of the functions of the involved structures. Usually this process is caused by large scars in area and volume after extensive purulent wounds and burns. Often there is a restriction or even absence of mobility in the joints, disruption of organ activity (with scars on the face, neck, perineum), and deterioration of the blood supply to the distal areas.

Hypertrophic scars and scars located in the most traumatized areas of the body are more often susceptible to ulceration. This is associated with constant trauma and infection.

Scar papillomatosis and malignancy also often develop against the background of hypertrophic scars and constant trauma.

Tetanus

The most effective method of preventing tetanus is active immunization with tetanus toxoid (AT-toxoid).

Protection against tetanus in children is usually created by immunization with DPT vaccine or DPT toxoid, in adolescents and adults – with DTP-M toxoid or AT toxoid. After a completed course of immunization, the human body for a long period (about 10 years) retains the ability to quickly (within 2–3 days) produce antitoxins in response to repeated administration of drugs containing AT toxoid. The completed course of active immunization includes primary vaccination and first revaccination. To maintain immunity against tetanus at a sufficient level, it is necessary to carry out revaccination periodically at intervals of 10 years by a single administration of drugs containing AT toxoid. To prevent the occurrence of tetanus in the event of injury, emergency prophylaxis is necessary.

Emergency immunoprophylaxis is carried out differentially depending on the patient's previous immunization against tetanus by administering AT toxoid and DTP-M toxoid (emergency revaccination), or using active-passive immunization by simultaneous administration of AT toxoid and tetanus antiserum (TAS) or immunoglobulin. Emergency active-passive prophylaxis in previously unvaccinated people does not guarantee the prevention of tetanus in all cases, in addition, it is associated with the risk of immediate and long-term reactions, as well as complications in response to the administration of TAS. To avoid repeated administration of TAS in the event of new injuries, all persons who received active-passive prophylaxis must complete the course of active immunization by a single revaccination with AT toxoid or DTP-M toxoid.

Drugs used for routine active immunization against tetanus:

Adsorbed pertussis-diphtheria-tetanus vaccine (DTP), containing in 1 ml 20 billion inactivated pertussis microbial cells, 30 flocculating units (FU) of diphtheria and 10 binding units (BU) of tetanus toxoid.

- Adsorbed diphtheria-tetanus toxoid (ADT), containing 60 Lf of diphtheria and 20 EU of tetanus toxoids in 1 ml.
- Adsorbed diphtheria-tetanus toxoid with reduced antigen content (DTP-M), containing 10 FU of diphtheria and 10 BU of tetanus toxoids in 1 ml.
- Adsorbed tetanus toxoid (AT), containing 20 BU in 1 ml.

Drugs used for emergency immunoprophylaxis of tetanus:

- Adsorbed tetanus toxoid (AT).

• Adsorbed diphtheria-tetanus toxoid with reduced antigen content (DTP-M).

• Equine anti-tetanus serum purified concentrated liquid (PSS). One prophylactic dose of PSS is 3000 IU (International Units).

• Human tetanus immunoglobulin (HTEI). One prophylactic dose of PSCH is 250 IU.

Populations subject to active immunization against tetanus:

All persons who do not have contraindications are subject to immunization. Active immunization is carried out with drugs containing tetanus toxoid, in accordance with Order of the Ministry of Health of Russia N 375 dated December 18, 1997 “On the calendar of preventive vaccinations” and in accordance with the Instructions for the use of drugs.

Emergency prevention of tetanus:

Emergency prophylaxis of tetanus is carried out when:

• injuries with violation of the integrity of the skin and mucous membranes;

• frostbite and burns (thermal, chemical, radiation) of the second, third and fourth degree;

• penetrating injuries of the gastrointestinal tract; out-of-hospital abortions;

• childbirth outside medical institutions; gangrene or tissue necrosis of any type, long-term abscesses, carbuncles;

• animal bites.

Emergency prevention of tetanus consists of primary surgical treatment of the wound and simultaneous specific immunoprophylaxis. Emergency immunoprophylaxis of tetanus should be carried out as early as possible and up to 20 days after injury, taking into account the length of the incubation period for tetanus.

The prescription of drugs for emergency immunoprophylaxis of tetanus is carried out differentiated depending on the availability of documentary evidence of preventive vaccination or data on immunological monitoring of the intensity of tetanus immunity, as well as taking into account the nature of the injury.

Drugs are not administered:

• Children and adolescents who have documented evidence of routine preventive vaccinations in accordance with age, regardless of the period that has passed since the next vaccination;

• Adults who have documented evidence of a full course of immunization no more than 5 years ago;

• Persons who, according to emergency immunological control, have a titer of tetanus antitoxin in the blood serum above 1:160 according to RPGA, which corresponds to a titer above 0.1 IU/ml according to the biological neutralization reaction – RN (protective titer).

Only 0.5 ml of AT toxoid is administered:

• Children and adolescents who have documentary evidence of a course of scheduled preventive vaccinations without the last age-specific revaccination, regardless of the date of the last vaccination.

• Adults who have documented evidence of a full course of immunization more than 5 years ago.

• Persons of all ages who received two vaccinations no more than 5 years ago, or one vaccination no more than 2 years ago.

• Children from 5 months of age, adolescents, conscripts and those who have served in the army for a specified period of time, whose vaccination history is unknown, and there were no contraindications to vaccinations.

• Persons who, according to emergency immunological control, have a tetanus toxoid titer in the range of 1:20-1:80 according to RPGA or in the range of 0.01–0.1 IU/ml according to RN. Instead of 0.5 ml of AT, 0.5 ml of DTP-M can be administered if immunization with this drug is necessary.

When carrying out active-passive prophylaxis of tetanus , 1 ml of AT is injected, then with another syringe into another part of the body – PSCH (250 IU) or after an intradermal test – PSS (3000 IU).

Active-passive prevention is carried out:

• Persons of all ages who received two vaccinations more than 5 years ago, or one vaccination more than 2 years ago.

• Unvaccinated persons, as well as persons who do not have documentary evidence of vaccination, excluding contingents.

• Persons who, according to emergency immunological control, have a tetanus antitoxin titer of less than 1:20 according to RPGA or less than 0.01 IU/ml according to RN.

All persons who received active-passive tetanus prophylaxis must be revaccinated with 0.5 ml AC or 0.5 ADS-M to complete the course of immunization in the period from 6 months to 2 years. Children under 5 months of age who have not been vaccinated for various reasons are given only 250 IU of PSCH or (in the absence of PSCH) – 3000 IU of PSS.

CONCLUSION

Active research not only in clinical disciplines, but also in fundamental ones, has made it possible to obtain new data on the wound process and forms of wound healing. It was thanks to new knowledge about the course of the wound process that the surgeon’s tactics changed from active intervention in phases 2–3 to passive. This contributed to the emergence of highly effective methods of treating wounds and the development of new directions in surgery. The study of the features of the development of the wound process continues to this day.

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REVIEW QUESTIONS

1. Define the concept “wound”.
2. List the existing classifications of wounds.
3. Give a detailed description of the classification of wounds according to the degree of their microbial contamination.
4. List the phases of the wound process and the main processes that take place in each phase.
5. What types of wound healing exist, what are their features?
6. What factors influence the course of the wound process?
7. What wound complications do you know?
8. What should be taken into account when assessing the condition of a wound?
9. List the tasks and basic principles of treating surgical wounds.
10. List the objectives and basic principles of treating contaminated wounds.
11. What is the primary surgical treatment of a wound?
12. List the tasks and basic principles of treating purulent wounds.
13. What is secondary surgical treatment of a wound?
14. How is control over the course of the wound process carried out?
15. Define the concept “drainage”.
16. List the types and methods of drainage.
17. List the types of drainage.
18. What advantages do active and flow-flushing drainage have over passive drainage?
19. Describe the procedure for installing counter-perforated drains into a postoperative wound.
20. List the main complications of drainage.
21. What are the objectives of local wound treatment?
22. How does local wound treatment depend on the phase of the wound process?
23. What is dressing and what are the indications for it?
24. What are the requirements for a modern dressing?
25. What is an interactive bandage?
26. What interactive bandage do you know?
27. What principles of dressing do you know?
28. List the stages of dressing.
29. How often should wounds be bandaged?

TEST TASKS

1. Indicate how the degree of wound gaping is determined…

a) depth of the wound;
b) intensity of bleeding;
c) direction of elastic fibers of the skin;
d) damage to the fascia;
e) muscle damage.
Correct answer: C.

2. Specify early complications of wounds…

a) shock;
b) suppuration of wounds;
c) secondary bleeding;
d) bleeding;
e) acute blood loss;
f) sepsis.
Correct answer: A, C.

3. Indicate which anatomical layer of the anterior abdominal wall is damaged as a criterion for the penetrating nature of the injury…

a) leather;
b) subcutaneous tissue;
c) muscles;
d) parietal peritoneum;
e) visceral peritoneum;
Correct answer: D.

4. With wounds, damage is a must…

a) internal organs;
b) skin and mucous membranes;
c) subcutaneous tissue;
d) neurovascular bundle.
Correct answer: B.

5. Contraindications to primary surgical treatment of a wound are…

a) shock;
b) the presence of necrotic tissue in the wound;
c) presence of foreign bodies in the wound.
Correct answer: A.

6. A wound penetrating into the abdominal cavity is called if there is damage to the peritoneum…

a) parietal;
b) visceral.
Correct answer: A.

7. Granulation tissue, visible to the eye, appears during…

a) preparatory;
b) biological treatment;
c) preliminary reparation;
d) final reparation.
Correct answer: C.

8. Early primary surgical treatment of the wound is carried out before…

a) 6 hours;
b) 24 hours;
c) 48 hours.
Correct answer: B.

9. Indicate what is the basis for the prevention of secondary wound infection…

a) compliance with the basic law of asepsis when providing assistance and treatment;
b) availability of broad-spectrum antibiotics;
c) knowledge of sterilization methods;
d) knowledge of ways infection enters a wound.
Correct answer: A.

10. The first phase of the wound process is…

a) epithelization;
b) hydration;
c) granulation;
d) dehydration;
e) angiospasm.
Correct answer: B.

11. The hydration phase is characterized by…

a) formation of granulations;
b) exudation;

c) collagen formation;
d) epithelial metaplasia;
e) scar formation.
Correct answer: B.

12. In which area of the gunshot wound does secondary necrosis occur?

a) in the area of the wound canal;
b) in the bruise area;
c) in the zone of molecular shaking;
d) in the area of the inlet;
e) in the area of the outlet.
Correct answer: C.

13. Wound suppuration occurs most often in the first…

a) 6 hours;
b) 12 o'clock;
c) per month;
d) two weeks;
e) 3–5 days.
Correct answer: E.

14. What will be the route of transmission of the infection if the latter got into wound from a wounding object…

a) exogenous contact;
b) endogenous contact;
c) implantation;
d) airborne;
e) lymphogenic.
Correct answer: A.

15. What will be the route of transmission of the infection if the latter got into … wound with suture material

a) exogenous contact;
b) endogenous contact;
c) implantation;
d) airborne;
e) lymphogenic.
Correct answer: C.

16. Indicate which wound heals faster than others…

a) rezanaya;
b) crushed;
c) bitten;
d) bruised.
Correct answer: A.

17. Indicate which of the listed wounds in most cases heal by primary intention…

a) bruised;
b) torn;
c) bitten
d) purulent;
e) cut.
Correct answer: E.

18. Indicate which soft tissue injuries are called combined wounds…

a) the presence of a wound with severe bruising and hemorrhage around the wound;
b) combination of a wound with damage to bone or internal organs;
c) combination of mechanical damage with other factors (poisons, thermal factor, etc.);
d) suppuration of wounds.
Correct answer: C.

19. All of the above circumstances worsen wound healing, except…

a) excessive use of electrocoagulation;
b) excessive tension of the wound edges;
c) insufficiency of hemostasis;
d) wound drainage;
e) eversion of the edges of the wound.
Correct answer: D.

20. Wound healing by primary intention is achieved

a) approaching the edges of the wound with an adhesive plaster;
b) stitching the edges of the wound;
c) tamponade of the wound and application of a tight pressure bandage;
d) constant irrigation with antibiotic solution.
Correct answer: B.

21. The second phase of the wound process is…

a) release of catecholamines;
b) hydration;
c) formation of a leukocyte shaft;
d) dehydration;
e) angiospasm.
Correct answer: D.

22. Indicate when clinical signs appear suppuration of wounds…

a) for 7–10 days;
b) for 2–3 days;
c) in 2–3 weeks;
d) first day after injury.
Correct answer: B.

23. The molecular shock zone exists when…

a) bruised wound;
b) gunshot wound;
c) chopped wound;
d) laceration;
e) bite wound.
Correct answer: B.

24. Causes of primary microbial contamination of wounds…

a) infection at the time of injury;
b) infection during primary surgical treatment;
c) infection during treatment.
Correct answer: A.

25. Is it true that all purulent wounds and wounds with a significant tissue defect heal by secondary intention?

a) yes;
b) no.
Correct answer: A.

26. Renewal or intensification of subsided pain in a wound usually indicates…

a) irritation and compression of nerve endings or nerves by hematoma;
b) development of infection in the wound;
c) wound healing by primary intention.
Correct answer: B.

27. If there is a cavity between the edges of the wound that is filled with granulation tissue, then the wound heals…

a) under a scab;
b) primary intention;
c) secondary intention.
Correct answer: C.

28. Is it true that the clinical picture of wounds consists of local symptoms such as pain, gaping, bleeding?

a) yes;
b) no.
Correct answer: A.

29. Primary surgical treatment of a wound includes…

a) applying a primary suture without pre-treatment of the wound;
b) closing the wound with sutures after treatment with antiseptic solutions;
c) excision of the edges, walls and bottom of the wound, stopping bleeding, removal of clearly non-viable tissues, followed by layer-by-layer suturing of the wound;
d) removal of necrotic tissue, opening of purulent leaks and drainage of the wound.
Correct answer: C.

30. Indicate what is a contraindication for performing primary surgical treatment…

a) shock;
b) bleeding;
c) HIV infection.
Correct answer: A.

31. Delayed primary suture is applied before…

a) 6 hours;
b) 12 o'clock;
c) 24 hours;
d) 5 days;
e) 10 days.
Correct answer: D.

32. Specify the timing of drainage of a purulent wound…

a) drainage of a purulent wound is indicated throughout the entire inflammation phase;
b) wound drainage is indicated in the dehydration phase;
c) wound drainage is indicated when granulations appear.
Correct answer: C.

33. Specify ways to prevent suppuration of accidental wounds…

a) primary surgical treatment;
b) use of chemical antiseptics during processing;
c) adequate drainage;
d) pain relief;
e) application of a primary delayed suture.
Correct answer: A, B, C.

34. Depending on the presence of microbial flora, wounds are distinguished…

a) infected;
b) purulent;
c) aseptic;
d) microbially contaminated;
e) poisoned.
Correct answer: A, B, C, D.

35. In relation to body cavities, wounds are distinguished…

a) penetrating;
b) chopped;
c) non-penetrating;
d) superficial;
e) cut.
Correct answer: A, C.

36. Wound healing happens…

a) under a scab;
b) primary intention;
c) secondary intention;
d) rubtsov tension;
e) granulation tension.
Correct answer: A, B, C.

37. Local symptoms of a wound are…

a) bleeding;
b) shock;
c) pain;
d) gaping;
e) anemia.

Correct answer: A, C, D.

38. Wounds can be…

a) cut;
b) stabbed;
c) chopped;
d) bruised;
e) torn.

Correct answer: A, B, C, D, E.

39. Specify the features of puncture wounds…

a) poverty of symptoms;
b) gaping edges;
c) significant depth of damage;
d) possibility of damage to internal organs;
e) frequent diagnostic errors;
f) heavy bleeding.

Correct answer: A, C, E, F.

40. Specify the features of gunshot wounds…

a) they often heal by primary intention;
b) high degree of infection;
c) high probability of anaerobic infection;
d) complex anatomical characteristics of the wound channel;
e) extent of damage;
f) damage is minimal.

Correct answer: B, C, D, E.

41. Indicate the areas of the gunshot wound..

a) wound channel area;
b) area of hemorrhage;
c) area of primary necrosis;
d) molecular shock zone;
e) parabiosis zone.

Correct answer: A, C, D.

42. Indicate which wounds are most prone to the development of purulent complications:

a) cut;
b) operating rooms;
c) bitten;
d) firearms;
e) chopped.
Correct answer: C, E.

43. List the characteristic local clinical signs of the wound…

a) bleeding;
b) shock may develop;
c) pain;
d) violation of the integrity of the integument (skin, mucous membranes);
e) possible dysfunction of organs and systems.
Correct answer: A, C, E.

44. Indicate the characteristic local clinical manifestations of the wound process in the inflammation phase…

a) no swelling;
b) infiltration of surrounding tissues;
c) pain of a bursting nature;
d) severe swelling and hyperemia;
e) there is no purulent discharge;
f) copious purulent discharge;
g) presence of necrotic tissue in the wound.
Correct answer: B, C, D, F, G.

45. Indicate the characteristic local clinical manifestations of the wound process in the regeneration phase…

a) reducing hyperemia and tissue infiltration;
b) sharp pain on palpation;
c) copious purulent discharge;
d) the amount of discharge from the wound decreases;
e) the wound is covered with fibrinous-purulent plaque;
f) granulation tissue develops.
Correct answer: A, D, F.

46. Specify the conditions necessary for primary wound healing tension…

a) tight contact of tissues;
b) gaping of wound edges exceeding 10 mm;
c) absence of foci of necrosis and hematomas;
d) asepticity of the wound;
e) purulent inflammation of the wound.
Correct answer: A, C, D.

47. Signs of the regeneration phase during the wound process…

a) relief of pain syndrome;
b) severe pain;
c) reducing tissue swelling;
d) decrease in local temperature;
e) severe swelling;
f) scanty wound discharge.
Correct answer: A, C, D, F.

48. Causes of secondary microbial contamination of wounds…

a) Infection during first aid;
b) Infection at the time of injury;
c) Infection during treatment;
d) Development of inflammatory reactions after wound healing.
Correct answer: A, B.

49. Wound healing by primary intention is possible with…

a) the concentration of infection in the wound is below a critical level;
b) complete and tight contact of the wound edges;
c) absence of hematoma, necrotic tissue, foreign bodies in the wound;
d) viability of wound edges.
Correct answer: A, B, C, D.

50. Wounds heal by secondary intention:

a) unsutured operating rooms;
b) if there are foreign bodies in them;
c) after primary surgical treatment with suturing;
d) with suppuration.
Correct answer: A, C, D.

51. General symptoms characteristic of a particular wound complication include…

a) anemia;
b) shock;
c) infection (sepsis);
d) none of the above.
Correct answer: A, B, C.

52. Based on the nature of the wound channel, wounds are distinguished…

a) through;
b) penetrating;
c) tangents;
d) non-penetrating;
e) blind.
Correct answer: A, C, E.

53. Wounds are distinguished by the type of wounding object…

a) chopped;
b) cut;
c) operating rooms;
d) random;
e) chopped;
f) bruised;
g) firearms;
h) mixed;
i) torn;
j) bitten;
k) poisoned;
l) crushed;
m) scalped
Correct answer: A–M.

54. According to the circumstances of infliction of the wound, they are divided into…

a) cut;
b) operating rooms (surgical);
c) combat;
d) firearms;
e) accidental (traumatic).
Correct answer: B, C, E.

55. Wounds heal by secondary intention when:

a) the presence of blood clots and foreign bodies in them;
b) lack of tissue plasticity (cachexia, vitamin deficiency);
c) good contact of their walls and absence of infection;
d) suppuration.
Correct answer: A, B, D.

56. Indicate the classifications of wounds known to you:

a) by the nature of the damage;
b) operating, postoperative;
c) by infection;
d) in relation to cavities;
e) simple, complicated;
f) chopped;
g) due to damage;
h) by type of wounding object.
Correct answer: A, C, D, E, F.

57. Wounds are classified according to infection:

a) clean;
b) aseptic;
c) operating rooms;
d) dirty;
e) purulent;
f) bacterial-contaminated;
g) infected.
Correct answer: B, F, G.

58. Indicate the phases of the wound process according to M.I. Cousin:

a) inflammatory phase;
b) rejection phase;
c) phase of regeneration, formation and maturation of granulations;
d) suppuration phase;
e) scar reorganization and epithelization phase.
Correct answer: A, C, E.

CASE TASKS

Task 1.

A patient with a puncture wound in the upper third of the right anterolateral surface of the abdominal wall was delivered to the hospital emergency department; 1.5 hours have passed since the injury was received. Objectively: on the anterolateral surface of the abdomen, in the upper third, there is a rounded punctate wound, up to 3 mm in diameter; along the edges of the wound, there is a settling of the skin and the presence of hemorrhages around the wound.

Questions:

1. Classify this wound
2. Why is this type of wound dangerous for the patient and "difficult" for the doctor to diagnose?
3. What complications of the wound may develop in this patient?

An example of solving a problem:

Based on the available information, it is possible to assume with a high degree of probability the following: the wound is sharp (was inflicted recently), contaminated (inflicted not by a surgeon in the operating room), punctured (the shape of the entrance gate), and abrasion and hemorrhages indicate an additional bruised component. A wound to the abdominal wall could presumably lead to the penetration of the weapon into the abdominal cavity. Difficulty in diagnosis is the inability to assess the depth of penetration and the degree of damage to internal organs during examination. The danger of such injuries is the possibility of developing internal bleeding, perforation of a hollow organ, as well as the development of complications: peritonitis, sepsis.

Task 2.

The patient has an incised wound 7.0 x 1.5 cm on the lateral surface of the upper third of the left shoulder, the edges and walls of the wound are smooth, with areas of hemorrhage, and there is scanty, sanguineous-purulent discharge in the wound; there is swelling and hyperemia around the wound, palpation around the wound is painful. I was wounded 2 days ago.

Questions:

1. Define the concept of "wound".
2. Classify this wound.
3. Determine the phase of the wound process.

An example of solving a problem:

1. Wound – damage to the integument (skin or mucous membranes, as well as deeper tissues or organs) due to mechanical or physical impact.

2. Stab, accidental, infected wound.

3. In the first phase of the wound process – the hydration phase.

Task 3.

The victim was taken to the trauma center; about 40 minutes have passed since the injury. Objectively: in the area of the palmar surface of the right hand there is an oblique transverse incised wound, the edges and walls of the wound are smooth, measuring 5.0 x 0.5 cm, inactive venous bleeding is noted from the wound, there are no active flexion movements in the interphalangeal joints of the II–IV fingers.

Questions:

1. Your preliminary diagnosis
2. What anatomical structures should be damaged?
3. What prevention and what specific wound infection should be carried out?

Example of problem solution

1. Infected incised wound on the palmar surface of the right hand.

2. You should think about damage to the flexor tendons of the II–IV fingers.

3. It is necessary to carry out tetanus prophylaxis – AT 1.0 ml, if the patient has not been additionally vaccinated against tetanus – PSS 3000 IU.

Task 4.

A young man, 23 years old, was admitted to the hospital with complaints of general weakness, headache, and increased body temperature. About three days ago I slipped on the street, fell, hit my head on the ice, and did not lose consciousness. At home I found blood on my hair and a wound in the back of my head. I washed the wound with warm boiled water. 10 hours before admission, the headaches intensified, and the body temperature rose to 38.5 °C. Objectively: examination revealed a wound in the occipital region, measuring 1.5 x 2.0 x 0.5 cm with a fibrin coating on the bottom; the edges of the wound are uneven, swollen, hyperemic; The wound is painful on palpation, there is no bleeding.

Questions:

1. Your preliminary diagnosis.
2. To what extent will you carry out wound care and surgical – treatment of the wound?
3. Is it possible to put stitches on this wound?
4. List the types of surgical treatment of wounds by timing.

An example of solving a problem:

1. Bruised, infected wound in the occipital region of the scalp.

2. Shave the hair around the wound at a distance of 2–3 cm, treat the edges of the wound with an alcohol-based antiseptic, rinse the wound with hydrogen peroxide and perform mechanical cleaning of the wound with tampons, drain the wound with latex graduates and apply rare single sutures, apply an aseptic bandage.

3. Yes it is possible and necessary, because All head wounds must be sutured.

4. Early, delayed, late surgical treatment of the wound.

Task 5.

A 37-year-old patient is admitted to the emergency department with complaints of severe weakness, sweating, chills, high body temperature, and "tugging" pain in the area of the sutured wound of the left thigh. According to the patient, he received the wound about 5 days ago by accident, while hunting, due to an unintentional shot from a gun. Immediately after the injury he sought medical help at the district hospital. Surgical debridement of the wound was performed, the wound was sutured tightly, and tetanus prophylaxis was administered. Objectively: in the area of the left thigh, along the anterior surface, there is a wound sutured with separate interrupted sutures; widespread swelling and hyperemia around the wound, local hyperthermia; palpation around the wound is sharply painful; upon palpation, the release of serous-purulent exudate between the sutures is noted.

Questions:

1. What is your preliminary diagnosis?
2. What tactical mistake was made by the emergency department doctor?
3. Explain the structure and features of a gunshot wound?
4. What surgical procedures and to what extent needed to be performed?

An example of solving a problem:

1. Suppuration of the sutured wound of the left thigh.

2. Gunshot wounds are not sutured tightly; they are sutured only with flow-through drainage.

3. Zone of direct tissue destruction – zone of contusion – zone of molecular concussion.

4. It is necessary to remove the sutures, inspect the wound, wash the wound with hydrogen peroxide, drain the wound, loosely tampon with a tampon moistened with a hypertonic solution or hydrophilic ointment, apply an aseptic bandage, and prescribe conservative anti-inflammatory therapy.

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На английском языке

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