

Medical and Pharmaceutical Care of the Wounded and Injured

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Abstract

In the course of conducting analytical studies, it was established that possible damage to a person with modern combat weapons causes severe injuries to the cavities, and musculoskeletal system, which is accompanied by massive bleeding, traumatic shock and requires urgent surgical assistance, often already at the site of the injury, rapid transportation to medical institutions, staged surgical - intensive care treatment and evacuation to specialized military medical centers. The course of injuries by high-energy weapons is accompanied by wound disease with early and late complications. The final stage of medical care for the wounded and injured is complex therapeutic and psychological rehabilitation with the restoration of working capacity and fighting capacity. Of course, the treatment of modern combat trauma cannot be separated from rehabilitation measures. Therefore, the treatment and rehabilitation of military personnel is an urgent issue that is facing both military and civilian medicine and social security services today. The evolutionary process of scientific and technical progress in the development of medicine and pharmacy shows the relevance of the task of treating wounds and wound infections. Along with the improvement of wound treatment methods, the means of inflicting wounds and injuries - weapons - are also improved.

Keywords: Soft medicinal products, Local application, Wounds, Pharmaceutical care, Injurers

INTRODUCTION

The presence of foreign bodies, necrotic tissues, and closed cavities in the wound - all contributes to the development of wound infection. Military actions on the territory of Ukraine (2014-2022) have shown that there is no universal method and means for treating wounds, that is, not only means of inflicting wounds are evolving, but also medicines intended for wound treatment. Complications of the wound process - a wound contaminated with microorganisms. Infection can occur even after clean surgical operations, which can complicate the course of the postoperative period. To this day, the task of effective treatment of surgical infection has not been solved, despite the appearance of new antibiotics and antiseptics. This is due to the ability of microorganisms to improve - resistant forms of bacteria to antimicrobial medicines develop. The growth of antibiotic-resistant strains of microorganisms is caused, among other things, by the irrational use of antimicrobial agents, which negatively affects the clinical results of wound treatment.

MATERIALS AND METHODS

Treatment of infectious complications of wounds is complex, combining the knowledge and practical experience of specialists of various profiles: clinicians, physiologists, microbiologists, pharmacologists, pharmacists, health care organizers, etc.

Specialists consider the wound process (WW) as a conglomerate of deep physicochemical and biochemical changes in organs and tissues, pronounced clinical manifestations that significantly affect the quality of life. This is a set of molecular and cellular links that successively occur in the wound and are aimed at repairing the damaged tissue and restoring its integrity [1-5]. Accordingly, a wound is any mechanical damage to the body, which is accompanied by a violation of the integrity of the covering tissues - skin or mucous membranes. The appearance of clinical signs of wounds (pain, bleeding, gaping) depends on the localization of the wound, the volume, and depth of the lesion, as well as the general condition of the patient [6-11].

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Treatment of infected wounds involves the creation of specific drugs for effective treatment and acceleration of tissue repair. However, the study of the pathogenesis of the wound process in general and in case of infectious damage, in particular, indicates the need to find the most effective tool from a wide arsenal of general and local tools aimed at optimizing the wound process and preventing the development of various complications, the most dangerous of which are infectious.

Improving the quality of wound treatment [12-14] is based on modern scientific achievements in the etiology and pathogenesis of wounds. The pharmacotherapeutic treatment makes it possible to purposefully create new effective drugs to influence the etiology and pathogenesis, as well as the symptoms of the wound process. Despite numerous studies, it is necessary to confirm the absence of a single therapeutic and diagnostic tactic and universal approaches to predicting the course of wounds [15-18].

RESULTS AND DISCUSSION

Analytical studies have proven that specialists distinguish three main interrelated sections in the science of wound and wound infection:

1. biological laws of wound healing and pathogenesis of wound infection;
2. objective assessment of the course of the wound process based on clinical and laboratory criteria;
3. local and general treatment of wounds [1, 3, 9, 10, 18-21].

Wound healing processes were characterized by scientists RUFANOV (1954), ROSS (1968), STRUCHKOV (1975), KUZYNIN (1977), DATSENKO (1985), SHALIMOV (2002).

The evolutionary development of the views of scientists on the phases of the wound process is shown in **Table 1**.

Table 1. Evolutionary development of views of scientists on phases of the wound process

The authors	The first phase (Day 1-5)	Phase II (5-14th day)	III phase (from the 15th day)	Phase IV
Rufanov (1954)	Hydration (swelling and removal of dead tissue)	Dehydration (repair and granulation)	-	-
Girgolav (1956)	Preparatory	Regeneration	Organization of the scar	-
Datsenko (1985)	Purulent-necrotic	Granulation	Epithelization	-
Kuzin and Kostyuchenok (1980, 1977, 1990) [22]	Inflammation (vascular changes and the period of cleaning the wound from necrotic tissues)	Regeneration (proliferation)	Reorganization scar	-
Chadaev (2002) [23]	Inflammation	Regeneration	Reorganization of the scar with epithelization	-
Shalimov (2002), Vinnyk (2015) [7, 18] Crane (2015) Devyatkin (2016) [9] Privolnev (2017) [21] Chernopyschuk (2017) and others. [3]	Purulent-necrotic	Granulation	Epithelization	-
Kornienko (2016) [24]	Hemostasis	Inflammation	Proliferative	Remodeling

The biological processes occurring in the wound are complex and diverse in nature. Modern science studies the peculiarities of the course of the wound process. The study of Kalnikovsky (2015), in which the results of the study of physicochemical and biochemical changes in the wound were published, is of interest [25]. The works of Kornienko (2016) and Devyatkin *et al.* (2016) [9, 24] are devoted to the study of the morphological and physiological aspects of the wound process, where it is stated that the same cellular elements

participate in all stages of the wound process, which in principle provide identical and general dynamics of the specified process [9]. The wounding process always occurs cyclically according to the development of functional and morphological changes in the wound and surrounding tissues, which can be divided into certain phases. In the pathogenesis of the wound process, there is a sequential development of the inflammatory and reparative reaction (**Figure 1**).

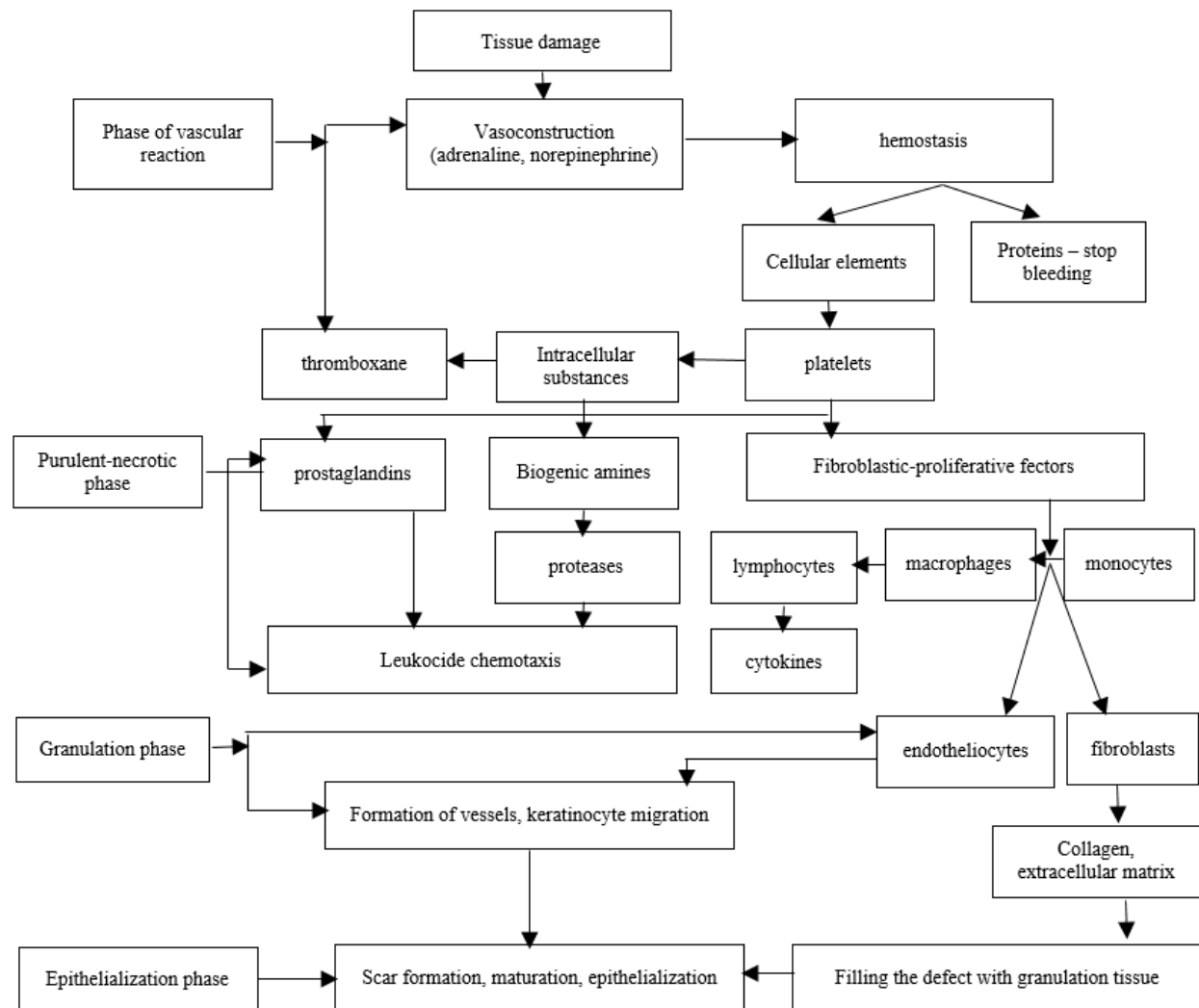


Figure 1. Scheme of development of inflammatory-reparative reaction in the wound process

In a general biological sense, inflammation is a protective reaction of the body, as well as a biological (functions due to adhesion and phagocytosis) and mechanical (formed by fibrin shedding from the blood, blockage of blood and lymphatic vessels, the proliferation of connective tissue cells at the border of damaged and normal tissue) barrier [9, 26, 27].

When evaluating the clinical course of the wound process and predicting its healing, the correct choice of its criteria is of essential importance. **Table 2** shows the classification of wounds depending on their signs [7, 28].

Table 2. Classification signs and types of wounds

Classification Mark	Types of wounds
Origin	surgical, accidental (domestic, industrial, road) suicidal, inflicted in wartime conditions
Depth of damage	surface, penetrating, deep, through, tangential
Complexity	simple, complex
The degree of destruction of tissues	wounds with small or large areas of damage
Degree of occurrence	fresh (within the first 24 hours after injury), delayed
Degree of infection	aseptic ("clean" or "conditionally clean"), contaminated (primarily, secondarily), infected
The location of the wound defect relative to body cavities	permeable, impenetrable

Localization of the affected part of the body	skin and subcutaneous tissue, coverings of the skull, brain and its membranes, neck, sternum wall, pleural cavity, lungs, organs of the abdominal cavity and pelvis, bones, and joints
Size and areas of damage	small (cut, punctured and chopped wounds do not cause a disorder of blood flow, lymphatic circulation, and innervation), large (stabbed, torn, scalped, bitten, crushed and gunshot wounds are characterized by a significant disorder of the specified processes, which inhibits the healing process and causes infection)
The nature of the lesion	pricked, cut, scored, torn, crushed, chopped, bitten, scalped, mixed, fire

Modern wars, armed conflicts, and terrorist operations on the territories of various states of the world, including the territory of Ukraine, make it possible to analyze, systematize and summarize the defeats and combat injuries. Yes, by the authors Ziemba (2012) [29]; Hinsley *et al.* (2005) [30]; Schreiber *et al.* (2008), Eskridge (2012) and Chan *et al.* (2012) [31, 32]; Orman (2012); Schoenfeld *et al.* (2013) [33]; Breeze *et al.* (2011) [34]; Kotenko *et al.* (2014) [35]; Gorbulina *et al.* (2015) [36]; Badyuk and Haida (2018) [37] analyzed combat injuries among the armed forces received during military campaigns - in Afghanistan, Georgia, Iraq, South Africa, and Ukraine.

The author identified a characteristic feature of modern warfare: the presence of several factors that determine the nature of sanitary losses. The main classes of sanitary losses by etiology and types of damage are:

- Mechanical damage - bullet, mine-explosive, shrapnel, closed, etc.;
- Thermal damage - burns, frostbite;
- Radiation damage - acute, chronic, combined as a result of the action of nuclear weapons;
- Injury by poisonous substances - a consequence of the action of chemical weapons;
- Infection with bacterial agents - biological weapons;
- Reactive (psychogenic) states – reaction to severe stress and adaptation disorders, especially when using weapons of mass destruction.

The authors indicated the structure of sanitary losses: light injuries – almost 50%; injuries of medium severity - 30%, severe injuries - 18%, and 2% - extremely severe injuries.

Sanitary losses of a therapeutic profile occur in the same way as surgical losses. That is, a qualitatively different and previously unstudied category of sanitary losses arose, which is commonly called "combat therapeutic pathology" [9, 20].

As a result of the study of the structure of sanitary losses, the conditions of providing surgical care to the wounded by Zarutskyi and Bily (2018), the commonality of many problems was revealed, in particular, the nature of the lesion and the pathogenesis of the course of the wound and traumatic disease both in the wounded and in the theater of combat. as well as in victims during emergencies. At the same time, the most complex problem is polytrauma (severe multiple, combined, and combined injuries), the share of which in the structure of sanitary losses is 30% [9, 30-33, 38, 39].

According to the data in the **Table 3**, the specific weight of injuries to the extremities is 52% (including injuries to the lower extremities – 30.6%). A fairly significant part of sanitary losses is caused by wounds to the head and gunshot wounds to the soft tissues of multiple parts of the body.

Table 3. Distribution of servicemen participating in hostilities by localization of wounds (according to data [30])

Localization wound	Structure injuries, %	Localization wound	Structure injuries, %
Lower limbs	30,6 ± 1,6	Aquabarotrauma	2,2 ± 0,1
Upper limbs	21,4 ± 1,1	Pelvis	1,9 ± 0,2
Head, neck	17,95 ± 1,1	Eye and orbit	1,8 ± 0,1
Open wounds in numerous areas	15,3 ± 0,8	Fiery fractures in numerous areas	1,4 ± 0,1
Chest	4,4 ± 0,5	Thermal injury	0,9 ± 0,1
Stomach	2,2 ± 0,2	In total	100 ± 4,3

It should be noted that gunshot wounds have certain differences (*Vulnus sclopetarium*) from other wounds: the presence of three injury zones, the complex anatomical nature of the injuries, and a high degree of infection. The authors analyzed the results of the treatment of more than a thousand wounded and traumatized combatants in Ukraine. It has been proven that all gunshot wounds were caused by high-velocity bullets and are accompanied by a general reaction of the body to injuries (increased body temperature, leukocytosis), which are characterized by the formation of a soft tissue defect, and in the case of bone damage, multiple fragmentary fractures with a bone tissue defect.

The use of modern types of weapons during hostilities in Ukraine has changed the structure of surgical trauma, and the scope and content of treatment-diagnostic and triage-evacuation measures. Thus, according to Zarutskyi (2018), the vast majority of modern armed conflicts are mine-explosive injuries – 72% of cases. Comprehensive treatment of wounds, which is considered the most rational by specialists, includes both local and general therapeutic measures. Tactically, wounds are treated simultaneously with local and general measures or local measures against the background of general therapy.

The work of Krane (2015) analyzed the methods of treating wounds in recent years. Despite a large number of specific features of various wounds, the main stages of their healing are fundamentally the same: struggle with early complications; prevention and treatment of the infectious

process in the wound; achieving healing in the shortest possible time; maximally complete restoration of functions of damaged organs and tissues.

The main principles of modern wound treatment are adherence to asepsis, surgical treatment, drainage, early closure of wounds (primary and secondary sutures, autodermoplasty), targeted antibacterial, and immunotherapy.

Among the more important principles of local treatment of infected wounds, the main one is the use of drugs according to the phase of the wound process [37]. Timely administration of the necessary drugs that fully correspond to the phase of the wound process allows you to quickly stop the purulent

process, shorten the period of surgical treatment of wounds, and significantly reduce the length of the patient's stay in the hospital [2]. It should be noted that today there are no means and methods that would be equally effective in all phases of the wound process. This is due to the fact that the tasks presented to drugs in the inflammation and reparation phase are fundamentally different. The local application of the medicinal product should also take into account the individual characteristics of a specific patient [23].

The assortment of medicinal forms for the local treatment of wounds is expanding. We are talking about a variety of dispersal systems that are used when assisting the wounded (**Figure 2**).

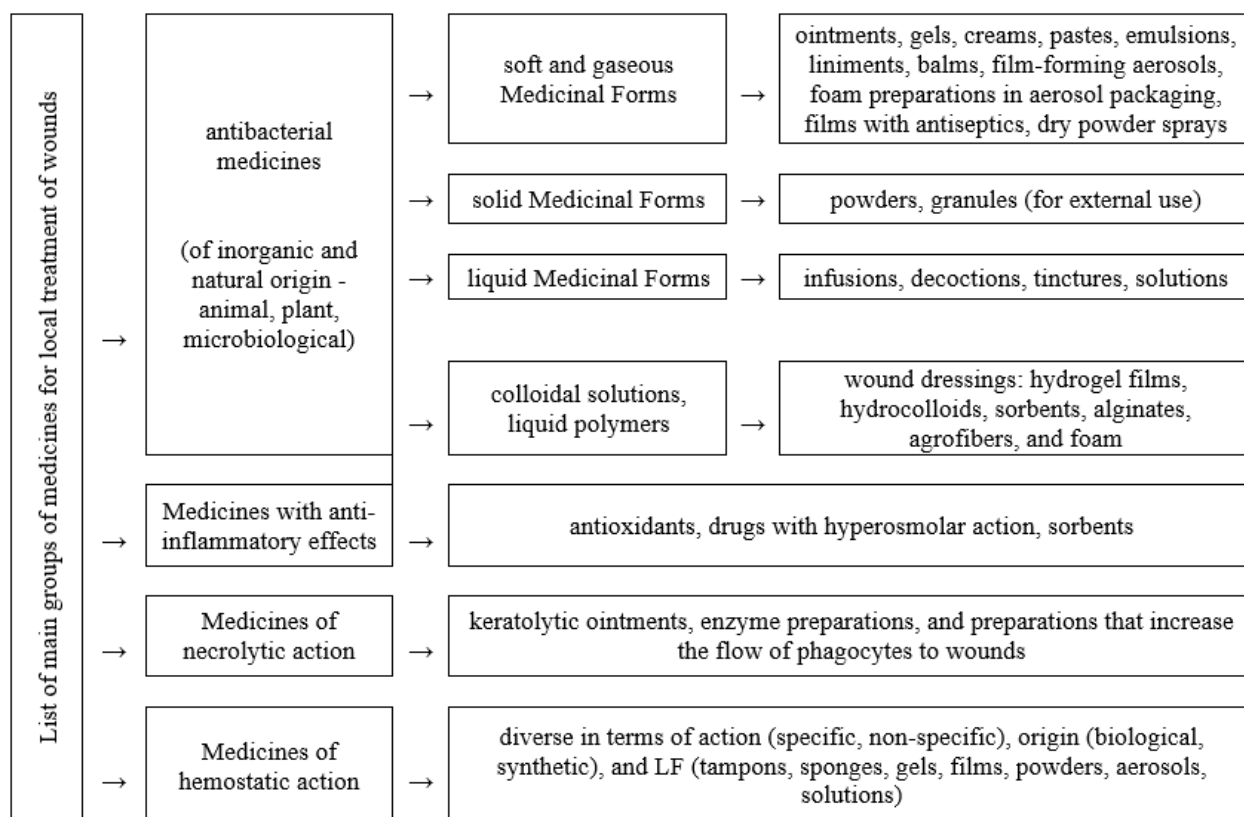


Figure 2. Groups of medicines for local treatment of wounds

According to experts, it is most effective for local treatment of wounds and their rapid healing to use systems with a soft dispersion medium. If all MLZ recommended for use in the treatment of wounds are 100%, then in the first phase of RP, 53% are proposed for use, in the second phase - 31%, and in the third - 16%. Moreover, the components of the drug in the corresponding direction are components with different directions of action [3].

The modern principle of drug selection and the use of treatment methods effective in a certain phase of RP has

practically been worked out and traditionally has not been reviewed for a long time.

The initial (purulent-necrotic) phase is of particular interest to specialists in studying the ways of RP correction because it determines the nature of its further course and the intensity of wound healing [3]. **Figure 2** is presented allows us to present the modern principles of the treatment of RP.

Compliance with the above positions is a guarantee of providing qualified assistance to the wounded.

Technological and biopharmaceutical aspects of the creation of drugs for the treatment of the wound process. As stated above, a special place in the treatment of wounds and wound infection belongs to LF with a plastic-elastic-viscous and gaseous dispersion medium, a diverse range of which is widely represented on the world pharmaceutical market. In particular, these are ointments, creams, pastes, emulsions, gels (oleo-, hydro- and medical), liniments, jellies, balms, fixed bandages with medicinal substances, film-forming and foam preparations in aerosol packaging, polymer films (especially with antiseptics), transdermal therapeutic systems, dry powder sprays, etc.

The main conditions for the action of any drug are the release of API from LF, penetration through biological membranes, and transportation to the site of action with the flow of physiological body fluids. The determining process of release of active substances is the initial and crucial stage of ensuring the therapeutic effect of the drug. A number of pharmaceutical factors are decisive at this stage, namely: the physical properties of the ingredients (API, excipients), the nature and amount of the base carrier and auxiliary substances, the type of drug, and the technology of drug production.

The choice of the method of drug administration is an important point in the treatment. The administration is possible by a natural route (enteral, inhalation, transdermal), in which the transport of medicinal substances (LR) to the body is ensured by the physiological absorption capacity of the mucous membrane and skin, or with the use of technical means, where there is a violent pathological entry of the substance into the body. For example, drugs intended for use in the form of aerosols are administered using an inhaler-sprayer; a dry powder inhaler, or a metered-dose inhaler under pressure. The goal of any of the developed methods, methods, and means of treatment of RP remains to accelerate the cleaning of the wound, suppress the infectious process in it, provide a protective effect on the tissues for further regeneration in the wound, and stimulate its healing.

As the literature review showed, the qualitative and quantitative composition of ointment-like forms is constantly being improved. Centuries-old competition of LF in this form polished their nomenclature, method of application, and manufacturing technology.

In our opinion, the results of the conducted pharmacotechnological studies of complex-acting soft drugs for the local treatment of wounds in military personnel are widely covered, scientists are trying to optimize the technological parameters of the specified drug.

The choice of ointments as an object of biopharmaceutical research constantly attracts scientists with their wide use in medical practice; the ability to incorporate various APIs in accordance with therapeutic, Physico-chemical and structural-rheological properties, concentration,

pharmacodynamics, and type of therapeutic action (surface, local, local) depending on the purpose; the possibility of changing the manufacturing methods and the composition of the ointment base.

A determining factor in the creation of new prescriptions for soft LF (MLF) is taking into account the role of factors that affect the degree of release of substances, the speed, completeness of absorption, and the purpose of LF. In particular, we are talking about the substantiation of the optimal temperature factor, Physico-chemical and structural-mechanical studies of MLF with the subsequent establishment of their compliance with the requirements of the DFU. Despite the above, in the scientific literature several problems arising in surgical practice when using MLZ are identified, namely:

- insufficient effectiveness of many drugs, which is associated with deficiencies of the base and/or monocomponent composition;
- a small number of drugs that have a specific focus on a certain phase of RP and corresponding osmotic activity;
- increasing resistance of pathogens of wound infections to existing drugs.

Undoubtedly, the historical events of recent years, related to the conduct of OOS/ATO on the territory of Ukraine, have somewhat adjusted the directions of scientific research. The creation of drugs with appropriate pharmacotherapeutic action (anti-inflammatory, wound-healing, anesthetic, antibacterial, reparative, etc.) is very relevant for carrying out medical and rehabilitation work, ensuring the high combat capability of military personnel. At the same time, special attention is paid to the pharmaceutical development of complex drugs for the needs of military medicine, the study of models of their construction, and clinical and pharmacological evaluation.

CONCLUSION

1. To this day, the fundamental principles of organizing aid to the wounded remain. It turned out that today, in addition to traditional wound therapy, several modern approaches and methods of RP treatment, which promote active reparative regeneration, have been developed and successfully applied. Experts from all over the world have repeatedly noted the increase in the number of complications in wounds, in particular, purulent ones, which require significant costs for treatment. This prompts us to continue the further search for new approaches and means of medicinal (both local and general) influence on the body of the wounded.
2. Doctors in many countries of the world have noted a tendency towards a gradual expansion of the spectrum of drugs for the treatment of RP depending on LF, which are various Physico-chemical and dispersed systems. The latter makes it possible to determine a rational technology for each LF, especially preparations with a plastic-elastic-viscous and gaseous dispersion medium.

3. The biopharmaceutical and technological aspects of the creation of pharmaceuticals (ointments, creams, pastes, gels, fixed dressings with medicinal substances, film-forming and foam preparations in aerosol packaging, polymer films, etc.) for the treatment of RP were analyzed. The growing popularity of applied LFs has been established, which makes it possible to consider them as a modern direction in the improvement of local treatment of wounds of various etiologies. But the processes related to the technological features of creating new and improving existing compositions of ointments, gels, and medical aerosols require further development of new scientific approaches and expansion of comprehensive and thorough biopharmaceutical research.

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