

УДК 616-001

Bohush Hryhorii

Chief of the Urgent Surgical Department,
Military Medical Clinical Center of the Central Region

Borysiuk Iryna

PhD in Pharmaceutical Sciences,
Head of the Drug Technology Department,
Odessa National Medical University
ORCID 0000-0003-2824-9118

TREATMENT OF INFECTIOUS COMPLICATIONS OF GUNSHOT WOUNDS OF THE LIMBS' SOFT TISSUES

Abstract. Currently, gunshot wounds are a problem not only in military medicine but also in the sphere of human health care. The first place in the system of complex treatment of gunshot wounds of the extremities, of course, belongs to the most complex and time-consuming part of it - the primary surgical treatment. Adequate and early, timely surgery is a guarantee of a successful outcome and the best method to prevent the development of infectious complications in the wound. The least number of complications occurs when the primary surgical treatment is one-time and comprehensive. Factors for the development of infectious complications are as follows: weakening of the body blood loss, physical and mental fatigue, irregular diet, cooling and comorbidities. The basic tasks of treatment of gunshot wounds are as follows: the maximum possible removal of necrotized tissues; creating favorable conditions for maintaining the viability of tissues in the area of secondary necrosis.

Key words: *gunshot wound, limbs (extremities), soft tissues, infection, complications, treatment.*

-

Problem statement. In all wars and armed conflicts, wounded with injuries of limbs amounted the largest number. Moreover, in armed conflicts since the second half of the XX century, there has been a steady trend towards increase in the structure of sanitary losses of limb injuries from explosive and fragmentation weapons, and especially severe injuries of the lower extremities. The wounded with injuries of extremities represent special value also due to the fact that this group of injured gives the greatest percent of return to service and serves as an important source of replenishment of personnel of armed forces.

Widespread application of various explosive devices, explosive munitions in terrorist acts has made the problem of gunshot wounds of the extremities relevant for surgeons of public health.

In case of gunshot wounds of extremities three tasks are set to the surgeon:

- saving the life of the wounded;
- saving the limb as an organ;
- restoration of functional full value of the damaged extremity.

It is particularly difficult to diagnose and treat the gunshot wounds of the extremities, accompanied by simultaneous damage of blood vessels, nerve trunks and bones of the extremities. They are characterized by the severity of the wound process, various infectious complications, a large number of adverse effects and high disability. Such injuries most often lead to amputation according to both primary and secondary indications.

Analysis of recent studies and publications. Currently, gunshot wounds are a problem not only in military medicine but also in the sphere of human health care. At the beginning of the XXI century there was an increase in the number of gunshot wounds among the civilian population of cities and towns in the world; herewith, the mass character of receipt of injured quite often takes place [1, 2, 3, 4, 5]. These circumstances require the improvement of military field doctrine, including the provision of medical care to persons aggrieved with gunshot

wounds of the extremities.

For all the ambiguity of the attitude to the definitions of “military-urban”, “military-civil” or “military-extreme” surgery, which have been used by B.V. Petrovsky et al. [6, 7] and, seemingly, inviolability of the military field doctrine, which ensures the rescue of thousands of wounded, the experience shows the legitimacy of these definitions. This is connected primarily with the changing conditions of medical and tactical measures and the possibility of early provision of specialized, high-tech care, and, hence, the improvement of treatment tactics within the conditions of city hospitals and large settlements. On the other hand, “civilian” surgeons lack experience in the treatment of combat injuries, especially with the mass influx of persons aggrieved in the context of terrorist acts [3, 4, 8].

Currently, as well as during World War II, gunshot wounds continue to occupy a leading place in the structure of mortality. Nowadays, 9 out of 10 wounded die from gunshot wounds in armed clashes and terrorist attacks. It has been established that gunshot wounds during local military conflicts and counter-terrorist operations are the cause of deaths, namely: in the center of the conflict - in 30-60% of cases, at the stages of medical evacuation – in 40-60%, at the stages of providing qualified and specialized medical care - in 8-15% of cases [5, 7, 8, 9, 10, 11, 12, 13]. The proportion of gunshot bullet injuries of the extremities remains high - in 40-87% of cases, with damage of bones - in 25-40%, joints – in 20%, blood vessels and peripheral nerves – in 6-15% of cases [1, 2, 3, 14, 15, 16, 17, 18]. These injuries are often accompanied by early and late complications in the form of purulent-septic processes, contractures, paralysis, etc. - 5-60% of cases [19, 20, 21, 22, 23].

The purpose of the academic paper is to find the optimal scheme for the treatment of infectious complications of gunshot wounds of the soft tissues of the extremities.

Presentation of the basic material. In the system of complex treatment of gunshot wounds of the extremities, the first place, undoubtedly, belongs to the

most difficult and labour-intensive part of it - primary surgical treatment. Surgery performed in adequate and at the earliest possible juncture is a guarantee of a successful outcome and the best method to prevent the development of infectious complications in the wound. The least number of complications occurs when the primary surgical treatment is one-time and comprehensive.

The efficiency of primary surgical treatment is significantly increased if it includes elements of restorative operations: stabilization of a gunshot fracture by means of external fixation devices or any other devices, a seam of a vessel and a nerve, various types of skin plasticity especially with use of microsurgical equipment.

In order for the actions of the surgeon to be more reasonable during surgical intervention in the wounded, it is necessary to be aware of the mechanism of occurrence of functional and pathomorphological changes in the tissues as a result of exposure to them when injured by the damaging factors of the shell. Unfortunately, ignorance of the algorithm of action and unpreparedness of surgeons of the general medical network to provide care to the wounded in the area of extremities can be the cause of various wound complications and deaths. In the course of treatment of gunshot wounds of the extremities, tactical and technical errors in the process of surgery are often taken place; intensive care in the pre- and postoperative periods is seldom carried out adequately and not to the full extent. However, taking into account all the circumstances, the results of treatment of the wounded in the extremities are still determined by the timing of their delivery to the hospital and the beginning of surgery and, of course, the quality of its implementation.

Factors for the development of infectious complications are as follows: weakening of the body blood loss, physical and mental fatigue, irregular diet, cooling and comorbidities.

It should also be noted that very often pus formations are combined with osteomyelitis and other purulent complications. In 100% cases of the wounded

with sepsis cases there are soft tissue pus formation or osteomyelitis.

The gunshot wound, in early terms after wounding, is followed by the expressed swelling of interstitial space, with accumulation of numerous microbes and necrobiosis products in intercellular space and regional lymph nodes. Excessive accumulation of edematous fluid in the fascial spaces leads to a compression effect on the microcirculation, while decompensation of lymphatic drainage is accompanied by accumulation of dysmetabolism and the spread of microbes in the area of molecular concussion of the gunshot wound (Figure 1, 2). In case of untimely surgical care, anti-edema and antibacterial therapy, this leads to the involvement of new areas of the zone of commotion in the pathological process with the development of tissue necrosis and purulent-septic complications. (Figure 3). The analysis of the available literature sources on this issue has made it possible to reveal the important role of the lymphatic system and its drainage function in the course and consequences of the wound process. Lymphotropic administration of antibiotics and stimulation of lymphatic drainage of the pathological process leads to a restriction of the necrosis area, resuscitates tissues in a state of parabiosis, prevents the progression of purulent-septic process, provides more physiological remodeling of granulation tissue. The study of the pharmacokinetics of antibiotics has revealed that traditional methods of administration of antibiotics do not create the maintenance of therapeutic concentrations of drugs in the lesion, lymphatic system and regional lymph nodes for a long time, which complicates the course of injury. Lymphotropic antibiotic therapy creates a long-term maintenance of therapeutic concentrations of antibiotics both in the area of the pathological process and in the spread of infection - in the lymphatic system, which is an important measure for the prevention of purulent septic process.

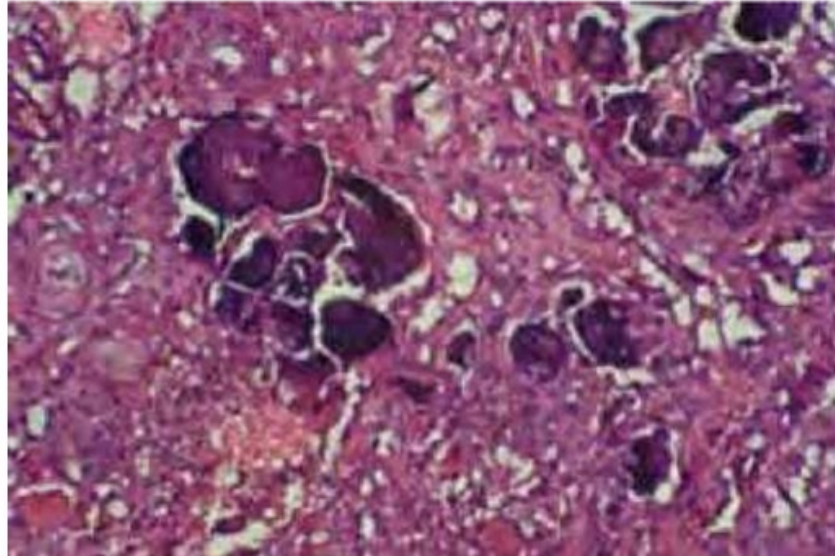


Figure 1. Edema, infiltration of stagnant microvessels at the border of the zone of primary and secondary necrosis.

Source: it has been formed by the author on the basis of Micropreparations.

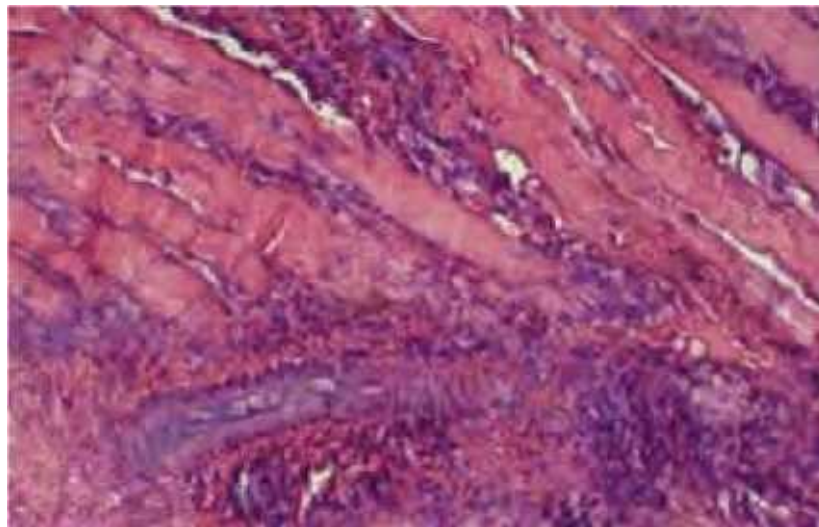


Figure 2. Dilated lymphatic capillaries, interstitial edema at the border of the zone of concussion and unaffected tissue

Source: formed by the author on the basis of Micropreparations.

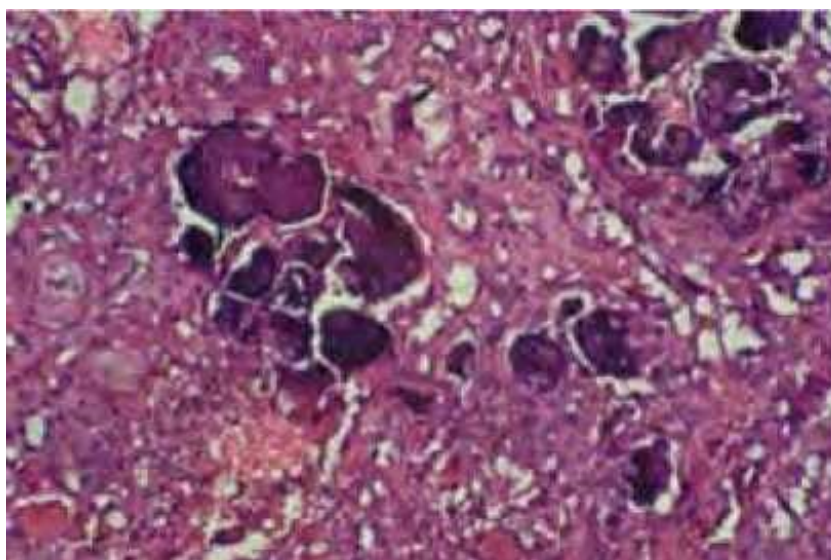


Figure 3. Necrotized myocytes, giant cells of foreign bodies in the zone of concussion

Source: formed by the author on the basis of Micropreparations.

The basic tasks of treatment of gunshot wounds are as follows: the maximum possible removal of necrotized tissues; creating favorable conditions for maintaining the viability of tissues in the area of secondary necrosis.

Analysis of the literature data shows that gunshot wounds of the extremities have characteristic pathophysiological and pathomorphological features [2, 3, 21, 24]. In this regard, we can identify three basic components of their successful treatment. The first step is an early delivery to the stage of specialized surgical care. The second step includes early primary surgical treatment of wounds, using a microsurgical approach to restore damaged structures and the use of early primary osteosynthesis. The third step - early rational antibacterial and anti-edematous therapy.

At injuries of soft tissues, early primary surgical processing of wounds is carried out to the overwhelming number of persons aggrieved. Typically, it includes three well-known components: dissection, excision and tissue repair. Contraindications to early primary surgical treatment are as follows: traumatic shock, agonal condition, as well as shallow soft tissue injuries without damage to bone, blood vessels and without a large hematoma. Early primary surgical

treatment, the use of early pathogenetically sound rational lymphotropic antibiotic therapy, with regional stimulation of lymphatic drainage, makes it possible to impose a primary suture for 66% of the wounded. Surgical infection in these wounded develops in 2, 5% of cases.

Another feature of primary surgical treatment within the conditions of military-urban surgery is the possibility of using an early microsurgical and reconstructive-restorative approach in case of damage of great vessels, peripheral nerves and tendons.

Indications for primary surgery are as follows: the patient has a gunshot wound with pronounced areas of primary and secondary necrosis, which can not independently get rid of necrotic tissue, in case of absence of signs of wound infection.

If there are signs of wound infection, the patient undergoes secondary surgical treatment.

1. Primary surgical treatment includes the following stages:

1.1. Dissection of the wound.

1.2. Removal of foreign bodies from the area of the wound defect of the wound canal.

1.3. Excision of non-viable tissues (areas of primary necrosis and formed areas of secondary necrosis).

1.4. Surgical intervention into damaged organs and tissues.

1.5. Wound drainage is carried out by installing drainages in the wound cavity formed after surgery and removing them through the counterpunctures in the lowest places in relation to the damaged area.

1.6. Wound closure. The primary suture is not applied after surgical treatment of the wound. This is due to the presence of a zone of secondary necrosis in the wound canal of the gunshot wound and the need to create conditions for rejection of newly formed foci of necrosis, which can be formed within 2-3 days after injury.

2. In case of small fragmentary and fractional wounds with damage of great vessels only dissection of a wound is carried out; in case of wounds with the big damage of soft tissues only excision is carried out; in case of wounds with the long wound channel of a difficult configuration obligatory imposing of counterpuncture openings is carried out.

3. In case of big destruction of soft tissues, damage of great vessels and nerves, fractures of bones, damage of joints, immobilization of an extremity is carried out, including with use of devices of external fixing.

4. After performing the surgical treatment, the patient is prescribed one of the following schemes of empirical antibacterial therapy (the dosage regimen for patients under 12 years is indicated in brackets):

- cephalosporins of III-IV generation:

- cefotaxime – 1, 0 g TDS i.m., i.v. (50-100 mg / kg / d in 3-4 injections);
- ceftriaxone - 1, 0 g BDS i.m., i.v. (20-75 mg / kg / d in 1-2 injections);
- cefepime - 1, 0 g BDS i.m., i.v. (50 mg / kg / d in 2-3 injections)

in combination with metronidazole – 0,5 g BDS, i.v. (7, 5 mg / kg / d in 3 injections)

- combined protected penicillins:

- amoxicillin / clavulanate – 1, 0 g BDS, i.v. (20-40 mg / kg / d in 3 injections)

in combination with metronidazole – 0, 5 g BDS, i.v. (7, 5 mg / kg / d in 3 injections)

- fluoroquinolones:

- ciprofloxacin – 0, 5 g BDS, i.v.;
- levofloxacin – 0, 5 g SID, i.v.

in combination with metronidazole – 0, 5 g BDS, i.v. (7, 5 mg / kg / d in 3 injections)

- carbapenems:

- imipenem - 0, 5 g TDS, i.v. (15-25 mg / kg / d in 4 injections);
- meropenem – 0, 5 g TDS, i.v. (10-20 mg / kg / d in 3 injections);
- ertapenem - 1.0 g SID, i.m., i.v. (15 mg / kg / d in 2 injections, but not more than 1, 0 g / d).

Dosage and frequency of administration of drugs, contraindications to their use are determined by the instructions for medical use.

Infusion therapy is prescribed (in the presence of medical indications - transfusion); drugs for improving microcirculation are also prescribed.

5. Hereafter, a repeated primary surgical treatment or repeated secondary surgical treatment is performed in order to assess the state of the wound process and the viability of tissues with an interval of 24-72 hours.

6. In case of absence of infectious complications on the 5-7th day after the primary surgical treatment the primary delayed suture is used to ensure wound healing by primary tension.

7. In case of suppuration and healing of a gunshot wound by the secondary tension, after reduction of infectious process and cleaning of a wound, at adequate approximation of edges of a wound without tension, the secondary early or secondary late seam is imposed.

8. If it is impossible to carry out approximation of the edges of the wounds without tension, a gradual convergence of the wound edges is carried out by dermatotension or performing skin grafting.

9. Secondary surgical treatment is performed in the same sequence and with the same stages as the primary surgical treatment. The scope of the separate stages of the operation is determined by the type of wound infection (abscess, phlegmon, suppuration) and their location. Treatment is prescribed in accordance with the general principles of treatment of patients with purulent-necrotic wounds, depending on the phase of the wound process.

Regional lymphatic therapy includes regional stimulation of lymphatic drainage (anti-edema therapy) and lymphotropic antibiotic therapy.

Method of performing: 16-32 U of Lydazum, diluted in a 0, 5-20.0% solution of novocaine, is injected without removing the needle subcutaneously, on the back surface of the hand or foot, in 5 minutes a solution of heparin (70 U / kg) is injected. The third stage, after pulling the needle by 0, 5 cm, the antibiotic is administered in a single therapeutic dose. Cephalosporin and aminoglycoside antibiotics (III generation) should be used, once a day, treatment course lasts 5-8 days. The application of the method is justified by experimental studies on animals with a model of a gunshot wound of the limb, the use of electron microscopy, as well as the study of pharmacokinetics [24, 25, 26].

Postoperative treatment. Immediately after the operation, washing the wound in the area of drainage is carried out with antibacterial drugs (0, 02% solution of Dekasan, 0, 1% solution of dioxidine, 3% solution of boric acid). Washing is carried out 3-6 times a day, and in severe cases - constantly, spending 1-2 liters of solution and more. The drainage is removed on the 8-14th day after surgery. Antibacterial therapy is obligatory. When choosing an antibiotic, the sensitivity of the suspected pathogen should be taken into account, its distribution in organs and tissues, compatibility with other drugs. The duration of antibiotic treatment depends on the severity of the infection: in case of local purulent process - 12-21 days, in case of sepsis – 1, 5-2 months or more. Transfusions of plasma, erythrocyte mass, platelet concentrate, albumin, protein hydrolyzate, equilibrated solutions of electrolytes, glucose, etc. is carried out for deintoxication, correct metabolic disorders, compensation for protein loss and combating anemia. For immunity, staphylococcal toxoid is administered subcutaneously in doses of 0.1-0.5-1.0-1.5-2.0 ml at intervals of 2-3 days.

In case of acute period of purulent wound infection, according to the indications, under the control of laboratory tests, anticoagulants (fragmin) and fibrinolytics, proteolytic enzymes and protease inhibitors may be used. Metabolic processes are stimulated by anabolic hormones. High-calorie diet, good care promotes rapid recovery.

Conclusions. The possibility of early delivery of persons aggrieved as a result of armed conflicts in cities and towns directly at the stage of providing specialized medical care makes it possible to improve approaches to the treatment of gunshot wounds of the extremities. The use of rational lymphotropic antibiotic therapy with regional lymphostimulation in the complex advanced treatment of limb injuries helps reduce the number of complications in patients under supervision. It is necessary to develop standards and protocols of tactical military-urban medicine in advance, depending on the medical-tactical situation, with the final stage of specialized medical care, carried out as soon as possible. It is necessary to prepare algorithms and schemes for re-profiling of departments, release of beds, deployment of reserves and permanent evacuation of minimally wounded and recovering patients to other hospitals of the city and nearby settlements. In cases of mass influx of wounded, it is advisable to use the principle of “damage control”. It is necessary to prepare civilian medics and medical administration to work in the conditions of terrorist attacks and local armed conflicts. The feature of military-urban medicine is the ability to quickly move to a higher level of work, by strengthening the staff structure with highly qualified personnel and timely logistics, as well as providing medical care by allied, functional specialists.

References:

1. Bryusov P.G., Zuyev V.K., Beslekoyev V.I. i dr. (1999) Organizatsiya okazaniya khirurgicheskoy pomoshchi ranennym v garnizonnom gospitale, usilennom spetsializirovannoy gruppoy [The organization providing surgical assistance to the wounded in the garrison hospital, enhanced specialized group // temporary residence.] // VMZH.- № 9.- S. 36-39.
2. Tolstykh M.P., Lutsevich O. E., Akhmedov B.A. i dr. (2005) Ognestrel'nyye raneniya konechnostey mirnogo vremeni [Gunshot wounds to the extremities of peacetime]. M: Meditsina. - 83 s.

3. Revskoy A.K., Lyufing A.A., Nikolenko V.K. (2007) Ognestrel'nyye raneniya konechnostey [Gunshot wounds of the extremities] M. Meditsine. - 272 s.
4. Burg A., Vachum G., Salai M., et a. (2009) Treating civilian gunshot wounds to the extremities in a level 1 trauma center. //Israel Association Journal.- vol.- II. №9. P.- 546-551.
5. Emergency war surgery Ed TE Bowen, R.F. (1988) Bellamy- US Department of Defense, Washington,- D.C- 225 p.
6. Petrovskiy B.V. (1998) Izbrannyye lektsii po voyennoy khirurgii (voyenno- polevaya i voyenno- gorodskaya khirurgiya) [Selected lectures on military surgery (military field and military-city surgery)] M.:Meditsina. - 112 s.
7. Eck K., Hultman L., (2007) One-sided violence against civilians in war: insights from new fatality data// Journal of Peace Research-. Vol.-44.- № 2. -March P- 233-246.
8. Fidarov E.Z. (1999) Okazaniye neotlozhnoy spetsializirovannoy khirurgicheskoy pomoshchi ranenym v lokal'nykh voynakh i chrezvychaynykh situatsiyakh mirnogo vremeni: [Provision of urgent specialized surgical care to the wounded in local wars and peacetime emergency situations] Avtoref. dis. kand. med. nauk. - M. 26 s.
9. Davydkin P.A. i soavt. (2000) Kharakteristika boyevoy travmy i lechebnyye meropriyatiya pri ognestrel'nykh perelomakh dlinnykh trubchatykh kostey konechnostey [Characteristics of combat trauma and therapeutic measures for gunshot fractures of the long bones of the extremities] // Voen.-med. zhurn. № 15. S. 4-12.
10. Karagezov P.A., Gorelik I.E. (1997) K voprosu okazaniya ranney spetsializirovannoy travmatologicheskoy pomoshchi postradavshim ot boyepripasov vzryvnogo deystviya [On the issue of providing early specialized trauma care to victims of explosive ordnance]// Voen.-med. zhurn. №9. S. 50-51.
11. Yefimenko N.A., Gumanenko Ye.K., Samakhvalov I.M. i dr. (1999) Khirurgicheskaya pomoshch' ranenym v vooruzhennom konflikte: organizatsiya i

soderzhanii spetsializirovannoy khirurgicheskoy pomoshchi [Surgical care for the wounded in an armed conflict: organization and maintenance of specialized surgical care] // VMZH. -№10.- S. 30-36.

12. Suchasne medikamentozne líkuvannya ran. (2002) [Suchasne medication for treatment of wounds] /Vídomcha ínstr./ za red. O.O.Shalímova, V.F.Saênka, B.M.Dotsenka ta ín. // Kiïv, – 36 s.

13. Ali M.A., Hussain S.A., Khan M.S. (2008) Evalution of results of interlocking nails in femur fractures due to high velocity gunshot injuris //Journal of Ayub Medical College - vol 20. №1.-P.16-19.

14. Artem'yev A.A., Smirnov A.V., Ivashkin A.N. i dr. (2009) Maloinvazivnyy osteosintez dlinnykh trubchatykh kostey u postradavshikh s mnozhestvennymi perelomami. [Minimally invasive osteosynthesis of long tubular bones in patients with multiple fractures] //VMZH. - №12. - S. 41-43.

15. Teoriya ta praktika místsevogo líkuvannya gníynikh ran. (1995) /Bezugla O.P., Bêlov S.G., Grul'ko V.G. ta ín. Za red. B.M. Datsenko [Theory and practice of the muscular treatment of gnar wounds] // K.: Zdorov'ya, – 384 s.

16. Yeryukhin I.A (1992) «O khirurgicheskoy obrabotke ognestrel'nykh ran [On the surgical treatment of gunshot wounds] //VMZH. - № 1. S.- 25-27.

17. Kornilova Ye.A. (2007) Vremennoye protezirovaniye arteriy konechnostey pri boyevoy khirurgicheskoy travme na etapakh meditsinskoy evakuatsii [Temporary prosthetics of limb arteries in combat surgical trauma at the stages of medical evacuation] : Aftoref. dis. kand. med. nauk. - SPb. - S 22-25.

18. Samokhvalov I.M., Zavrazhnov A.A., Kornilov Ye.A., Margaryan S.A. (2006) Khirurgicheskaya taktika pri sochetannykh ognestrel'nykh raneniyakh konechnostey s povrezhdeniyami magistral'nykh arterii. [Surgical tactics for combined gunshot wounds of the extremities with injuries of the main arteries] //Vest. Khirurgii. - № 5.- S. 45-49.

19. Beschastnykh V.V., Maramokhin V.N. (2010) Novyy sposob aktivnogo lecheniya gnoynykh ran myagkikh tkaney [A new way of active treatment of

purulent wounds of soft tissues] . Izvestiya vysshikh uchebnykh zavedeniy. Meditsinskiye nauki: - № 3- S. 17-22.

20. Nelin N.I. i soavt. (2001) Faktory, opredelyayushchiye khirurgicheskuyu taktiku pri minno-vzryvnykh raneniyakh nizhnikh konechnostey [Factors determining surgical tactics for mine-blast wounds of the lower extremities] // Mat. nauch. konf. «Aktual'nyye voprosy meditsiny». M., S 154.

21. Minnulin I.P., Gritsanov A.I., Gulyabzay M.U (1991) Osobennosti patogeneza, lecheniya obshchey gnoynoy infektsii pri mnozhestvennykh ognestrel'nykh raneniyakh [Features of pathogenesis, treatment of general purulent infection in multiple gunshot wounds] // VMZH.- №7. - S. 14-16.

22. Nikitin V.F. (2000) Vrachebno-ekspertnyye i organizatsionno-klinicheskiye aspekty okazaniya meditsinskoy pomoshchi ranenym v konechnosti v usloviyakh lokal'nogo vooruzhennogo konflikta [Medical-expert and organizational-clinical aspects of providing medical care to the wounded in the limb in a local armed conflict] // Avtoref. diss. kand. med. nauk. M., 24 s.

23. Dufour D., Kroman Jensen S., O Smith M., et al. (1988) Surgery for niktims of war.-Geneva: Journ.Com. Ked. Cross.- P. -227-229.

24. Dzhumabayev E.S., Mirzayev K.K., Tukhtayev ZH.T. (2008) Novyye podkhody profilaktiki i lecheniya khirurgicheskoy infektsii ognestrel'nykh ran. [New approaches to the prevention and treatment of surgical infection of gunshot wounds] //Zhurnal «Khirurg» - №6. - S. 3-8.

25. Dzhumabayev E.S., Mirzayev K.K. (2008) Limfotropnaya antibiotikoterapiya v kompleksnom lechenii ekstremal'nykh ognestrel'nykh ran myagkikh tkaney [Lymphotropic antibiotic therapy in the complex treatment of extreme gunshot wounds of soft tissues] //Vestnik limfologii. -2008.-№2- S.14-16.

26. Mirzayev K.K., Dzhumabayev E.S., Khakimov V.A. (2008) Metod profilaktiki i lecheniya gnoynykh oslozhneniy ognestrel'nykh ran konechnostey [Method of prevention and treatment of purulent complications of gunshot wounds of extremities] //Vestnik limfologii. - №3.- S13-17.