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ЗМІСТ / CONTENTS

Results. Surgical correction of a rupture of the sacroiliac joint was observed in 84% in group A and 76% in group B. Other observations revealed residual diastasis of more than 5 mm with unreduced displacement of the iliac bone of more than 10 mm. The developed program of active rehabilitation in the early postoperative period made it possible to significantly (p <0.05) reduce the stay in bed for patients of the main group compared to control group B. The use of educational programs helped patients understand the features of their condition, the goals and objectives of early rehabilitation, and the safety of treatment, contributed to a significant improvement in functional results in the main group in the long-term post-traumatic period.

Conclusions. The use of an early rehabilitation program made it possible to improve the functional results of surgical treatment both in the group with an anatomically restored sacroiliac joint and in those with preserved residual post-traumatic deformity.

Key words: unstable pelvic injury, rupture of the sacroiliac joint, surgical correction, residual post-traumatic deformity of the pelvic ring, early rehabilitation.

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EVALUATION OF THE EFFICIENCY OF COMBINED TREATMENT OF ISOLATED GUNSHOT INJURIES OF SOFT TISSUES

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An analysis of 120 patients with gunshot shrapnel blind wounds of soft tissues was carried out. Patients were divided into two groups depending on the timing of suturing. The treatment methods of the main group were modified by combining suturing with the introduction of platelet-rich autoplasma into the wound.

The results showed that the incidence of postoperative complications in patients of the main group was significantly reduced (subgroup C), wound suppuration was detected in 2 (3.33%) patients (U=120.00, p=0.000001). And in subgroup D, seroma formation was detected in one patient (1.67%) (U=220.00, p=0.0385), while in the comparison group 24 (40.00%) patients were diagnosed. The duration of inpatient treatment of the wounded in the comparison group (subgroup A) was 21±2.3 days, while in the main group (subgroup C) this indicator was 16±3.1 days (U=290.00, p=0.0354). In the comparison group (subgroup B), the duration of inpatient treatment was 27±3.5 days, while in the main group (subgroup D) it was 22±2.1 days.

The modification method of treatment of gunshot shrapnel blind wounds of soft tissues significantly reduced the number of postoperative complications and accelerated the duration of inpatient treatment, which indicates the antibacterial, fungicidal and regenerative capabilities of platelet-rich autoplasma.

Key words: *gunshot wound, autoplasm, secondary sutures.*

Connection of the publication with planned research works.

The work was performed within the framework of the research work of the Department of General Surgery and Postgraduate Surgical Education of Zaporizhzhia State Medical University "Modification of surgical aspects of treatment of patients of different age groups in peacetime and wartime", state registration number 0122U201230.

Introduction.

In the current conditions of hostilities and war on the territory of Ukraine, the problem of gunshot wounds is becoming relevant and extremely important for medical practice. With the increasing number of isolated blind gunshot shrapnel wounds, there is a need to develop and improve surgical treatment methods aimed at maximising tissue repair and ensuring rapid recovery of the functions of injured organs [1, 2, 3, 4]. Traditional methods of treating such injuries are often associated with a long rehabilitation period, the risk of developing infectious complications and insufficiently effective repair of damaged tissues.

Current medical progress demonstrates the importance of optimising the treatment of gunshot wounds. In the context of the military conflict on the territory of Ukraine, an essential stage in the treatment of the

wounded is the use of combined methods that allow for faster and more effective restoration of damaged tissues and reduce the risk of complications, contributing to the rapid restoration of the functionality of injured organs [5, 6, 7].

In recent years, researchers and clinicians have increasingly focused on finding innovative treatment approaches, including regenerative medicine.

The use of a combined method of surgical treatment of primary deferred or early secondary sutures with platelet-rich autoplasma injections is becoming an innovative element aimed at improving tissue regeneration and reducing recovery time.

Therefore, due to the growing number of wounded, improving surgical methods of treating isolated blind gunshot shrapnel wounds through a combination of primary-deferred or early secondary sutures with platelet-rich autoplasma injections is becoming an urgent problem aimed at improving treatment outcomes and promoting faster recovery of the functionality of injured organs.

The aim of the study.

To evaluate the effectiveness of combined treatment of patients with isolated gunshot shrapnel wounds of soft tissues depending on the time of suturing in combination with platelet-rich autoplasma injections.

Object and research methods.

The material for the study was the analysis of the results of the examination and treatment of 120 patients with isolated blind gunshot shrapnel wounds of soft tissues who were treated in the surgical hospital of the Municipal Non-Profit Enterprise "City Hospital No. 7" Zaporizhzhia city council, in the period from 2022 to 2024.

All patients were divided into two groups.

The comparison group consisted of 60 (50.0%) patients who underwent surgery at the second stage of medical evacuation and were delivered to the surgical hospital of the Municipal Non-Commercial Enterprise "City Hospital No. 7" of the Zaporizhzhia City Council, which in turn was divided into two subgroups. Subgroup A – 30 (25.0%) patients who underwent primary surgical treatment at the 2nd stage of medical evacuation and were admitted to the hospital with primary delayed sutures (6-7 days). Subgroup B – 30 patients (25.0%) who underwent early secondary sutures on day 8-15.

The main group included 60 patients (50.0%), divided into two subgroups. Subgroup C – 30 (25.0%) wounded whose local treatment was modified by a combination of primary delayed sutures and platelet-rich plasma (PRP) injection into the wound. Subgroup D included 30 (25.0%) patients in whom local treatment was modified by combining early secondary suturing with PRP injection into the wound.

The mean age in the comparison group was 34.8±3.6 years and in the main group 36.2±3.1 years U=380.00, p=0.0895. There were 111 patients of active working age (18-49 years) **(table 1).**

The inclusion criteria were age from 18 to 60, shrapnel blind or tangential soft tissue wounds of the forearm, shoulder, thigh, posterior surface of the lower leg, anterior abdominal wall, and anterior chest, non-penetrating nature of the injury, absence of damage to major vessels and large nerve trunks, bone structures, and consent to participate in the study.

Table 1 – Distribution of wounded in the study groups according to age (n=120)

Age (years)	The main group		Comparison group		Total	
	Abs	%	Abs	%	Abs	%
18-44	53	88,33	49	81,67	102	85,00
45-59	7	11,67	11	18,33	18	15,00

To ensure the reliability of the study, we selected patients with isolated injuries in the marked areas. Patients with multiple or combined injuries were excluded.

Prior to suturing, both groups of patients were treated in accordance with the standards for the treatment of gunshot wounds [8, 9, 10]. This included wound rehabilitation – dressings with antiseptic solutions (Chlorhexidine aqueous solution 0.05%) once a day, complex anti-inflammatory analgesic therapy (dexketoprofen 2. 0 ml, IV, 3 times/day; paracetamol 100.0 ml, IV infusion 2 times/day, for 7-10 days), proton pump inhibitors (omeprazole 40 mg, 1 tablet, once/day, for 10-14 days).

The study used identical methods to examine the wounded in both groups. This included an ultrasound examination of the wound canal using the Mindray M6 ultrasound diagnostic system, linear measurement of the wound defect (length, width, depth, volume and area of the wound defect), X-ray of the extremities and chest, complete blood count and blood chemistry.

The observation groups did not differ statistically by the nature of the injuries. Soft tissue defects within the skin-subcutaneous tissue were observed in n=92 (76.67%) cases, and in n=28 (23.33%) blind wound channels with damage to superficial and deep muscles were observed. The comparison groups were homogeneous in terms of the location of the injuries.

In the comparison group of 60 (50%) patients, the wound defect was closed in subgroup A – 30 (25.00%) patients, at the 2nd stage of medical evacuation, where they underwent primary surgical treatment and primary delayed sutures (6-7 days), after which they were taken to the hospital of the surgical department, who continued conservative therapy and daily dressings. Subgroup B – 30 patients (25.00%) who received early secondary sutures on day 8-15 and continued conservative treatment and daily dressings by current standards for the treatment of gunshot wounds.

The modification of local treatment in the main group of 60 (50%) patients consisted of a combination of suturing and PRP injections into the wound. In subgroup C, 30 (25%) patients underwent primary delayed suturing for 6±1.1 days with the introduction of platelet-rich autoplasma (PRP) into the wound. Subgroup D – 30 (25%) patients underwent early secondary suturing on 12±2.2 days after injury with PRP injection into the wound. Plasma was obtained by taking from 18 ml to 36 ml of whole blood from the patient's cubital vein into a vacuum tube with sodium heparin at the rate of 15 IU per 1 ml of blood and a separation gel in the amount of 0.5 ml, and the tube with the material was centrifuged for 15 minutes at a speed of 3200 rpm. During centrifugation, three parts of the material were obtained: the first layer (sediment) under the separation gel was represented by red blood cells, the second layer (supernatant) above the separation gel was platelet-rich plasma (PRP), and the third layer was actual plasma (PPP – platelet poor plasma). The wound area was anaesthetised in layers using

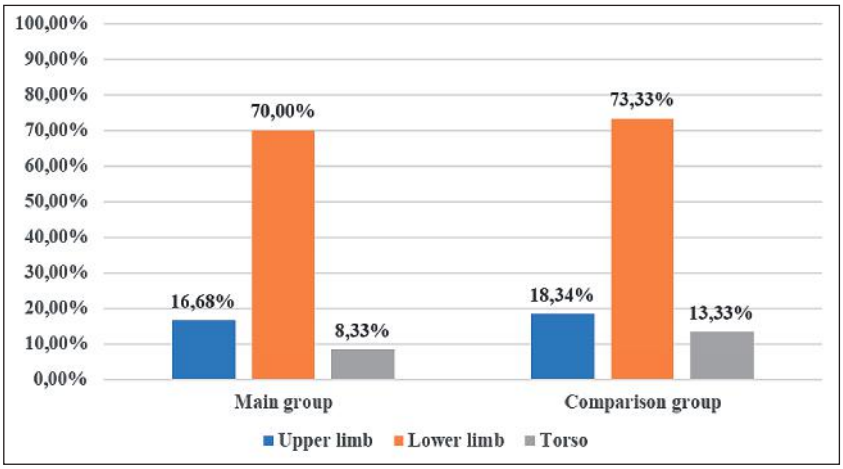

Figure 1 – Distribution of patients by location of injury in the study groups (n=120).

infiltration anaesthesia with 0.5% novocain solution in 5 to 20 ml. The supernatant obtained after centrifugation in the amount of 9 to 18 ml, depending on the size of the wound, was injected into the wound edges, circular pricking of the wound edges was performed with 1 ml at a frequency of 10 mm, and 5 ml was additionally injected into the wound bottom. For early secondary sutures, a nodal adaptive П-shaped (looped) Donati suture was used with polyamide suture USP 1/0.

Postoperative treatment in the main group included third-generation cephalosporins (ceftriaxone 1.0 g, i.m., twice daily for 5 days), combined anti-inflammatory analgesia (dexketoprofen 2.0 ml, i.m, three times a day, paracetamol 100.0 ml IV infusion, twice a day, for 10-14 days), proton pump inhibitors for the prevention of NSAID gastropathy (omeprazole 40 mg, 1 tablet, once a day, for 10-14 days). Antibiotic therapy was continued in the event of inflammatory changes in the wound and/or a complete blood count (left shift in the leukocyte count). Antibiotic therapy was adjusted depending on the results of the bacteriological culture of the wound.

According to the phases of the wound process of gunshot fragmentation wounds, it was considered expedient to assess the course of the wound process under the sutures on the 8th and 14th day after the injury in subgroups A and C. In subgroups B and D, on the 14th and 20th day after the injury.

The results were statistically processed using the computer software packages STATISTICA 13.0 from TIBCO Software Inc. (Licence JPZ804I382130ARCN10J) and MICROSOFT EXCEL 2013 (Licence 00331-10000-00001-AA404). Non-parametric statistical analysis methods, in particular the Mann-Whitney U test for unrelated groups, were used to determine the reliability of the difference between the groups.

The results are presented as M±m (arithmetic mean ± standard deviation) in the case of a normal distribution of the studied trait. For distributions other than normal, the data are presented as Me (Q1; Q3) (sample medians with the upper (75%) and lower (25%) quartiles). To determine statistically significant results, p values <0.05 were considered.

The study was conducted following the principles of the World Medical Association's Declaration of Helsinki 'Ethical Principles for Medical Research Involving Human Subjects' (amended in October 2013). Written informed consent was obtained from all patients who participated in the study.

Research results.

All 120 (100.0%) patients were urgently admitted to the third stage of medical evacuation and treated according to standard protocols for treating this pathology at the third stage of medical evacuation.

As for the location of the wound defect, 60 (50.00%) of the wounded in the comparison group were distributed as follows: 44 (73.33%) patients with lower limb injuries, 11 (18.34%) with upper limb injuries and 5 (8.33%) with torso injuries. In the main group, 60 (50.00%) wounded were also selected, the location of wounds in this group was similar to the comparison group and included 5 (16.67%) patients with upper limb wounds, 21 (70.00%) wounded with lower limb wounds, and 4 (13.33%) patients with torso wounds **(fig. 1).**

The graph shows that the largest number of injuries was observed in the lower extremities (n=42 (70.00%) in the study group and n=44 (73.33%) in the comparison group, p=0.8387), and in the upper extremities and torso (n=18 (30.00%) and n=16 (26.67%), respectively, p=0.6627).

On the 8th day after the injury in subgroups A and C, visual examination of the wounds revealed no hyperaemia or suppuration. According to the linear measurement, the area and volume of the wound surface were distributed depending on the location of the wounds, and these indicators are presented in **table 2**.

Table 2 – Main parameters of linear wound measurement according to the diagnostic ultrasound system in the study groups on the 8th day after injury after primary delayed suturing

Injury area	Subgroup A, n=30		Subgroup C, n=30		p (S)	p (V)
	S, mm²	*V, mm³*	*S, mm²*	*V, mm³*		
Upper limb	95,0±25,2	221,6±65,2	96,1±24,2	244,5±67,7	0,9373	0,9434
Lower limb	194,7±50,7	706,3±190,4	193,5±48,7	732,6±188,9	0,6098	0,6079
Torso	50,0±13,9	80,0±29,4	46,4±12,3	77,3±21,9	0,8553	0,8562

Notes: S – wound area, V – wound volume.

Table 3 – Main parameters of linear wound measurement according to the diagnostic ultrasound system in the study groups on the 14th day after injury after early secondary suturing

Injury area	Subgroup B, n=30		Subgroup D, n=30		p (S)	p (V)
	S, mm²	V, mm³	S, mm²	V, mm³		
Upper limb	99,2±25,2	221,6±65,2	98,1±24,2	244,5±67,7	0,9373	0,9434
Lower limb	221±50,7	589,3±190,4	207,5±48,7	620,6±188,9	0,6098	0,6079
Torso	61,0±13,9	79,0±29,4	58,2±12,3	82,7±21,9	0,8553	0,8562

Notes: S – wound area, V – wound volume.

On the 14th day after injury in subgroups B and D, visual examination of the wounds also revealed no hyperaemia or suppuration. Linear measurement data, wound surface area and volume are presented in **table 3**.

The wound healing process was assessed on day 11-14 in subgroups A and C, and on day 19-23 in subgroups B and D. Visual inspection of the wound, linear measurement of the wound defect area and ultrasound assessment of the wound volume were performed **(tables 4, 5).**

Table 4 – Main parameters of linear wound measurement according to the diagnostic ultrasound system in the study groups on the 11th-14th day after the injury after primary delayed suturing

Injury area	Subgroup A, n=30		Subgroup C, n=30		p (S)	p (V)
	S mm²	V mm³	S mm²	V mm³		
Upper limb	43,3±12,6	53,3±13,9	28,2±8,5	23,2±7,1	0,0435	0,0457
Lower limb	84,7±28,1	190,5±56,5	56,4±19,6	102,4±21,1	0,0344	0,0377
Torso	20,5±7,2	22,5±5,4	12,3±3,2	10,4±2,9	0,0245	0,0268

Notes: S – wound area, V – wound volume.

Table 5 – Main parameters of linear wound measurement according to the data of the diagnostic ultrasound system of the study groups on day 19-23 after the injury after early secondary suturing

Injury area	Subgroup B, n=30		Subgroup D, n=30		p (S)	p (V)
	S mm²	V mm³	S mm²	V mm³		
Upper limb	34,3±12,6	43,3±13,9	29,2±8,5	27,5±7,1	0,0410	0,0398
Lower limb	75,7±28,1	134,5±56,5	51,4±19,6	97,4±21,1	0,0379	0,0403
Torso	25,5±7,2	29,5±5,4	14,3±3,2	18,4±2,9	0,0342	0,0314

Notes: S – wound area, V – wound volume.

When reviewing the results of treatment at 11±2.9 days after the injury in the comparison group (subgroup A), complications were detected in 24 (40.00%) patients, of whom 17 (28.83%) had seroma formation and 7 (11.67%) had haematoma with wound suppuration. In subgroup B, the results of treatment were assessed on day 19±2.5, and complications were also observed – 7 (11.67%) in the form of wound edge separation – 4 (6.67%) patients, and 3 (5.00%) patients had a haematoma with suppuration. In the same period, in the main group (subgroup C), wound suppuration was detected in 2 (3.33%) patients (U=120.00, p=0.000001). And in subgroup D, seroma formation was detected in one patient (1.67%) (U=220.00, p=0.0385), **(fig. 2).**

The total duration of inpatient treatment at the third stage of medical evacuation for the wounded in the comparison group (subgroup A) was 21±2.3 days, while in the main group (subgroup C) this figure was 16±3.1 days (U=290.00, p=0.0354). In the comparison group (subgroup B), the duration of inpatient treatment was 27±3.5 days, while in the main group (subgroup D) it was 22±2.1 days.

It is important to note that all the wounded achieved full recovery, despite the complications and the difference in treatment duration.

These results indicate the effectiveness of the combined method of treatment of isolated blind gunshot shrapnel wounds of soft tissues, including the application of early secondary and primary delayed sutures with injections of platelet-rich autoplasma, compared with traditional methods.

Discussion of the research results.

Our study revealed several complications in the classical treatment of gunshot fragmentation wounds of soft tissues in the comparison group (subgroup A), where only primary delayed sutures were used, 24 (28.33%) patients had complications, in particular, in 17 (11.67%) cases, seroma formation was observed, and in 7 (11.67%) – hematoma with wound suppuration. In subgroup B, where the method of surgical treatment was the application of only early secondary sutures, the incidence of complications was lower and amounted to 7 (11.67%) cases, of which 4 (6.67%) patients had wound edge discontinuity, and 3 (5.00%) patients had haematoma with suppuration. These statistics are in line with the world literature [11, 12, 13, 14, 15].

The introduction of a method of surgical treatment by combining suturing with the administration of platelet-rich autoplasma into the wound has significantly reduced the number of postoperative complications due to the presence of plasma clot formation products and platelet-derived growth factors in PRP, which ensure healing and haemostasis, is the basis for its use. PRP contains not only growth factors, but also adhesive molecules and cytokines that stimulate repair and anabolic processes in damaged tissues and have an anti-inflammatory effect [16, 17]. According to other researchers, the use of autologous platelet-rich plasma (platelet rich plasma [PRP] therapy) is a specialised local therapy for wounds that do not heal for a long time (Mehta S., 2008). Platelets in the plasma initiate wound healing by releasing local growth factors (Knighton D.R. et al., 1988), which are released during degranulation of α-granules. The latter contain secretory proteins (platelet-derived factor 4 [PF4], transforming growth factor β

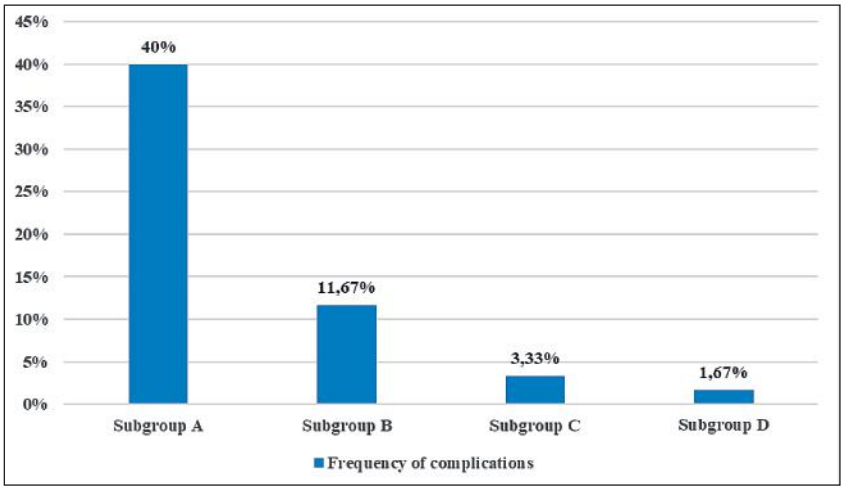

Figure 2 – Complication rates in both evaluated groups.

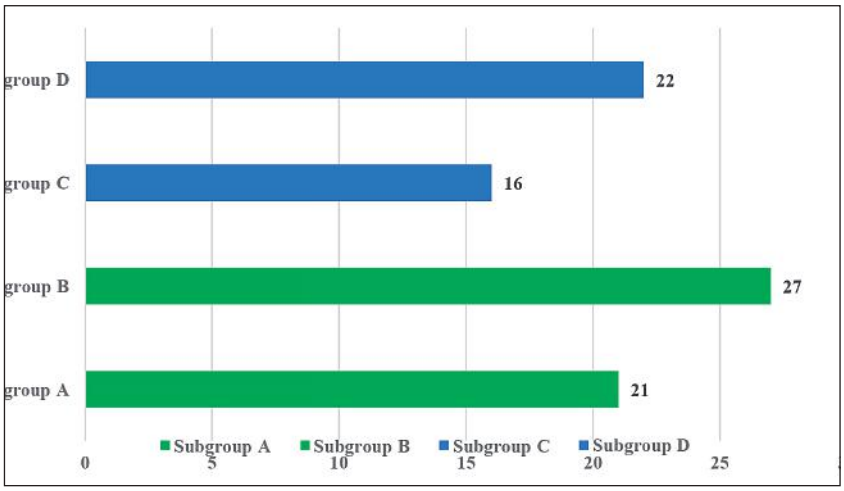

Figure 3 – Treatment period for patients at the third stage of medical evacuation.

[TGF-β], vascular endothelial growth factor [VEGF], epidermal growth factor [EGF], osteocalcin, osteonectin, fibronectin). These factors contribute to the involvement of undifferentiated cells in the newly formed matrix, limiting the area of inflammation and accelerating the healing process (Bhanot S., 2002) [18, 19].

Based on the study, it was found that the number of postoperative complications in the main group (subgroup C) was only 2 (3.33%) patients were found to have wound suppuration (U=120.00, p=0.000001), and in subgroup D, seroma formation was found in only one patient (1.67%) (U=220.00, p=0.0385).

These results suggest that wounds treated with platelet-rich plasma have a higher rate of regeneration than control groups, with increased angiogenesis and granulation tissue formation, as well as accelerated reepithelialisation and epithelial differentiation [20].

The low percentage of complications, such as suppuration and seroma formation, emphasises the method's advantages in accelerating the healing process and reducing the risk of infectious complications.

The most important stage in the treatment of gunshot shrapnel wounds of soft tissue is the rehabilitation period and the return of a serviceman to duty.

Our proposed method allowed us to reduce the treatment time at the third stage of medical evacuation: for the wounded in the comparison group (subgroup A) it was 21±2.3 days, while in the main group (subgroup C) this figure was 16±3.1 days (U=290.00, p=0.0354). In the comparison group (subgroup B), the duration of inpatient treatment was 27±3.5 days, while in the main group (subgroup D) it was 22±2.1 days. This indicates a reduction in the overall rehabilitation time for military personnel who sustained isolated blunt gunshot shrapnel wounds of soft tissues by combining suturing with platelet-rich autoplasma injections **(fig. 3).**

This comprehensive approach, which combines suturing with platelet-rich autoplasma injections, has proven effective in reducing complications, accelerating healing, and improving treatment outcomes.

Conclusions.

1. The use of PRP significantly reduced the incidence of postoperative complications in the comparison group (subgroup A) – 24 (40.00%) complications, seroma formation – 17 (28.83%), wound suppuration – 7 (11.67%) cases – subgroup B – 7 (11.67%) cases, wound edge discontinuity – 4 (6.67%) patients, wound suppuration – 3 (5.00%). In the main group (subgroup C), wound suppuration occurred in 2 (3.33%) cases (U=120.00, p=0.000001). In subgroup D, seroma formation was observed in 1 (1.67%) patient (U=220.00, p=0.0385), which allows closing the wound defect as early as possible compared to classical methods.

2. The use of platelet-rich autoplasma allows to accelerate the time of wound defect closure, which significantly reduces the length of hospital stay at the third stage of medical evacuation in the comparison group (subgroup A) was 21±2.3 days, while in the main group (subgroup C) this figure was 16±3.1 days (U=290.00, p=0.0354). In the comparison group (subgroup B), the duration of inpatient treatment was 27±3.5 days, while in the main group (subgroup D) it was 22±2.1 days (U=312.00, p=0.0221).

3. The use of our proposed method stimulates wound healing and accelerates the processes of repair, so that on 12±3.2 days from the moment of injury in the main group (subgroup C) and in the comparison group (subgroup A), when evaluated on 20±3.5 days in the main group (subgroup D) and in the comparison group (subgroup B), a significant reduction in the area and volume of the wound defect was observed.

Prospects for further research.

Research and development of new methods of treatment to improve the results of surgical intervention in patients with gunshot wounds.