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- Vasyl Z. Netiazhenko, Serhii I. Mostovyi, Olga M. Safonova, Vitaly G. Gurianov, Kyrylo O. Mikhaliiev  
INTRACARDIAC HEMODYNAMICS, CEREBRAL BLOOD FLOW AND MICROEMBOLIC SIGNAL BURDEN IN STABLE CORONARY  
ARTERY DISEASE PATIENTS WITH CONCOMITANT COVID-19 1205
- Oleksandr L. Nikishyn, Igor V. Altman, Iyad I. Al-Qashkish, Anatoliy I. Gavretskiy, Sergiy I. Savolyuk, Mykola I. Muz  
DRUG-ELUTING STENTS IN THE TREATMENT OF PATIENTS WITH OCCLUSIVE-STENOTIC LESIONS OF THE SUPERFICIAL FEMORAL ARTERY 1216
- Alina O. Pletenetska, Ivan S. Demchenko  
ANALYSIS OF DEFECTS IN THE DIAGNOSIS OF TRAUMATIC BRAIN INJURY FOR THE DECEASED WITHIN 24 HOURS FOLLOWING ADMISSION 1220
- Olena V. Ponomarenko, Victor V. Pysanko, Dmytro S. Mialkovskiy, Dmytro V. Tkachuk  
THE MANAGEMENT OF THE VICTIMS WITH GUNSHOT WOUNDS OF THE EXTREMITIES WITH EXTENSIVE DEFECTS  
OF THE SOFT TISSUES AT THE LEVEL OF QUALIFIED MEDICAL CARE. CASE-SERIES 1227
- Volodymyr O. Shaprynskyi, Vasyl V. Shaprynskyi, Nataliia V. Semenenko  
MANAGEMENT OF MINIINVASIVE TREATMENT OF PRIMARY VARICOSE SUPERFICIAL VEINS 1233
- Vasyl V. Shaprynskyi  
LATE RESULTS OF TREATING PATIENTS WITH OCCLUSIVE-STENOTIC LESIONS OF THE AORTA INFRARENAL SEGMENT'S MAIN ARTERIES 1239
- Olga V. Sherbul, Ilona A. Srebniak, Ivan O. Kuzmuk  
FLUCTUATING HEARING LOSS AS A SYMPTOM OF ACQUIRED PERILYMPHATIC FISTULA (PLF) UNDER EXTERNAL INJURIES FACTOR 1246
- Volodymyr O. Shkorbotun, Olena O. Dyadyk, Yaroslav S. Nachesa  
MORPHOLOGICAL FEATURES OF MAXILLARY SINUS CYSTS BASED ON THE STUDY OF PARTICULAR HISTOCHEMICAL  
AND IMMUNOHISTOCHEMICAL FACTORS OF INFLAMMATION 1252
- Ivan M. Todurov, Oleksandr V. Perekhrestenko, Sergii V. Kosiukhno, Viktoriia V. Yevsieieva, Yurii B. Lisun  
ASSESSMENT OF THE EFFICIENCY OF ANALGETIC ACTION OF LAPAROSCOPICALLY ASSISTED TAP BLOCK AS A COMPONENT  
OF PERIOPERATIVE MULTIMODAL ANALGESIA PLAN IN OBESE PATIENTS UNDERGOING METABOLIC SURGERY 1259
- Volodymyr M. Tverezovskyi, Valeriy A. Kapustnyk, Borys O. Shelest, Nataliia K. Sukhonos  
ASSOCIATION OF CASPASE-8 LEVELS WITH RESPIRATORY PARAMETERS AND PRESENCE OF HYPERTENSION IN COPD PATIENTS 1265
- Lyudmila A. Ustinova, Borys I. Palamar, Yevhen V. Havrylko, Vitaliy L. Bohaienko, Natalia V. Kurdil  
ASSESSMENT OF THE CONSEQUENCES OF THE DETERIORATION OF THE EPIDEMIOLOGICAL SITUATION DURING HOSTILITIES 1272
- Tetiana V. Vasheka, Oksana M. Lych, Borys I. Palamar, Svitlana P. Palamar, Victoria V. Zhelanova, Tetiana Yu. Safir, Natalia V. Kurdil  
PSYCHOLOGICAL FACTORS OF STUDENTS' VITALITY DURING THE WAR IN UKRAINE 1279

# THE MANAGEMENT OF THE VICTIMS WITH GUNSHOT WOUNDS OF THE EXTREMITIES WITH EXTENSIVE DEFECTS OF THE SOFT TISSUES AT THE LEVEL OF QUALIFIED MEDICAL CARE. CASE-SERIES

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**Olena V. Ponomarenko<sup>1</sup>, Victor V. Pysanko<sup>2</sup>, Dmytro S. Mialkovskiy<sup>2</sup>, Dmytro V. Tkachuk<sup>2</sup>**<sup>1</sup>ZAPORIZHZHIA STATE MEDICAL AND PHARMACEUTICAL UNIVERSITY, ZAPORIZHZHIA, UKRAINE<sup>2</sup>ZAPORIZHZHIA MILITARY HOSPITAL, ZAPORIZHZHIA, UKRAINE

## ABSTRACT

**The aim:** To highlight the original experience of diagnosis and treatment of patients with gunshot wounds of the extremities with extensive defects of the soft tissues.

**Materials and methods:** The total number of treated patients with massive gunshot wounds from February 2022 to March 2023 was 60 males. Basic laboratory tests, X-rays of the affected limbs were performed to all patients. USS of the vessels with color Doppler was performed to those casualties who had no peripheral pulses on the wounded extremity. All injured persons underwent wound debridement and fasciotomy on the day of admission, 8 more casualties underwent surgical interventions on the major vessels and nerves.

**Results:** Good treatment outcomes for patients with extensive soft tissue injury were achieved by early surgical intervention to remove non-viable tissue. Limb preservation was achieved in 98.3% of cases.

**Conclusions:** The study's conclusion emphasizes the importance of a multidisciplinary approach to treating patients with gunshot wounds to the limbs with extensive soft tissue injury. Early surgical interventions with the removal of non-viable tissues are necessary for good outcomes. Revascularization of the affected limb is essential in case of major vessel injury if there is no threat to the life.

**KEY WORDS:** gunshot wounds of the extremities, extensive soft tissue defects, injury to the neurovascular bundle, limb salvage surgery, vacuum-assisted wound therapy

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## INTRODUCTION

Gunshot wounds to the lower extremities are the most common among all gunshot wounds in the war time and account for 70-75% according to various authors [1-3]. The frequency of lower limb injuries is twice as common as upper limb injuries. As extremity injuries are evaluated, each of the four functional components (nerves, vessels, bones, and soft tissues) must be considered individually and together [4]. To achieve the best treatment outcomes, a multidisciplinary approach involving vascular surgeons, orthopedics, plastic surgeons, and rehabilitation specialists is necessary. In modern medicine, limb salvage is preferred in cases of severe gunshot injuries [3]. While maximum efforts are directed towards avoiding amputation in cases of extensive upper limb injuries, severe lower limb injuries can pose a threat to life and dictate the necessity of amputation under such circumstances [1,2]. Measures

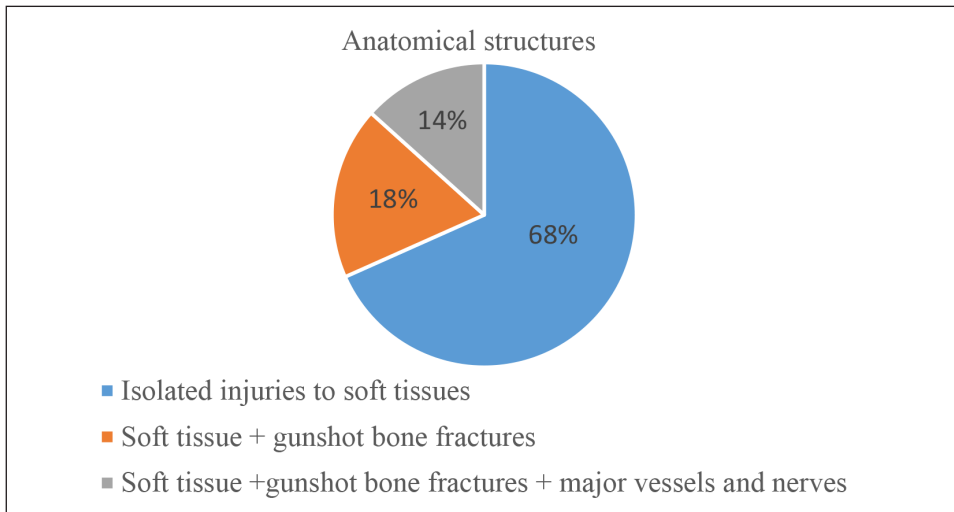
for early return of limb function after reconstruction are necessary but may not always be implemented.

## THE AIM

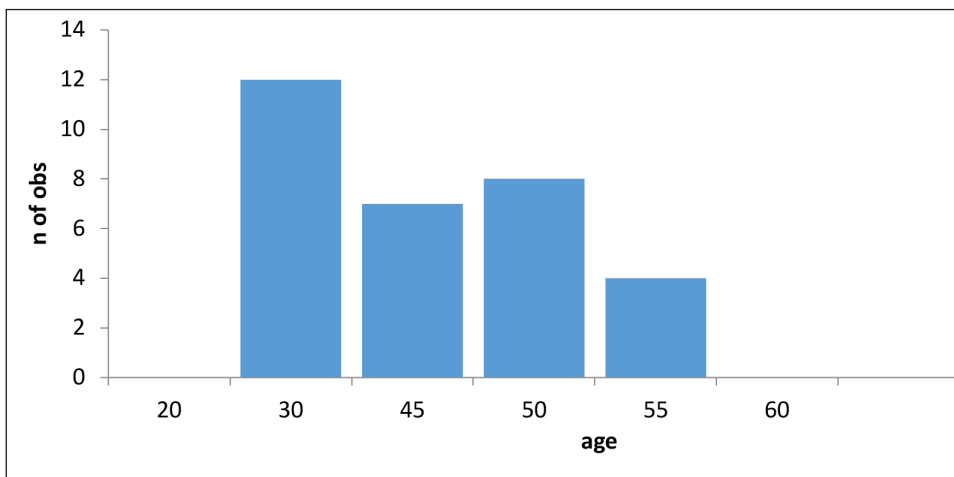
To improve the diagnostics and treatment of the casualties with gunshots of the extremities with extensive soft tissue injury.

## MATERIALS AND METHODS

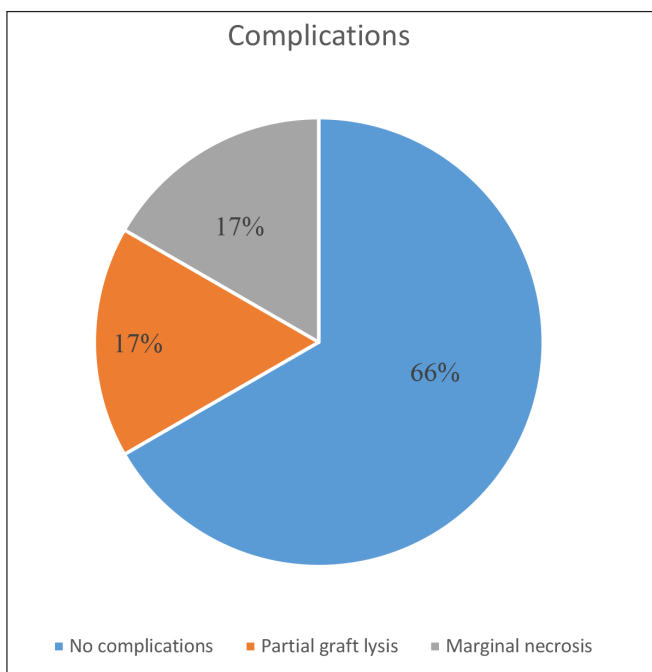
From February the 24<sup>th</sup>, 2022 to March the 23<sup>d</sup>, 2023, the case-series 60 wounded male patients with gunshots of the lower extremities and extensive defects of the soft tissues were treated in the surgical department of the Zaporizhzhia Military Hospital. All sixty patients were men aged 21 to 63 years, with a mean age (mean (M) ± standard deviation [SD]) of 36,2±9,7 years.



**Fig. 1.** Distribution of the wounded by injuries of different anatomical structures of the limb.



**Fig. 2.** Histogram of the distribution of patients by age.



**Fig. 3.** The outcomes of the soft tissue defects closure.

The general condition was considered severe in 19 wounded patients, while the rest of the 41 were of

moderate to severe condition. All the patients received initial medical aid on the battlefield, then at stabilization points, and later medical assistance in advanced surgical groups (medical-surgical teams, advanced surgical groups). Combined and associated injuries were accounted in 19 (32%) of the wounded militaries, while isolated limb injuries occurred in the rest of the 41. All patients gave consent for the processing of personal data. The types of associated injuries are presented in Table I.

Isolated defects of the soft tissues were present in 41 (68%) of cases, 11 (18%) were diagnosed with gunshot bones fractures, and in 8 (14%), there were gunshot fractures of large tubular bones with damage to major vessels and nerves (Figure 1).

Seventeen (28,3%) patients had comorbidities (Table II).

Upon arrival of the casualties and the triage, an assessment of their general condition and injuries was carried out. Urgent measures were taken according to the MARCH protocol. After physical examination and blood tests, the casualties underwent an X-ray examination of the affected limbs. Other additional diagnostic methods (FAST protocol, CT of the head, neck, chest,

**Table I.** Associated injuries in patients with gunshot wounds of the extremities with extensive soft tissue injuries

Associated injuries	Number of patients
Head injury	5
Acoustic trauma	6
Hemopneumothorax	2
Eardrum rupture	2
Injury to the ligaments of the limbs	2
Total	15

**Table II.** Comorbidities in the patients with extensive soft tissue injury

Comorbidities	Number of patients
High blood pressure	6
Coronary artery disease	4
Chronic obstructive pulmonary disease	3
Blood diseases	1
Peptic ulcer	1
Benign prostatic hyperplasia	1
Others	1
Total	17

**Table III.** Surgical procedures performed on the patients

Type of surgery	Number of patients
Wound debridement	42
Wound debridement + NPWP	5
Wound debridement + External fixation of the fractures	6
Wound debridement + intervention to major vessels + External fixation of the fractures	6
Amputation	1
Total	60

abdomen, pelvis, and ultrasound examination with color doppler) were performed as indicated. Special attention was paid to ultrasound examination with color doppler using the VSCAN AIR device, which was performed on 48 patients. Arterial and venous blood flow in the distal parts of the limbs upon admission of the casualties were assessed. Before the closure of soft tissue defects with skin-muscle flaps, a thorough US examination of the vascular pedicles with marking was performed.

Patients with severe general conditions were stabilized in the intensive care room. All casualties underwent surgical interventions on the day of admission after performing basic diagnostic tests and stabilizing severe conditions. The types of surgical interventions are presented in Table III.

The decision regarding salvage VS amputation of the injured limb with major vessels injury was made

using Mangled Extremity Severity Score (MESS). Primary revascularization using autologous venous graft was performed in all eight cases of injuries to major vessels, with no use of temporary shunts. An external fixation device was applied to 12 (20%) of patients with gunshot fractures of long bones. Early closure of soft tissue defects was performed in 6 (10%) of patients, using split-thickness skin grafting in 4 cases, keystone flap reconstruction in 1 case, and a rotated flap on a vascular pedicle in 1 case.

Negative pressure wound therapy (NPWT) was performed in 5 (8.3%) of the patients at this level. After the completion of the surgeries, 31 (52%) of the injured militaries were sent to the next level of care within 24-72 hours. The average length of stay for the remaining 29 patients was 8 days. Further observation was carried out through telephone interviews with the patients and retrospective analysis of medical records.

Statistical data analysis was conducted in the program Statistica 13. The data were checked for normality of distribution according to the Shapiro-Wilk criterion. Quantitative variables were presented as  $M \pm SD$ , qualitative ones – as percentages. The statistical significance of the differences between the groups was established by the Student's criterion. The level of statistical significance was  $p < 0.05$ .

## RESULTS

All sixty patients were men aged 21 to 63 years, with a mean age (mean (M)  $\pm$  standard deviation [SD]) of  $36,2 \pm 9,7$  years (Figure 2).

The figure 2 shows that the distribution has a positive asymmetry, that is, a shift towards older age, but the deviation from the normal distribution law has not acquired statistical significance ( $p > 0.05$  according to the Shapiro-Wilk criterion).

It should be noted that patients with comorbidities were statistically significantly older in age, their average age was  $46,5 \pm 6,3$  years ( $p = 0.0001$  compared with the entire group of patients ( $36,2 \pm 9,7$ )). The average age of those who did not have comorbidities was  $32,1 \pm 7,6$ .

After initial evaluation 34 patients had absent pulse on the dorsalis pedis and posterior tibial arteries, therefore injury to the major vessels was suspected. US doppler revealed the absence of the central blood flow (only collateral flow was present) in 8 patients. Injury to major vessels was confirmed intraoperatively in 7 of those, therefore the sensitivity of the USS was 87,5%. One patient whose USS of the vessels was normal was diagnosed intraoperatively with the side injury of the superficial femoral artery; thus, false negative result of the method was 12,5%.

Surgical debridement, fasciotomy, and external fixation of the fractured bones were uneventful in all patients. 4 (66%) patients who underwent primary wound closure had no graft complications. The grafts were viable and the wounds healed by primary tension. One patient with split-thickness skin graft developed partial lysis of the graft. One patient developed marginal necrosis of the flap on the vascular pedicle. Both underwent secondary grafting with good outcomes. Outcomes of soft tissue defects closure in Figure 3.

Surgical revascularization was successful in 7(87,5%) cases. One patient developed thrombosis of the popliteal artery distal to the anastomosis developed, which required reoperation, vascular exploration and thrombectomy. Below knee amputation was performed in one case due to massive soft tissue loss. All 5 patients who received NPWT tolerated the procedure well and continued at the next level. There were no mortality cases during the treatment period in our facility.

## DISCUSSION

Fast diagnostics of the injuries in wounded militaries with gunshots to the extremities is essential in achieving the best outcomes, limb salvage and good functionality. A plain X-ray of the injured limb and basic laboratory tests is enough for diagnosis unless an injury to the neuro-muscular bundle or associated injury is suspected. In our study ultrasound scan with colored doppler was performed in case of absent pulses on the dorsalis pedis/posterior tibial artery in 34 patients. The sensitivity of the method was high (87,5%). The false negative result was in one case, therefore USS with color doppler is highly useful in case of a gunshot wound of the extremities with extensive soft tissue injury if an injury to the major vessels is suspected. Speed, noninvasiveness, and accessibility of the USS make the diagnosis quick and lead to improvement of the limb salvage.

The urgent surgical removal of non-viable tissue is a necessary condition for achieving best treatment outcomes in patients with extensive soft tissue injury [13]. In our study, all patients underwent surgery on the day of hospitalization, including critically ill patients after stabilization of their general condition. Application of external fixation device (EFD) in case of associated fracture of the long bones is necessary not only for restoring bone integrity but also for preventing soft tissue injury to the affected limb [4,5], creating more favorable conditions for faster wound healing, regardless of whether plastic closure of defects was performed or not. We performed wound debridement and fasciotomy to all patients on the day of admission including those in severe condition after the stabilization in intensive care room. In our study, external fixation device was applied to all twelve patients with gunshot fractures, allowing us to focus on

treating soft tissue defects during the postoperative period. Revascularization of the limb in case of damage to major arteries is a priority if limb salvage surgery is feasible (less than 7 points according to the MESS scale) [7]. In our study, temporary vascular shunts were not used as the patient's stable general condition, absence of mass casualty situation, available equipment, and qualifications of vascular surgeons allowed for primary revascularization, which is a necessary condition according to most authors [8,9]. Amputation of the lower limb was performed in one case. The indication was extensive soft tissue loss and a negative prognosis for the functional state of the limb. We agree with the majority of authors' opinion [10, 14, 15] that prosthetic replacement of the lower limb provides better functional outcomes than limb salvage surgery when there is extensive muscle loss and significant nerve injury. Early closure of the soft tissue defects has reduced the time for wound healing and expedited the return to military duty despite of minor complications (33% of cases) like split-thickness graft lysis and partial necrosis of the rotated flap on the vascular pedicle. NPWT is a highly effective method of treating extensive soft tissue defects in the absence of contraindications [11,12]. In our study, NPWT was performed in five patients, and the vacuum dressing was applied on the second day after surgery - we believe that the immediate use of a vacuum dressing after surgery is not safe due to the increased risk of bleeding from the "fresh" wound. In cases of extensive extremities soft tissue injury due to gunshots the efforts are made to avoid amputation. Good outcomes were achieved in 93% of cases as a result of chosen diagnostic plan and surgical strategy in gunshot wounds of the extremities with extensive soft tissue injury. Most of the patients were evacuated in stable condition, and vacuum dressings were used on further levels of care.

## CONCLUSIONS

1. Management of patients with gunshot wounds to extremities and extensive defects of soft tissues is a challenging problem that requires a multidisciplinary approach. Basic diagnostic methods are sufficient for making a treatment plan. USS with colored doppler is sensitive (87,5%) in diagnostics of injury to major vessels; false negative results are rare (12,5%).
2. Extensive soft tissue injury and gunshot bone fractures made the use of external fixation devices, NPWT, and early wound closure with a flap necessary to speed up the recovery time and the time to return to military duty.
3. Good outcomes were achieved in 93% of cases as a result of chosen diagnostic plan and surgical strategy in gunshot wounds of the extremities with extensive soft tissue injury at the level of qualified medical care.



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*The ethical approval was obtained from Bioethics Committee of the Zaporizhzhia State Medical and Pharmaceutical University. The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008, as well as the national law. Informed consent was obtained from all the patients included in the study.*

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**ORCID and contributionship:**

*Olena V. Ponomarenko: 0000-0001-9220-2942<sup>A,F</sup>*

*Victor V. Pysanko: 0009-0008-0020-9230<sup>A</sup>*

*Dmytro S. Mialkovskiy: 0000-0001-5565-0850<sup>C,E</sup>*

*Dmytro V. Tkachuk: 0009-0007-2634-4193<sup>B,D</sup>*

**Conflict of interest:**

*The Authors declare no conflict of interest.*

## **CORRESPONDING AUTHOR**

**Dmytro V. Tkachuk**

Zaporizhzhia State Medical and Pharmaceutical University

2 Poshtova st, 69000 Zaporizhzhia, Ukraine

tel: +380634397567

e-mail: dimca96.ua@gmail.com

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