Український журнал клінічної хірургії
The Ukrainian Journal of Clinical Surgery

Ukrainian Journal of Clinical Surgery. 2026. May/June; 93(3):58-66
DOI: 10.26779/2786-832X.2026.3.58

# The Efficacy and Safety of Regional Anesthesia in Patients with Combat–Related Limb Injuries During Treatment in Frontline Hospitals and Interhospital Transport

**D. O. Tymchyshyn[1,2], O. O. Budnyuk[1]**

[1]Odessa National Medical University,
[2]Military Medical Clinical Center of the Southern Region, Odessa

## Abstract

**Objective.** A comparative analysis of the efficacy and safety of various types of analgesia for patients with combat–related limb injuries during treatment in frontline hospitals and interhospital transport.

**Materials and Methods.** The study included 100 patients with combat–related limb injuries. Treatment without regional anesthesia was performed on 50 patients (Group 1), and treatment with regional anesthesia was performed on another 50 patients (Group 2). Regional blocks were performed using ultrasound guidance. Pain levels (10–point visual analog scale), mean arterial pressure, and heart rate were recorded at four time points: 1st–upon arrival of the patient at the frontline hospital; 2nd – upon completion of the surgical procedure; 3rd – at the start of interhospital transport; 4th – upon completion of interhospital transport.

**Results.** At stage 1**,** no statistically significant differences were found between groups 1 and 2 in terms of pain scores on the visual analog scale, mean arterial pressure, or heart rate ($p > 0.05$, respectively). In stages 2 and 3, groups 1 and 2 differed statistically significantly in terms of VAS scores, mean arterial pressure, and heart rate ($p < 0.05$, respectively); a consistently low level of pain and stable hemodynamic parameters were observed in the second group. Between stages 3 and 4, an increase in pain levels was observed in group 1, resulting in the development of hypertension and tachycardia; in group 2, pain levels remained consistently low and hemodynamic parameters were stable. At stage 4, a statistically significant difference was observed between the 1st and 2nd groups in terms of visual analog scale scores, mean arterial pressure, and heart rate ($p < 0.05$, respectively).

**Conclusions.** The use of regional analgesic blocks in multimodal pain management regimens for patients with combat–related limb injuries significantly reduces the intensity of pain during treatment in frontline hospitals and during interhospital transport.

**Keywords:** combat surgical trauma, regional analgesia, pain.

Providing care for combat injuries among the military contingent and civilian population of Ukraine is currently of utmost importance [1]. Based on the experience of military conflicts in the 20th and 21st centuries, the proportion of wounded with limb injuries ranged from 50–75% [2]. Therefore, the issue of treating wounded with combat limb injuries occupies a central place in military medicine.

Due to the ongoing hostilities in Ukraine, anesthesiologists face many challenges regarding the provision of medical care to patients with combat–related injuries [3]. It is particularly challenging for the anesthesiology service to organize high–quality pain management for the wounded in frontline hospitals–which are Level II medical care facilities for the wounded, or Role 2–as well as during subsequent medical evacuation between medical care facilities. After all, pain management and monitoring the effectiveness of analgesia during wartime are an integral part of treating and caring for the wounded [4].

It is well known that regional analgesia, as part of multimodal pain management, significantly improves long–term treatment outcomes and enhances the patient's quality of life [5]. Over the past 15 years, the field of regional anesthesia has advanced significantly [6]. Many scientific studies indicate that regional analgesic blocks should be implemented as the modern standard for perioperative pain management [7]. Prompt regional anesthesia for patients with combat–related injuries provides sustained analgesia without impairment of consciousness or significant fluctuations in vital signs [8]. The effectiveness of regional analgesic techniques during the medical evacuation of 84 wounded patients who underwent limb amputation was analyzed. In patients who received regional analgesic blocks, the use of narcotic analgesics was significantly reduced [9]. However, the vast majority of studies on the performance of regional analgesic blocks in frontline hospitals are descriptive in nature, focusing on individual cases; in particular, D. M. Scott [10] reported on the advantages of regional analgesia using the example of pain management in 3 patients with combat–related limb injuries.

Study objective: a comparative analysis of the efficacy and safety of various types of analgesia for patients with combat–related limb injuries during treatment in frontline hospitals and during interhospital transport.

## Materials and Methods

This is a prospective randomized study conducted as part of the research project "Improvement of Anesthesiological Support and Intensive Care Methods in Surgical Interventions and Critical Conditions" (No. 0124U002183) by the Department of Anesthesiology, Intensive Care, and Emergency Medicine at Odessa National Medical University, complies with the requirements of the World Medical Association's Declaration of Helsinki on the ethical principles of conducting medical research involving human subjects, and was approved by the Bioethics Committee of Odessa National Medical University (Minutes No. 18 dated December 6, 2023).

The study included 100 wounded individuals with isolated combat injuries to the upper or lower extremities (upper extremity–no higher than the upper third of the shoulder; lower extremity–no higher than the knee joint), who received emergency surgical and anesthesiological care in frontline hospitals (the city of Kherson and – 2025 in frontline hospitals (the city of Kherson and the the city of Snigurivka in the Mykolaiv region), as well as during medical evacuation to medical facilities of the next levels of care (the cities of Mykolaiv and Odesa). Patients were randomly assigned to two groups using the sealed–envelope method according to the selected anesthesia and postoperative analgesia protocols. Group 1 included 50 patients with combat–related limb injuries who did not receive regional anesthesia for anesthesia and postoperative analgesia. Surgical procedures were performed using the following types of anesthetic management: general intravenous anesthesia with tracheal intubation, neuromuscular blockade, and mechanical ventilation, or general intravenous anesthesia with spontaneous breathing. Depending on the location of the gunshot wound to the limb, patients in Group 1 were divided into two subgroups: Subgroup 1.1 (n = 25) included patients with combat–related upper limb injuries, and Subgroup 1.2 (n = 25) included patients with combat–related lower limb injuries. Group 2 included 50 patients with combat–related limb injuries who received regional anesthesia for anesthetic management and postoperative analgesia. Surgical procedures were performed using combined anesthesia (intravenous anesthesia + regional analgesic blocks). Depending on the location of the gunshot wound to the limb, patients in the second group were divided into two subgroups: subgroup 2.1 (n = 25) included patients with combat–related upper limb injuries, and subgroup 2.2 (n = 25) included patients with combat–related lower limb injuries. A VF13–5 linear probe (4.1–12.1 MHz) of the "SIEMENS ACUSON P500" ultrasound scanner (Germany) was used to visualize nerve structures. For patients in subgroup 2.1, ultrasound–guided brachial plexus blocks were performed via the supraclavicular approach; the dose of local anesthetic administered to the brachial plexus was 100 mg of bupivacaine perineurally (0.5% solution in a volume of 20 mL). Patients in subgroup 2.2 underwent the following procedures using ultrasound guidance: sciatic nerve block via a popliteal approach and femoral nerve block; the dose of local anesthetic for the sciatic nerve was 100 mg of bupivacaine administered perineurally (0.5% solution in a volume of 20 mL), and the dose of local anesthetic for the femoral nerve was 50 mg of bupivacaine administered perineurally (0.5% solution in a volume of 10 mL).

Inclusion criteria for patients in the study: age 18 years or older; informed consent from the patient to participate in the study; a gunshot wound to a single limb (upper limb–no higher than the upper third of the shoulder; lower limb–no higher than the knee joint).

Exclusion criteria for patients: age under 18 years; patient refusal to participate in the study; inability to obtain the patient's informed consent to participate in the study due to a critically ill condition resulting from massive blood loss (Algover–Burri index greater than 1) or lack of productive communication upon arrival (Glasgow Coma Scale score of less than 12 points, as well as a Richmond Agitation–Sedation Scale score of more than +2 and less than –2 points); presence of polyvalent drug allergy or a history of allergic reaction to medications used in the study.

Another criterion for excluding a patient from the study during its conduct was the development of massive bleeding, both intraoperatively and in the postoperative period (including during interhospital transport).

All patients in the study groups were male.

The efficacy and safety indicators of the selected type of anesthesia were recorded in four stages: Stage 1 – upon arrival at the frontline hospital; Stage 2 – upon completion of the surgical procedure performed at the frontline hospital; Stage 3 – at the start of medical evacuation to healthcare facilities at subsequent levels of care; Stage 4 – upon completion of inter–hospital transport.

To study the efficacy and safety of the selected types of analgesia, the following indicators were used: self–assessment of pain level on a 10–point visual analog scale (VAS); changes in physical examination parameters, namely: mean arterial pressure (MAP) and heart rate (HR).

The data were analyzed using Statistica for Windows version 12.6. The normality of the distribution of indicators was tested using the Shapiro–Wilk test. If the distribution of indicators was normal, the results are presented as the arithmetic mean (M) ± standard deviation (σ); the Student's t–test was used to determine the level of significance of the difference between groups. If the null hypothesis of normal distribution was rejected, the results were presented as the median (Me) and the 25th ($Q_{25}$) and 75th ($Q_{75}$) percentiles; the Mann–Whitney U–test was used to determine the signif-

icance level of differences between groups. The Wilcoxon W–test was used to determine the significance level of differences between dependent variables over time. To assess the incidence of events between groups, Pearson's $\chi^2$ test was used. To determine the distribution of observations between two categorical variables, Fisher's exact two–sided φ–test was used. Differences were considered statistically significant if p–values were less than 0.05.

## Results

Patients in the study groups did not differ statistically significantly ($p > 0.05$) in anthropometric parameters and hemoglobin levels (*Table 1*).

The study groups were homogeneous in terms of the distribution of gunshot wound locations on the limb; there was no statistically significant difference ($p > 0.05$) between them for this indicator (*Table 2*).

The following types of surgical interventions were performed on the patients: limb amputation (upper limb–at the shoulder or forearm level; lower limb–at the lower leg level) or amputation of its distal segments (upper limb–amputation of the fingers; lower limb – resection of the forefoot or amputation of the toes); extra–articular compression–distraction osteosynthesis using external fixation devices for gunshot fractures of limb bones; primary surgical debridement and cleaning of gunshot wounds.

The study groups did not differ statistically significantly ($p > 0.05$) in the frequency of performing one or another surgical procedure (*Table 3*).

Table 1. **Characteristics of patients in the study groups based on anthropometric parameters and hemoglobin levels**

| Parameter | Patient group | | p |
|---|---|---|---|
| | Group 1 (n = 50) | 2nd (n = 50) | |
| Age (years), M ± σ | 38.5 ± 9.4 | 37.2 ± 9.3 | 0.49* |
| Height (cm), M ± σ | 177.2 ± 7.3 | 177.6 ± 6.1 | 0.77* |
| Body weight (kg), Me ($Q_{25}$ ; $Q_{75}$ ) | 71 (65; 85) | 77 (70; 86) | 0.24** |
| BMI ($^{kg/m^2}$), Me ($Q_{25}$; $Q_{75}$) | 23.1 (21.5; 26.6) | 24.1 (22.1; 27.0) | 0.36** |
| Hemoglobin (g/L), Me ($_{Q25}$; $_{Q75}$) | 129.5 (119; 137) | 133 (122; 141) | 0.22 |
| *Note.* To determine the statistical significance of differences between groups, the following were used: * – Student's t-test; ** – Mann–Whitney U-test; BMI – body mass index. | | | |

Table 2. **Distribution of patients in the study groups by location of the gunshot wound to the limb**

| Location of the gunshot wound to the limb | Patient group | | | | p |
|---|---|---|---|---|---|
| | Group 1 (n = 50) | | 2nd (n = 50) | | |
| | abs. | % | abs. | % | |
| Shoulder | 9 | 18 | 8 | 16 | 1.0 |
| Forearm | 13 | 26 | 13 | 26 | 1.0 |
| Brush | 3 | 6 | 4 | 8 | 1.0 |
| Shin | 12 | 24 | 10 | 20 | 0.81 |
| Foot | 13 | 26 | 15 | 30 | 0.82 |
| *Note.* To determine the distribution of observations between two categorical variables, Fisher's exact two-sided ϕ-test was used. | | | | | |

Table 3. **Distribution of patients in the study groups by type of surgical procedure performed**

| Type of surgical procedure | Patient group | | | | p |
|---|---|---|---|---|---|
| | Group 1 (n=50) | | 2nd (n=50) | | |
| | abs. | % | abs. | % | |
| Limb amputation | 11 | 22 | 9 | 18 | 0.62 |
| Extra-articular compression-distraction osteosynthesis using external fixation devices | 12 | 24 | 13 | 26 | 0.82 |
| Initial surgical treatment, wound debridement | 27 | 54 | 28 | 56 | 0.84 |
| *Note.* Pearson's $\chi^2$ test was used to assess the incidence of events between groups. | | | | | |

Table 4. **Pain intensity scores in patients of the study groups**

| Indicator | Patient group | | p |
|---|---|---|---|
| | Group 1 (n=50) | 2nd (n=50) | |
| YOUR (points), Me ($Q_{25}$; $Q_{75}$) | | | |
| Stage 1 | 7 (6; 8) | 7 (6; 7) | 0.57 |
| Stage 2 | 3 (3; 4) | 1 (1; 2) | < 0.05 |
| Stage 3 | 3 (2; 3) | 1 (1; 2) | < 0.05 |
| Stage 4 | 5 (4; 6) | 1 (1; 2) | < 0.05 |
| *Note.* The Mann–Whitney U test was used to determine the statistical significance of differences between groups. The same applies to Table 6. | | | |

Table 5. **Changes in pain intensity over time in patients of the study groups**

| Patient group | VAS (points), Me ($Q_{25}$ ; $Q_{75}$ ) | | | | p |
|---|---|---|---|---|---|
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 | |
| 1st (n = 50) | 7 (6; 8) | 3 (3; 4) | 3 (2; 3) | 5 (4; 6) | $p_{1-2} < 0.05$<br>$p_{2-3} < 0.05$<br>$p_{3-4} < 0.05$ |
| 2nd (n=50) | 7 (6; 7) | 1 (1; 2) | 1 (1; 2) | 1 (1; 2) | $p_{1-2} < 0.05$<br>$p_{2-3} = 0.11$<br>$p_{3-4} = 0.07$ |
| *Note.* The Wilcoxon W-test was used to determine the level of statistical significance of differences between indicator values over time; the level of statistical significance between VAS pain scores at stages 1 and 2 is $p_{1-2}$; at stages 2 and 3, it is $p_{2-3}$; between stages 3 and 4—$p_{3-4}$. | | | | | |

A comparative analysis of the intensity of pain syndrome in patients of the study groups was performed (*Table 4*).

Upon arrival at the frontline hospital, 64 patients rated their pain intensity on the VAS scale as 7 to 9 points, corresponding to severe pain, while 36 patients rated it as 4 to 6 points, corresponding to moderate pain. No statistically significant difference was found between VAS pain scores at stage 1 in patients in group 1–7 (6; 8) points–and group 2–7 (6; 7) points (p = 0.57).

Upon the patients' awakening following surgery performed at a frontline hospital, a decrease in the intensity of the pain syndrome was observed over time compared to the corresponding indicators from the first stage of the study. None of the surveyed patients rated the intensity of the pain syndrome on the VAS as 7 to 9 points. In the first group, 23 patients rated pain intensity on the VAS from 4 to 6 points; 27 patients rated it from 1 to 3 points (moderate pain or no pain). In contrast, in the second group, only 1 patient rated pain intensity on the VAS from 4 to 6 points, while 49 patients rated it from 1 to 3 points. A statistically significant (p < 0.05) difference was found between the VAS pain scores at the second stage in patients of the first and second groups–3 (3; 4) points and 1 (1; 2) points, respectively.

At the time of medical evacuation to healthcare facilities providing the next level of medical care, none of the surveyed patients reported pain intensity on the VAS scale ranging from 7 to 9 points. In Group 1, 11 patients rated their pain intensity on the VAS from 4 to 6 points; 39 patients rated it from 1 to 3 points. In Group 2, only 3 patients rated pain intensity on the VAS from 4 to 6 points, and 47 patients rated it from 1 to 3 points. A statistically significant difference (p < 0.05) was found between the VAS pain scores at the third stage in patients of the first and second groups–3 (2; 3) points and 1 (1; 2) points, respectively.

At the end of interhospital transport, patients in the study groups exhibited varying trends in the intensity of their pain syndrome. In Group 1, 5 patients rated their pain intensity on the VAS from 7 to 9 points; 39 patients rated it from

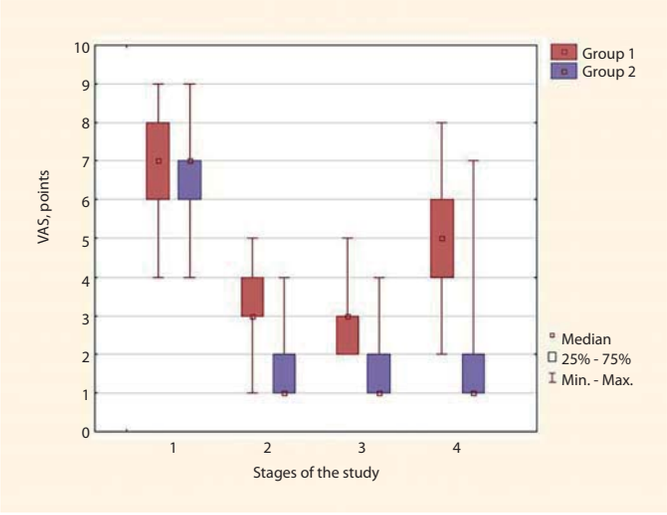


Fig. 1.
Changes in pain intensity levels over time among the injured subjects in the study groups.

Table 6. **Hemodynamic parameters of patients in the study groups**

| Parameter | Study stages | Patient group | | p |
|---|---|---|---|---|
| | | 1st (n=50) | 2nd (n=50) | |
| Mean BP (mmHg), Me ($Q_{25}$ ; $Q_{75}$ ) | 1 | 103 (94; 116) | 104.5 (96; 114) | 0.53 |
| | 2 | 86 (81; 97) | 85 (79; 92) | 0.12 |
| | 3 | 87.5 (83; 95) | 83.5 (80; 89) | < 0.05 |
| | 4 | 98.5 (91; 104) | 83.5 (81; 87) | < 0.05 |
| HR (per min), Me ($Q_{25}$ ; $Q_{75}$ ) | 1 | 108 (96; 114) | 108 (96; 114) | 0.81 |
| | 2 | 84 (72; 90) | 72 (66; 78) | < 0.05 |
| | 3 | 78 (78; 84) | 72 (72; 78) | < 0.05 |
| | 4 | 96 (84; 102) | 72 (66; 78) | < 0.05 |

4 to 6 points; and 6 patients rated it from 1 to 3 points. In Group 2, 2 patients rated their pain intensity on the VAS as 7–9 points; 5 patients rated it as 4–6 points; and 43 patients rated it as 1–3 points. A statistically significant difference ($p < 0.05$) was found between the VAS pain scores at stage 4 in patients of the first and second groups–5 (4; 6) points and 1 (1; 2) points, respectively.

A comparative analysis was conducted of the intensity of pain over time in patients in the study groups (*Table 5 and Figure 1*).

An analysis of the dynamics of pain intensity between the first and second stages of the study revealed a decrease in both Group 1 and Group 2 patients, with a statistically significant difference ($p < 0.05$) between the VAS scores at the 1st and 2nd stages. Analysis of the dynamics of pain intensity between the 2nd and 3rd stages of the study in patients in Group 1 revealed a decrease, with a statistically significant ($p < 0.05$) difference between VAS scores at the 2nd and 3rd stages. In contrast, patients in Group 2 had a consistently low level of pain intensity with no statistically significant difference ($p = 0.11$) between VAS scores at the 2nd and 3rd stages. Analysis of the dynamics of pain intensity between the 3rd and 4th stages of the study in patients in Group 1 revealed an increase with a statistically significant difference ($p < 0.05$) between VAS scores at the 3rd and 4th stages, whereas in patients in Group 2, no statistically significant ($p = 0.07$) differences were observed between VAS scores at stages 3 and 4.

A comparative analysis of hemodynamic parameters in patients from the study groups was conducted (*Table 6*).

A comparative analysis of the dynamic changes in mean blood pressure (*Fig. 2*) and heart rate (*Fig. 3*) was performed in the injured patients of the study groups.

At the first stage of the study, mean BP values exceeding 110 mmHg were observed in 24 patients in Group 1 and in 17 patients in Group 2; HR values exceeding 100 beats per minute were observed in 34 and 35 patients, respectively. No statistically significant difference was found between the mean BP ($p = 0.53$) and HR ($p = 0.81$) values in patients of the first and second groups.

In the second phase of the study, there was a decrease in mean blood pressure in both patients in Group 1–from 103 (94; 116) mm Hg (in the first phase) to 86 (81; 97) mm Hg–and in patients in Group 2–from 104.5 (96; 114) mmHg (in the first stage) to 85 (79; 92) mmHg, with a statistically significant difference ($p < 0.05$) between the values of this parameter in the first and second stages (Wilcoxon's W–test was used). A decrease in heart rate was also observed in patients in Group 1 from 108 (96; 114) beats per minute (at Stage 1) to 84 (72; 90) beats per minute, and in patients in Group 2 from 108 (96; 114) per minute in the first stage to 72 (66; 78) per minute, with a statistically significant difference ($p < 0.05$) between the values of this parameter in the first and second stages (Wilcoxon's W–test was used). In patients in Groups 1 and 2, no statistically significant difference ($p = 0.12$) was found between the mean BP values at the second stage; however, a statistically significant difference ($p < 0.05$) was found between HR values at stage 2 (Mann–Whitney U test was used).

In the third stage of the study, the mean blood pressure in patients in Group 1 increased from 86 (81; 97) mm Hg (in the second stage) to 87.5 (83; 95) mmHg, with no statistically significant difference ($p = 0.34$) between the mean BP values in the second and third stages (Wilcoxon's W–test was used). At the same time, patients in the second group showed a decrease in mean BP from 85 (79; 92) mm Hg (at stage 2) to 83.5 (80; 89) mmHg, with no statistically significant difference ($p = 0.14$) between the mean BP values at stages 2 and 3 (Wilcoxon's W–test was used). Also, in the 3rd stage, the mean BP values ( ) in patients of the 1st group were statistically significantly ($p < 0.05$) higher than in patients of the 2nd group (Mann–Whitney U–test used). A decrease in HR values was observed in patients in Group 1 from 84 (72; 90) per minute (at the 2nd stage) to 78 (78;

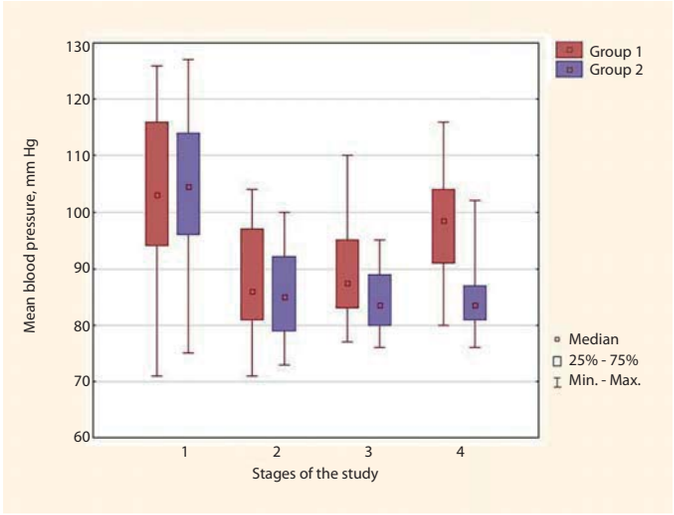


Fig. 2.
Changes in mean blood pressure in the injured study groups.

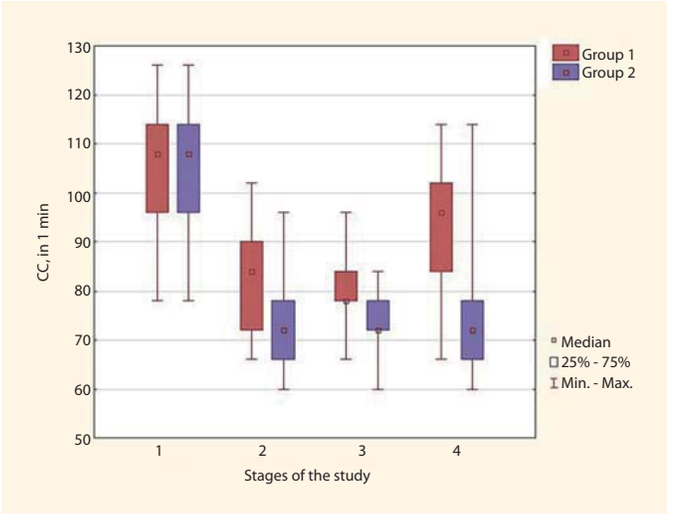


Fig. 3.
Changes in heart rate over time in the injured study groups.

84) per minute, however, without a statistically significant difference ($p = 0.11$) between HR values at the 2nd and 3rd stages (Wilcoxon's W–test was used). At the same time, patients in Group 2 had stable HR values: 72 (66; 78) per minute in the second stage and 72 (72; 78) per minute in the third stage, with no statistically significant difference ($p = 0.26$) between them (Wilcoxon's W–test was used). Additionally, in patients in Group 1 during the third stage, HR values were higher than in patients in Group 2, with a statistically significant difference ($p < 0.05$) between them (Mann–Whitney U test used).

In the fourth stage of the study, an increase in mean blood pressure was observed in patients in Group 1, from 87.5 (83; 95) mm Hg (in the third stage) to 98.5 (91; 104) mm Hg, with a statistically significant difference ($p < 0.05$) between these values (Wilcoxon's W–test was used). At the same time, patients in Group 2 had stable mean BP values: 83.5 (80; 89) mmHg at stage 3 and 83.5 (81; 87) mmHg at stage 4, with no statistically significant difference ($p = 0.33$) between these values (Wilcoxon's W–test was used). A statistically significant difference ($p < 0.05$) was found between the mean BP values at stage 4 in patients in groups 1 and 2 (Mann–Whitney U–test used). In patients in group 1, HR values increased from 78 (78; 84) per minute (at stage 3) to 96 (84; 102) per minute, with a statistically significant difference ($p < 0.05$) between them (Wilcoxon's W–test was used). At the same time, patients in Group 2 showed stable HR values: 72 (72; 78) beats per minute in the 3rd stage and 72 (66; 78) per minute in the 4th stage, with no statistically significant difference ($p = 0.78$) between these values (Wilcoxon's W–test was used). A statistically significant difference ($p < 0.05$) was found between HR values in the 4th stage in patients in the 1st and 2nd groups (Mann–Whitney U–test used).

## Discussion

The changes in pain intensity levels among the injured patients in the study groups between the first and second phases of the study demonstrated the effectiveness of their pain management during the perioperative period. However, the pain intensity levels in patients in Group 1 were statistically significantly higher than those in patients in Group 2. This indicates greater effectiveness of the selected type of anesthetic management for surgical procedures specifically in patients of the second group (regional analgesic blocks as part of combined anesthesia) compared to the selected type of anesthetic management in patients of the first group. The dynamics of pain intensity in the wounded study groups between the 2nd and 3rd stages of the study demonstrated the high efficacy of the prescribed postoperative analgesia regimens based on the principles of multimodal analgesia. Another factor contributing to the improvement in patients' condition was the change from the dangerous conditions of intense combat operations to the relative calm of a medical facility. However, the statistically significant difference observed between VAS scores at the third stage in patients of the 1st and 2nd groups indicates greater efficacy of postoperative analgesia regimens incorporating regional analgesic blocks compared to postoperative analgesia regimens without regional analgesic blocks. According to the dynamics of pain intensity between the 3rd and 4th stages of the study, pain intensity increased in patients in Group 1 with a statistically significant difference ($p < 0.05$) between VAS pain scores at the 3rd and 4th stages, whereas in patients in Group 2, no statistically significant differences were observed between VAS pain scores at the 3rd and 4th stages ($p = 0.07$). The intensity of pain syndrome in patients in Group 1 was statistically significantly ($p < 0.05$) higher than in patients in Group 2. The vast majority of patients reported an increase

in pain intensity during the movement of the medical transport, especially during maneuvers and driving on roads with damaged pavement. Under conditions of movement, analgesia with systemic medications was significantly less effective than analgesia with the same medications at rest. Even the additional administration of opioids did not significantly improve the level of analgesia in patients during transport. In contrast, the prolonged duration of action of regional analgesic blocks provided higher–quality analgesia in the postoperative period, both at rest and during transport. The results demonstrate a statistically significant greater efficacy of analgesia in patients who underwent regional analgesic blocks compared to the efficacy of analgesia in patients who did not undergo regional analgesic blocks.

Patients who were admitted to the frontline hospital with signs of massive blood loss (as determined by the Algovar–Burri index) were excluded from the study. In this regard, the hemodynamic parameters of patients recorded during the first stage of the study were interpreted as signs of severe pain syndrome and the effects of psychoemotional stress, rather than as a compensatory response of the body to blood loss. Subsequently, massive bleeding in patients–both intraoperatively and in the postoperative period (including during interhospital transport)–which could have affected peripheral hemodynamic parameters, was considered a criterion for excluding patients from the study during its conduct. Consequently, changes in hemodynamic parameters were interpreted as changes in the intensity of pain syndrome, the effects of anesthetic (analgesic) agents on the body, as well as the patient's emotional state and comfort during treatment (including during interhospital transport). Changes in hemodynamic parameters in the injured study groups during the 1st and 2nd stages of the study consisted of a decrease in the median values of mean BP and HR to reference levels (without critical hypotension or bradycardia), which may positively characterize the selected methods of pain management in the perioperative period. However, we believe that the reduction in hemodynamic parameters in patients of the 1st group is possible not only as a result of high–quality analgesia but also as a consequence of higher doses of drugs administered for general anesthesia (compared to the doses administered to patients in the 2nd group), while the improvement in hemodynamic parameters in patients in Group 2 may be due to the influence of more effective analgesia (given that the intensity of pain, as assessed by the VAS, was statistically significantly higher in patients of Group 1 than in patients of Group 2 during the second stage), indicating greater efficacy of the selected type of anesthetic management during surgical procedures in patients of Group 2 (regional analgesic blocks as part of combined anesthesia). Additionally, no hemodynamic disturbances (hypotension, bradycardia, cardiac arrhythmias, etc.) or signs of systemic toxicity from the local anesthetic (tremors, convulsions, altered consciousness, etc.) were observed during the observation period in patients in Group 2. A comparison of the median mean BP values during the second stage in patients of Groups 1 and 2 revealed no statistically significant difference ($p > 0.05$) between them. Thus, blood pressure values did not differ significantly in patients who underwent regional analgesic blocks compared to those who did not undergo regional analgesic blocks. A comparison of the median HR values during the second stage in patients in groups 1 and 2 revealed a statistically significant difference ($p < 0.05$) between them; however, in none of the patients in the second group were HR values in the second stage less than 60 beats per minute, which cannot be considered a manifestation of systemic toxicity from the local anesthetic. Changes in hemodynamic parameters in all wounded patients across the study groups during the second and third stages of the study demonstrated stability in the median values of mean blood pressure and heart rate post–surgery in an inpatient setting, indicating the high efficacy of the prescribed postoperative analgesia regimens. Patients also noted a shift from the dangerous conditions of intense combat operations to the relative calm of a medical facility, which similarly contributed to the stability of hemodynamic parameters. At the start of interhospital transport and at its completion, the median values of mean BP and HR in patients in Group 1 increased with a statistically significant difference ($p < 0.05$) between them at stages 3 and 4, while patients in Group 2 exhibited stable median values of mean BP and HR without a statistically significant difference ($p > 0.05$) between them at stages 3 and 4. A statistically significant difference ($p < 0.05$) was also found between the median values of mean BP and HR at the 4th stage in patients in the 1st and 2nd groups. Given that at the end of interhospital transport, the intensity of pain in patients in Group 1 was also statistically significantly higher than at the start of interhospital transport, we consider the increase in hemodynamic parameters to be a consequence of the intensification of pain. In patients of Group 2, we consider the stability of hemodynamic parameters during interhospital transport to be a consequence of a stable level of pain intensity due to the regional analgesic blocks they received. We also believe that the stability of hemodynamic parameters during interhospital transport may indicate the safety of analgesia for patients with combat–related limb injuries using regional analgesic blocks during medical evacuation from a frontline hospital to medical facilities at subsequent levels of care.

To date, there is a lack of research on the specifics of regional anesthesia for patients with combat injuries in frontline hospitals and during their subsequent transport. These issues have received little attention in the scientific literature. There is a large number of publications on pain man-

agement using regional analgesic blocks in combat–wounded patients in rear medical facilities. As for frontline hospitals, the priority task of military medicine during military conflicts in the 20th century was to ensure high–quality triage of the wounded, and the problem of pain management was not given significant attention [11]. V. M. Moshkovsky and co–authors [12] analyzed data from the medical records of 46 patients with combat injuries to the upper extremities and determined that the proportion of regional analgesia methods was only 8%. It was suggested that the time required to perform infiltration of nerves and plexuses with a local anesthetic solution and the time to onset of anesthesia are sometimes impractical in cases of mass transport of the wounded. There are studies describing the care of patients with limb injuries who were admitted to the emergency departments of civilian hospitals for urgent indications. Researchers from Canada conducted a survey among 1,435 emergency department physicians at medical centers across the country to determine the frequency of regional anesthesia use during the provision of urgent care to victims and injured individuals. The survey results indicated that regional analgesic blocks were routinely used in their practice by only 149 (10.4%) physicians [13]. Yu. L. Kuchin and co–authors [14] analyzed the results of pain management in 280 combat–wounded patients and found that during transport to military field hospitals, pain levels ranged from 6 to 7 on the VAS. This suggests a lack of pain control and low effectiveness of pain management strategies during medical evacuation. According to an analysis of the treatment of 769 combatants following gunshot wounds, the incidence of chronic pain ranged from 63.4% to 78.5% [15].

## Conclusions

1. The study results indicate significantly more effective pain relief in patients who underwent regional analgesic blocks.

2. In patients with combat–related limb injuries who did not receive regional anesthesia, a negative trend in the intensity of pain was observed during interhospital transport.

3. In patients with combat–related limb injuries who received multimodal analgesia (including regional anesthesia as one component), a positive trend in pain intensity was observed both during treatment in frontline hospitals and during interhospital transport.

4. The stability of hemodynamic parameters in patients with combat–related limb injuries during treatment in frontline hospitals and inter–hospital transport indicates the safety of analgesia using regional analgesic blocks.

5. The issue of optimizing pain management for patients with combat–related limb injuries during treatment in frontline hospitals and interhospital transport is of utmost importance.

**Funding.** No external funding was received for this work.

**Authors' contributions.** O. O. Budnyuk—research concept and design; D. O. Tymchyshyn—collection and processing of materials, analysis of the data obtained, and writing of the text.

**Conflict of interest.** The authors declare that they have no conflict of interest.

**Consent to Publication.** Both authors have read and approved the final version of the manuscript and have consented to its publication.

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Received December 5, 2025
Reviewed December 28, 2025
Accepted for publication May 28, 2026
Published online June 19, 2026