

**ULTRASOUND-GUIDED ASSESSMENT OF VOLEMIC STATUS OF ANESTHESIA
IN SURGICAL DEBRIDEMENT OF GUNSHOT WOUNDS**

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The increasing number of mine-blast injuries of the lower extremities resulting from modern military conflicts necessitates improvement of anesthesiologic approaches during repeated surgical wound debridement. One of the controversial issues remains the safety of neuraxial blocks in patients with potentially occult hypovolemia. The study included 46 patients with blast injury of one lower extremity caused by anti-personnel mines. All patients underwent noninvasive ultrasound assessment of volemic status, including evaluation of dynamic changes in inferior vena cava diameter, passive leg raising test, and rapid fluid challenge test. Patients were randomly divided into two groups: Group I received spinal anesthesia, while Group II received regional anesthesia. Hemodynamic parameters were compared during surgery and in the early postoperative period. According to ultrasound assessment, no signs of hypovolemia were detected in patients of either group. During surgery, patients in the spinal anesthesia group demonstrated a statistically significant decrease in arterial pressure and heart rate compared with the regional anesthesia group ($p < 0.05$). However, no critical hemodynamic disturbances were observed. Regional anesthesia was associated with more stable hemodynamic parameters. Noninvasive ultrasound assessment of volemic status is an appropriate method of preoperative evaluation in patients with combat trauma. In the absence of signs of hypovolemia, spinal anesthesia may be used without development of critical hemodynamic disturbances; however, regional anesthesia provides more stable hemodynamic performance.

Key words: gunshot wounds, combat surgical trauma, ultrasound examination, regional anesthesia, pain.

Connection of the publication with planned research work.

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Introduction.

Since the beginning of the full-scale invasion of the territory of Ukraine in 2022, the number of patients with mine-blast injuries has significantly increased among both military personnel and civilians [1]. Russian troops actively employ more than twelve modifications of anti-personnel mines, resulting in mass human casualties and causing extensive mine contamination [2]. According to the United Nations Children's Fund (UNICEF), as a consequence of the prolonged military conflict, Ukraine is currently one of the most mine-contaminated countries in the world [3]. According to U.S. military medical publications, within the chronological spectrum of armed conflicts involving American military personnel, a substantial change in combat injuries has been observed depending on the type of weaponry used. Studies confirm a progressive increase in the proportion of injuries caused by improvised explosive devices and booby traps: whereas during World War II this rate accounted for only 1.9%, during the Vietnam War it increased to 17%, and during the military campaigns in Afghanistan and Iraq it constituted the majority of all injuries – 64% [4].

At present, many issues regarding optimization of the treatment of patients with blast injuries at different levels of medical care remain unresolved. The choice of anesthesiologic support for patients during surgical debridement of gunshot wounds also remains a complex and incompletely resolved issue. Since the time of I World War, the use of neuraxial blocks (spinal anesthesia) as the

anesthetic technique of choice during primary surgical debridement has remained controversial due to arterial hypotension associated with hypovolemia [5, 6]. For a sufficiently long period, under the conditions of frontline hospitals, primary surgical debridement in patients with gunshot injuries was performed either under local infiltration anesthesia or general anesthesia. Since the end of the twentieth century, publications by foreign authors based on the experience of providing medical care during NATO military operations have appeared, proposing the performance of primary surgical debridement in patients with gunshot injuries of the extremities under regional anesthesia using ultrasound guidance [7]. Similar domestic publications began to appear from 2014 onward [8]. However, unfortunately, it is not possible to speak about widespread implementation of the described techniques, since anesthesiologists working in frontline hospitals do not always possess the necessary experience, time, or technical equipment (ultrasound scanner, nerve stimulator, needles for regional blocks).

This raises the question: is it possible to use spinal anesthesia in cases of blast injury caused by anti-personnel mine involving only one lower extremity (with fractures of the foot bones and soft tissue defects affecting only one foot) during repeated surgical debridement of gunshot wounds at the next level of medical care on the day following injury? To answer this question, it is necessary to clearly determine whether hypovolemia is present in this category of patients, since hypovolemia itself constitutes a limitation to spinal anesthesia. Clearly, regional anesthesia may be used as an alternative to general anesthesia, and hypovolemia is not considered a contraindication for its performance [9]. Unfortunately, this technique is technically more complex, as the safety and reliability of blocks depend on many factors: the physician's experience and knowledge of topographic anatomy, availability of equipment for reliable verification and visualization of nerve trunks, etc. In contrast, spinal anesthesia is used al-

most universally, is relatively simple to perform, and provides an adequate level of analgesia and relaxation of the operative wound.

Patients with blast injury of the foot caused by anti-personnel mines are usually evacuated to a tertiary-level medical institution on the day following injury. During the initial examination, standard physical and instrumental assessment, in most cases there are no obvious signs of hypovolemia at first glance: stable vital signs are recorded, while laboratory findings reveal either no anemia (hemoglobin level >130 g/L) or only mild anemia (hemoglobin level >110 g/L). This may be explained by the relatively small volume of blood loss at the time of injury – according to literature data, estimated blood loss in isolated gunshot injuries of the foot is up to 1 L [10]. Moreover, it has been reliably demonstrated that rapid and proper application of a hemostatic tourniquet to the injured extremity according to generally accepted TCCC (Tactical Combat Casualty Care) algorithms significantly reduces blood loss volume and decreases mortality from hemorrhage after injury by 15–18% [11]. At the second level of medical care, anti-shock measures were performed during primary surgical debridement and in the postoperative period, including transfusion of blood products.

However, based solely on the results of initial examination and laboratory investigations, it is impossible to definitively exclude hypovolemia or predict further fluid management strategy, as well as determine the risk level associated with neuraxial blocks. In intensive care units, among the most commonly used methods for assessment of volemic status are central venous pressure (CVP) measurement and urine output monitoring; however, numerous studies have demonstrated the low predictive value of relying solely on CVP values, as well as the inaccuracy of urine output as a target parameter [12]. Currently, many different approaches to the assessment of volemic status have been proposed. Invasive methods are considered the most accurate (“gold standard” – transpulmonary thermodilution measurement), although their widespread availability remains limited because, in addition to procedural invasiveness, specialized expensive equipment is required [13]. The most promising noninvasive methods for assessment of volemic status and fluid responsiveness are considered to be hemodynamic tests (the rapid fluid challenge test and passive leg raising test), as well as assessment of dynamic changes in inferior vena cava (IVC) diameter, all of which require proficiency in ultrasound-guided examination [14, 15]. In evaluating volemic status using hemodynamic tests, the key parameter is cardiac output (CO), calculated using echocardiographic data [16, 17]. Prior to the rapid fluid challenge test, CVP is measured, CO is calculated using ultrasound, and crystalloid solution at a dose of 5–10 mL/kg (on average 300–500 mL) is infused over 10–20 minutes, after which CVP and CO are reassessed. The test is considered positive in cases of an increase in CVP by 3–5 cm H₂O and CO by 250–300 mL/min, indicating hypovolemia. Prior to the passive leg raising test, CO is calculated using ultrasound, after which the head of the bed is elevated to 45°, the foot end of the bed is slowly raised to 45°, and the head end is immediately returned to the horizontal position. The patient remains in this position for 60–90 seconds, after which CO is reassessed using ultrasound. The test is considered positive if CO increases by 10% or more, indicating hypovolemia.

Assessment of respiratory modulation of the inferior vena cava is also performed using ultrasound. The IVC diameter decreases during inspiration and increases during expiration. The level of volemia is assessed according to the size of the IVC and the degree of its collapse.

It may be assumed that some patients with blast injury caused by anti-personnel mine involving only one lower extremity are transferred from the second level of medical care on the day following injury without ultrasound-confirmed signs of hypovolemia. However, is it safe to use neuraxial blocks as anesthesiological support in such cases? The vast majority of publications recommend assessment of volemic status primarily to determine further fluid management strategy rather than to establish indications or contraindications for spinal anesthesia. We were unable to identify available medical literature addressing how assessment of volemic status using modern techniques influences the choice of anesthesiological support and whether spinal anesthesia may be safely performed during repeated surgical debridement in patients with blast injury of the foot on the day following injury.

The aim of the study.

To assess volemic status using ultrasound in order to determine the method of anesthesia in patients with blast injuries of the lower extremities; and, based on hemodynamic parameters, to investigate the safety of neuraxial blocks in patients with blast injuries of the lower extremities.

Object and research methods.

The study included 46 patients treated for blast injury caused by anti-personnel mine injury to one of the lower extremities during 2025 at the Municipal Non-Commercial Enterprise “Odesa Regional Clinical Hospital” of the Odesa Regional Council. The study was conducted in accordance with bioethical principles and the Declaration of Helsinki. Written informed consent for participation in the study was obtained from all patients. All patients were male, aged 21 to 57 years, with a body mass index (BMI) ranging from 21 to 32.4 kg/m², and physical status class I or II according to the ASA classification.

The inclusion criteria were: injury involving only one lower extremity not above the distal third of the lower leg, time from injury ranging from 18 to 28 hours, previously performed primary surgical debridement of wounds, hemoglobin level > 110 g/L according to laboratory blood analysis, consent to regional anesthesia and participation in the study, as well as the presence of normovolemia according to all three tests of noninvasive volemic status assessment. Exclusion criteria were: refusal of regional anesthesia, ASA physical status III or higher, alimentary obesity, coagulopathy, hemoglobin level < 110 g/L according to laboratory blood analysis, as well as signs of hypovolemia according to at least one of the three noninvasive volemic status assessment tests.

Upon admission on the day following injury, transferred from the second level of medical care where anti-shock infusion therapy and primary surgical debridement had been performed under general anesthesia (in isolated cases under combined anesthesia: regional anesthesia + analgosedation or general anesthesia + regional anesthesia), stable vital signs were recorded, examination and radiography of the lower extremity bones were performed, and a decision regarding repeated surgical debridement was made based on the obtained findings. In addition to standard laboratory and instrumental in-

vestigations, noninvasive assessment of volemic status was performed. Dynamic changes in inferior vena cava diameter were assessed. Using the Esaote MyLab X25 ultrasound machine with a convex probe CA 631 1.8–5.0 MHz, the IVC was visualized at the level of the liver and diaphragm, and its diameter (cm) and degree of collapse during inspiration (%) were recorded.

For the passive leg raising test, echocardiography was performed using a sector cardiac probe PA 230E 1.0–4.0 MHz; end-diastolic and end-systolic volumes were recorded, and cardiac output was calculated. Upon completion of the test, cardiac output was reassessed using ultra-

Table 1 – Characteristics of patient groups according to demographic parameters

Parameter	I group (n=23)	II group (n=23)	p
Age (years), $M \pm \sigma$	35.1 $\pm$ 10.3	37.4 $\pm$ 8.2	0.42
BMI (kg/m ²), $M \pm \sigma$	24.5 $\pm$ 2.4	25.4 $\pm$ 2.7	0.23

The safety assessment of spinal anesthesia was performed by comparing hemodynamic parameters in patients of Groups I and II during surgical interventions. The following parameters were analyzed: blood pressure (BP), including systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart

Table 2 – Characteristics of patient groups according to the results of noninvasive volemic status assessment tests

Noninvasive volemic status assessment test	Parameter	I group, (n=23)	II group, (n=23)	p
Assessment of dynamic changes in inferior vena cava (IVC) diameter:	IVC diameter, cm, ($M \pm \sigma$)	1.7 $\pm$ 0.3	1.8 $\pm$ 0.3	>0.05
	Degree of IVC collapse during inspiration, %, ($M \pm \sigma$)	42.3 $\pm$ 2.1	41.9 $\pm$ 2.3	>0.05
Passive leg raising test:	CO before the test, mL/min, ($M \pm \sigma$)	5253.5 $\pm$ 201.3	5177.7 $\pm$ 207.2	>0.05
	CO after completion the test, mL/min, ($M \pm \sigma$)	5249.2 $\pm$ 207.7	5187.4 $\pm$ 211.3	>0.05
	Difference in CO, mL/min, ($M \pm \sigma$)	107.2 $\pm$ 21.4	101.7 $\pm$ 23.2	>0.05
Rapid fluid challenge test:	CO before the test, mL/min, ($M \pm \sigma$)	5247.5 $\pm$ 211.4	5217.2 $\pm$ 209.7	>0.05
	CVP before the test, cm H ₂ O, ($M \pm \sigma$)	7.4 $\pm$ 2.1	7.9 $\pm$ 2.2	>0.05
	CO after completion the test, mL/min, ($M \pm \sigma$)	5261.7 $\pm$ 216.1	5299.7 $\pm$ 217.0	>0.05
	CVP after completion the test, cm H ₂ O, ($M \pm \sigma$)	7.5 $\pm$ 2.2	7.9 $\pm$ 2.3	>0.05
	Difference in CO, mL/min, ($M \pm \sigma$)	117.1 $\pm$ 20.1	111.7 $\pm$ 21.1	>0.05
	Difference in CVP, cm H ₂ O, ($M \pm \sigma$)	0.8 $\pm$ 0.03	0.7 $\pm$ 0.04	>0.05

sound. Subsequently, after 10–15 minutes, the rapid fluid challenge test was performed: CVP was measured, echocardiography was repeated, cardiac output was calculated, infusion therapy was administered, after which CVP and cardiac output were reassessed using ultrasound.

Normovolemia was defined as simultaneous fulfillment of all three test criteria, namely: IVC diameter $\geq$ 1 cm, inspiratory collapse of the IVC $\leq$ 50%, difference in cardiac output before and after passive leg raising $\leq$ 300 mL/min, and differences in cardiac output and CVP before and after rapid fluid challenge $\leq$ 300 mL/min and $\leq$ 2.5 cm H₂O, respectively. Any deviation from these values in at least one test was regarded as hypovolemia.

Depending on the type of anesthesiologic support, patients were randomly divided into two groups (23 patients in each group). No statistically significant intergroup differences were observed regarding demographic characteristics, hemodynamic parameters, or results of all three tests of noninvasive volemic status assessment. Patients of Group I underwent spinal anesthesia (2.5 mL of 0.5% hyperbaric bupivacaine solution injected at the L3–L4 level), whereas patients of Group II underwent regional anesthesia (under ultrasound guidance using a linear probe LA 523 5.0–10 MHz: popliteal sciatic nerve block with 20 mL of 0.5% bupivacaine solution and femoral nerve block with 10 mL of 0.5% bupivacaine solution). In Group I patients, following surgery, for postoperative analgesia, a popliteal sciatic nerve block with 20 mL of 0.25% bupivacaine solution was additionally performed under ultrasound guidance.

The characteristics of patient groups according to demographic parameters are presented in **table 1**.

The characteristics of patient groups according to the results of noninvasive volemic status assessment tests are presented in **table 2**.

rate (HR). The observation period was conventionally divided into five stages: before the initiation of anesthesia (Stage 1), after completion of regional blocks (Stage 2), after revision of the gunshot wound (Stage 3), at the end of surgery (Stage 4), and 3 hours postoperatively (Stage 5).

Statistical analysis was performed using Microsoft Excel software. Normality of data distribution was assessed using the Shapiro–Wilk test. The results are presented as mean $\pm$ standard deviation ($M \pm \sigma$). The statistical significance of intergroup differences was evaluated using Student's t-test, with $p < 0.05$ considered statistically significant.

Research results and their discussion.

Hemodynamic parameters in patients of the study groups during the observation period are presented in **table 3** and **table 4**.

Before the initiation of anesthesia (1st period), analysis of the obtained results demonstrated hemodynamic parameters within normal ranges, as well as the absence of statistically significant differences in hemodynamic parameters between patients of both study groups: mean SBP values in Group I patients were 114.2 $\pm$ 6.9 mmHg, whereas in Group II patients they were 112.0 $\pm$ 8.8 mmHg ($p > 0.05$); mean DBP values were 72.3 $\pm$ 7.5 mmHg and 70.2 $\pm$ 5.1 mmHg, respectively ($p > 0.05$); mean MAP values were 85.2 $\pm$ 7.3 mmHg and 84.3 $\pm$ 7.4 mmHg, respectively ($p > 0.05$); mean HR values were 79.0 $\pm$ 12.7 bpm and 76.4 $\pm$ 11.6 bpm, respectively ($p > 0.05$).

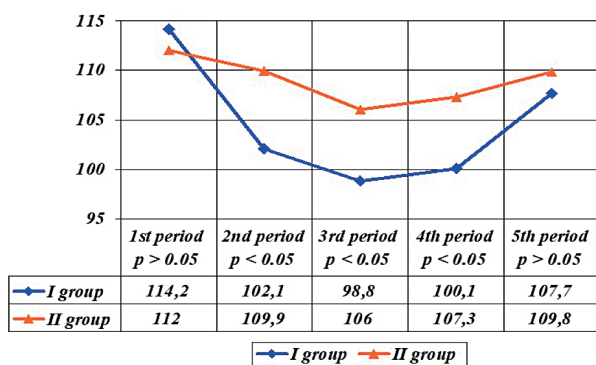
After performance of the blocks and initiation of anesthesia (2nd period), analysis of the obtained results demonstrated the first clinically significant and statistically significant decrease in hemodynamic parameters, with substantial statistically significant differences in hemodynamic parameters between patients of both study

groups: mean SBP values in Group I patients were 102.1 ± 5.0 mmHg, whereas in Group II patients they were 109.9 ± 4.8 mmHg ($p < 0.05$); mean DBP values were 62.3 ± 7.7 mmHg and 69.5 ± 5.2 mmHg, respectively ($p < 0.05$); mean MAP values were 74.3 ± 5.7 mmHg and 83.1 ± 4.9 mmHg, respectively ($p < 0.05$); mean HR values were 66.2 ± 6.4 bpm and 73.8 ± 8.6 bpm, respectively ($p < 0.05$).

During revision of the gunshot wound of the foot (3rd period), analysis of the obtained results also revealed substantial statistically significant differences in hemodynamic parameters between patients of both study groups: mean SBP values in Group I patients were 98.8 ± 6.5 mmHg, whereas in Group II patients they were 106.0 ± 6.3 mmHg ($p < 0.05$); mean DBP values were 59.1 ± 5.1 mmHg and 67.3 ± 4.2 mmHg, respectively ($p < 0.05$); mean MAP values were 72.2 ± 5.9 mmHg and 80.3 ± 5.3 mmHg, respectively ($p < 0.05$); mean HR values were 69.4 ± 6.2 bpm and 78.8 ± 8.9 bpm, respectively ($p < 0.05$).

At the end of the surgical intervention (4th period), analysis of the obtained results demonstrated that substantial statistically significant differences in hemodynamic parameters between patients of both study groups still persisted: mean SBP values in Group I patients were 100.1 ± 5.8 mmHg, whereas in Group II patients they were 107.3 ± 5.3 mmHg ($p < 0.05$); mean DBP values were 60.6 ± 4.0 mmHg and 67.9 ± 3.6 mmHg, respectively ($p < 0.05$); mean MAP values were 73.9 ± 5.1 mmHg and 81.1 ± 4.9 mmHg, respectively ($p < 0.05$); mean HR values were 67.8 ± 5.6 bpm and 77.0 ± 9.1 bpm, respectively ($p < 0.05$).

Dynamics of systolic blood pressure, mmHg



Dynamics of mean arterial pressure, mmHg

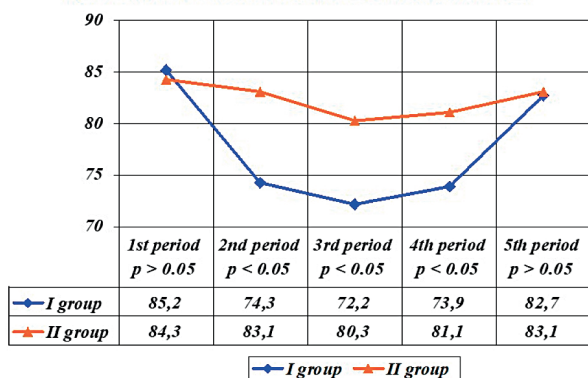


Table 3 – Hemodynamic parameters during the observation period in patients of Group I

Parameter / periods	1 st period	2 nd period	3 rd period	4 th period	5 th period
SBP, mmHg, (M±σ)	114.2±6.9	102.1±5.0	98.8±6.5	100.1±5.8	107.7±9.0
DBP, mmHg, (M±σ)	72.3±7.5	62.3±7.7	59.1±5.1	60.6±4.0	69.1±6.9
MAP, mmHg, (M±σ)	85.2±7.3	74.3±5.7	72.2±5.9	73.9±5.1	82.7±7.3
HR, bpm, (M±σ)	79.0±12.7	66.2±6.4	69.4±6.2	67.8±5.6	75.4±8.1

Table 4 – Hemodynamic parameters during the observation period in patients of Group II

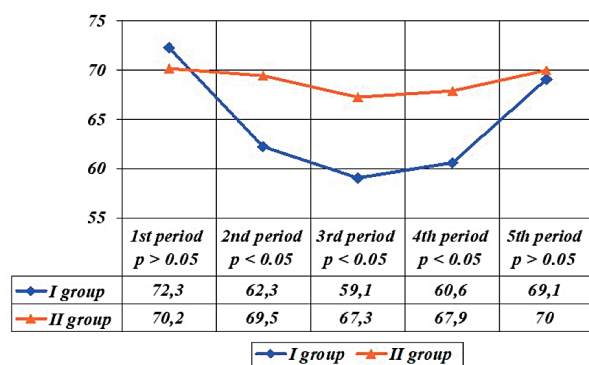
Parameter / periods	1 st period	2 nd period	3 rd period	4 th period	5 th period
SBP, mmHg, (M±σ)	112.0±8.8	109.9±4.8	106.0±6.3	107.3±5.3	109.8±7.1
DBP, mmHg, (M±σ)	70.2±5.1	69.5±5.2	67.3±4.2	67.9±3.6	70.0±5.3
MAP, mmHg, (M±σ)	84.3±7.4	83.1±4.9	80.3±5.3	81.1±4.9	83.1±6.5
HR, bpm, (M±σ)	76.4±11.6	73.8±8.6	78.8±8.9	77.0±9.1	76.4±7.7

Only three hours after completion of the surgical intervention (5th period), analysis of the obtained results demonstrated the absence of statistically significant differences in hemodynamic parameters between patients of both study groups: mean SBP values in Group I patients were 107.7 ± 9.0 mmHg, whereas in Group II patients they were 109.8 ± 7.1 mmHg ($p > 0.05$); mean DBP values were 69.1 ± 6.9 mmHg and 70.0 ± 5.3 mmHg, respectively ($p > 0.05$); mean MAP values were 82.7 ± 7.3 mmHg and 83.1 ± 6.5 mmHg, respectively ($p > 0.05$); mean HR values were 75.4 ± 8.1 bpm and 76.4 ± 7.7 bpm, respectively ($p > 0.05$).

The dynamics of hemodynamic parameters in patients of the study groups during the observation period are presented in figure.

Analyzing the obtained results, it can be concluded that noninvasive ultrasound assessment of volemic status

Dynamics of diastolic blood pressure, mmHg



Dynamics of heart rate, bpm

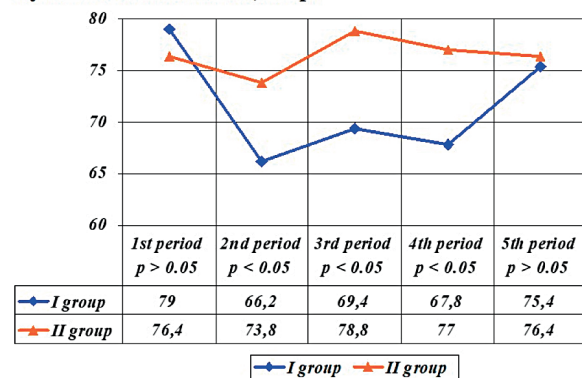


Figure – Dynamics of hemodynamic parameters in patients of the study groups during the observation period.

is appropriate not only for determining further fluid management strategy, but also for planning the choice of anesthesiologic support for surgical interventions, including in the treatment of patients with combat trauma. Owing to the methods of volemic status assessment, it may be stated that in the present study no patient underwent spinal anesthesia in a state of hypovolemic shock. The observed decrease in hemodynamic parameters in Group I patients following subarachnoid administration of the anesthetic solution and initiation of spinal anesthesia may be characterized as occurring without critically low blood pressure and heart rate values (as may occur during spinal anesthesia in shock states), and were nearly identical to those commonly registered after a similar procedure during elective traumatological surgery in patients with ASA physical status I-II [18].

A decrease in hemodynamic parameters during the traumatic stage of surgery itself (predominantly arterial pressure, whereas HR fluctuations were clinically less significant as evidence of adequate antinociceptive protection) was recorded in patients of both study groups. Therefore, it cannot be categorically stated that hypotension developed solely as a consequence of spinal anesthesia, but rather primarily as a response to intraoperative blood loss. Unfortunately, predicting blood loss volume during surgery for combat trauma remains extremely difficult and unresolved at present. Similarly, even using noninvasive volemic status tests (and this likely also applies to invasive methods), it is impossible to predict the hemodynamic response to each episode of blood loss. This is especially relevant within the relatively short and insufficient period following restoration of volemic status after injury, despite the high compensatory reserve of the patients (young age and absence of chronic comorbidities).

It cannot be stated that the choice of anesthetic technique influenced the degree of intraoperative blood loss. Nevertheless, it was observed that hemodynamic parameters were significantly lower during intraoperative blood loss in Group I patients who underwent spinal anesthesia. Thus, the state of hypotension, in addition to blood loss as the primary cause, was further aggravated by the vasodilatory effect of spinal anesthesia. At the same time, patients of Group II who underwent regional anesthesia demonstrated significantly smaller hemodynamic fluctuations. It may be unequivocally stated that regional anesthesia is safer in situations of unstable patient condition,

especially in the presence of a risk of blood loss. However, it is impossible to categorically declare an absolute contraindication to spinal anesthesia in similar clinical situations. Perhaps its use should be avoided in surgical procedures even with relatively small anticipated blood loss volumes.

In our study, in order to compensate for circulating blood volume deficit caused by intraoperative blood loss, blood transfusions were performed in 12 patients (7 patients from Group I and 5 patients from Group II). In addition, administration of sympathomimetics (norepinephrine) was prescribed in 5 patients from Group I and 1 patient from Group II. By the end of surgery (4th observation period), a gradual positive trend toward stabilization of hemodynamic parameters was already observed. Although arterial pressure values in Group I patients still remained clinically and statistically lower compared to those of Group II patients, despite administration of sympathomimetics and blood transfusion. Only later, three hours after completion of surgery (5th observation period), stabilization of hemodynamic parameters without statistically significant clinical differences between all patients of both study groups was observed.

The obtained results indicate the impossibility of providing an unequivocal answer regarding the safety of neuraxial blocks as anesthesiologic support for repeated surgical debridement performed within 18-28 hours after injury in patients with blast injury of one foot caused by anti-personnel mines.

Conclusions.

1. Noninvasive ultrasound assessment of volemic status is an appropriate method of preoperative evaluation in patients with combat trauma of the lower extremities.

2. In patients without ultrasound signs of hypovolemia, spinal anesthesia was not associated with the development of critical hemodynamic disturbances.

3. Regional anesthesia provided more stable hemodynamic parameters compared with spinal anesthesia during repeated surgical wound debridement.

4. The use of spinal anesthesia in patients with mine-blast trauma requires an individualized approach and careful assessment of the risk of possible hemodynamic complications.

Prospects for further research.

Further investigation of the peculiarities of determining volemic status in patients with gunshot injuries of the extremities using ultrasound examination.

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ВИБІР МЕТОДУ АНЕСТЕЗІЇ ПРИ ХІРУРГІЧНИХ ОБРОБКАХ ВОГНЕПАЛЬНИХ РАН ЗА ДОПОМОГОЮ УЛЬТРАЗВУКОВОГО ДОСЛІДЖЕННЯ ВОЛЕМІЧНОГО СТАТУСУ

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Резюме. Вибір методу анестезії у поранених з вибуховою травмою нижніх кінцівок залишається дискусійним, через ризик прихованої гіповолемії та розвитку гемодинамічних порушень під час нейроаксіальних блокувань.

Мета дослідження – оцінка волемічного статусу пацієнтів з вибуховою травмою нижніх кінцівок за допомогою ультразвукових методик та дослідження безпеки використання спінальної анестезії.

Дослідження проведено за участю 46 пацієнтів з вибуховим ураженням однієї з нижніх кінцівок, що надійшли протягом 18–28 годин після поранення. Виконано ультразвукову оцінку рівня волемії: визначення показників динамічних змін діаметру нижньої порожнистої вени, тест з пасивним підйомом ніг та тест з швидким інфузійним навантаженням. Пацієнтам I групи проводилась спінальна анестезія, пацієнтам II групи – регіонарні блокади.

До початку операції у всіх пацієнтів визначались стабільні показники гемодинаміки та відсутність ознак гіповолемії. Після виконання анестезії, а також протягом оперативного втручання, у групі спінальної анестезії спостерігалось достовірне зниження показників гемодинаміки, порівняно з групою регіонарної анестезії ($p < 0,05$). Вазопресорну підтримку проведено 5 пацієнтам I групи та 1 пацієнту II групи. Через 3 години після операції міжгрупові різниці гемодинамічних показників не виявлено. Регіонарна анестезія характеризувалась більшою гемодинамічною стабільністю, проте спінальна анестезія може застосовуватись у ретельно відібраних пацієнтів без ознак гіповолемії.

Ультразвукова оцінка волемії є доцільною перед вибором методу анестезії у пацієнтів з вогнепальними пораненнями. Регіонарна анестезія забезпечувала більшу гемодинамічну стабільність. Вибір методу анестезії потребує індивідуалізованого підходу.

Ключові слова: вогнепальні поранення, бойова хірургічна травма, ультразвукове дослідження, регіонарне знеболення, біль.

ULTRASOUND-GUIDED ASSESSMENT OF VOLEMIC STATUS OF ANESTHESIA IN SURGICAL DEBRIDEMENT OF GUNSHOT WOUNDS

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Abstract. The choice of anesthetic technique in wounded patients with blast injuries of the lower extremities remains controversial due to the risk of occult hypovolemia and the development of hemodynamic disturbances during neuraxial blocks.

The aim of the study is to assess the volemic status of patients with blast injuries of the lower extremities using ultrasound techniques and to investigate the safety of spinal anesthesia.

The study was conducted in 46 patients with blast injuries to one of the lower extremities admitted within 18–28 hours after injury. Ultrasound assessment of volemic status was performed, including evaluation of dynamic changes in inferior vena cava diameter, the passive leg raise test, and the rapid fluid challenge test. Patients in Group I underwent spinal anesthesia, whereas patients in Group II received regional nerve blocks.

Prior to surgery, all patients demonstrated stable hemodynamic parameters and no signs of hypovolemia. Following anesthesia administration, as well as throughout the surgical intervention, patients in the spinal anesthesia group exhibited a significant decrease in arterial blood pressure and heart rate compared with the regional anesthesia group ($p < 0.05$). Vasopressor support was required in 5 patients of Group I and 1 patient of Group II. Three hours after surgery, no intergroup differences in hemodynamic parameters were detected. Regional anesthesia was associated with greater hemodynamic stability; however, spinal anesthesia may be used in carefully selected patients without signs of hypovolemia.

Ultrasound assessment of volemic status is advisable prior to selecting the anesthetic technique in patients with gunshot injuries. Regional anesthesia provided greater hemodynamic stability. The choice of anesthetic technique requires an individualized approach.

Key words: gunshot wounds, combat surgical trauma, ultrasound examination, regional anesthesia, pain.

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The authors declare no conflict of interest.

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article.

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PROGNOSTIC MODELING OF FUNCTIONAL STATUS IN PATIENTS WITH NEUROGENIC BLADDER BASED ON CLINICAL AND URODYNAMIC PREDICTORS

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Neurogenic bladder is associated with complex lower urinary tract dysfunction that may lead to functional limitations and impaired quality of life. Considerable interindividual variability in clinical outcomes highlights the need for personalized prediction of rehabilitation results. The aim of the study was to develop prognostic models of functional limitations and quality of life in patients with neurogenic bladder at 3 months. The study included 40 patients with neurogenic urinary tract dysfunction. Demographic, clinical, and urodynamic characteristics were assessed, together with lower urinary tract symptoms using the ICIQ-OAB questionnaire, functional status using WHODAS 2.0, and quality of life using WHOQOL-BREF. Prognostic models were developed using multiple linear regression analysis based on eight predefined predictors. Five statistically significant prognostic models were developed. The WHODAS 2.0 model explained 64.9% of the variance (adjusted $R^2=0.559$; $p<0.001$), while the four WHOQOL-BREF domain models explained 60.0–64.5% of the variance (adjusted $R^2=0.496–0.553$; $p<0.001$). The ICIQ-OAB score was the most consistent independent predictor, while urinary tract infection made a statistically significant contribution to all models. The developed prognostic equations enable quantitative estimation of expected functional limitations and quality-of-life outcomes at 3 months and may provide a basis for personalized rehabilitation planning. Further prospective validation of the models is required.

Key words: neurogenic bladder, urodynamic study, prognostic model, functional limitations, quality of life, rehabilitation management.

Connection of the publication with planned research work.

The study was conducted in accordance with the consolidated research plan of the research topic “Medical, physiotherapeutic and occupational therapy support of sports, health-promoting and rehabilitation training” (state registration number 0121U114435) of the Department of Physical Rehabilitation, Sports Medicine and Vasculariology, Dnipro State Medical University.

Introduction.

Neurogenic lower urinary tract dysfunction is one of the most common and complex manifestations of neu-

rological diseases and injuries of the nervous system [1]. It accompanies a wide range of pathological conditions, including spinal cord injury, multiple sclerosis, spina bifida, Parkinson's disease, stroke, and other disorders of the central and peripheral nervous systems [2]. According to current studies and clinical guidelines, symptoms of neurogenic urinary dysfunction occur in more than 70–90% of patients after spinal cord injury, in 50–90% of patients with multiple sclerosis, and in a substantial proportion of individuals with cerebrovascular and neurodegenerative diseases [3–7].