https://doi.org/10.21320/1818-474X-2026-1-133-144

Comparative analysis of the development of adverse events of regional anesthesia during clavicle surgery: a randomized controlled trial

A.N. Adamenko, A.A. Ezhevskaya*, V.I. Zagrekov

Privolzhsky Research Medical University, Nizhny Novgorod, Russia

Abstract

INTRODUCTION: The combination of interscalene brachial plexus block and superficial cervical plexus block can cause up to 100 % incidence of ipsilateral diaphragmatic paralysis or paresis due to the anatomical spread of local anesthetics in this region, along with other adverse effects. Alternative nerve block techniques for these plexuses could improve patient safety and comfort. **OBJECTIVE:** To compare the incidence of adverse events and the severity of diaphragmatic paresis during regional anesthesia using supraclavicular nerve and upper trunk brachial plexus block (SCUT-block), fascial supraclavicular nerve group block combined with upper trunk brachial plexus block (FSCUT-block), and the conventional ISB + SCB combination (ISSC-block) in patients undergoing clavicular surgery. **MATERIALS AND METHODS:** A prospective study included 85 patients divided into three groups based on analgesia technique: Group 1 (n = 25) — FSCUT-block; Group 2 (n = 30) — SCUT-block; and the Group 3 (n = 30) — ISSC-block. Analgesia duration, sensorimotor block duration, diaphragmatic excursion dynamics, and respiratory rate were assessed before and after surgery. **RESULTS:** The highest incidence of paresis and paralysis of the diaphragm was observed in the control group of the ISSC-block (p = 0.006, p < 0.001). The phenomena of diaphragm dysfunction were completely resolved in all groups within 24 hours after the blockade (p = 0.427). The average duration of analgesia and sensorimotor blockade was the lowest in the SCUT-block group (p < 0.001) and the maximum in the group ISSC-block (p < 0.001). The frequency of respiratory movements increased significantly more in the ISSC-block group than in the SCUT-block and FSCUT-block groups (p = 0.006). **CONCLUSIONS:** FSCUT blockade provides effective and safe analgesia for clavicle surgery, with duration comparable to traditional methods. Its advantage lies in lower rates of diaphragm paresis and no observed paralysis, making it a preferable technique.

Сравнительный анализ развития нежелательных явлений регионарной анестезии при операциях на ключице: рандомизированное контролируемое исследование

А.Н. Адаменко, А.А. Ежевская*, В.И. Загреков

ФГБОУ ВО «Приволжский исследовательский медицинский университет» Минздрава России, Нижний Новгород, Россия

Реферат

АКТУАЛЬНОСТЬ: Межлестничная блокада плечевого сплетения в комбинации с блокадой поверхностного шейного сплетения могут стать причиной до 100 % частоты развития ипсилатерального паралича или пареза диафрагмы, обусловленных особенностями распространения анестетика в данной анатомической области, а также других нежелательных явлений. Применение альтернативных способов блокады нервов этих сплетений позволит повысить безопасность пациентов. **ЦЕЛЬ ИССЛЕДОВАНИЯ:** Сравнить частоту развития нежелательных явлений и степень выраженности пареза диафрагмы при выполнении регионарной анестезии способами фасциальной блокады группы надключичных нервов с блокадой верхнего ствола плечевого сплетения (FSCUT-блокада) и блокады надключичных нервов и верхнего ствола плечевого сплетения (SCUT-блокада) в сравнении с комбинацией межлестничной блокады плечевого сплетения и блокады шейного сплетения (ISSC-блокада) у пациентов, которым требовалось проведение операции на ключице. **МАТЕРИАЛЫ И МЕТОДЫ:** В проспективное исследование включено 85 пациентов, которые были разделены на три группы в зависимости от способа анестезии: 1-я группа (n = 25) — анестезия методом FSCUT-блокады, 2-я группа (n = 30) — анестезия методом SCUT-блокады и 3-я группа (n = 30) — анестезия по методике ISSC-блокады. Оценивали длительность анальгезии и сенсомоторного блока, динамику экскурсии диафрагмы и частоту дыхательных движений до оперативного вмешательства и после него. **РЕЗУЛЬТАТЫ:** Наибольшая частота встречаемости пареза и паралича диафрагмы отмечалась в контрольной группе ISSC-блокады (p = 0,005, p < 0,001). Явления дисфункции диафрагмы полностью разрешились во всех группах в течении 24 ч после блокады (p = 0,427). Средняя длительность анальгезии и сенсомоторной блокады была наименьшей в группе SCUT-блокады (p < 0,001) и максимальной в группе ISSC-блокады (p < 0,001). Частота дыхательных движений статистически значимо больше нарастала в группе блокады ISSC, чем у групп SCUT-блокады и FSCUT-блокады (p = 0,006). **ВЫВОДЫ:** Применение селективной блокады FSCUT позволяет достичь эффективной, безопасной и комфортной анальгезии при операциях на ключице. Сравнимая с традиционным методом длительность анальгезии, отмечаемая при выполнении блокады FSCUT, а также меньшая частота пареза диафрагмы в сравнении с другими способами анестезии и отсутствие паралича диафрагмы позволяют отдать ей предпочтение.

KEYWORDS: nerve block, brachial plexus block, cervical plexus block, ultrasonography, respiratory paralysis

КЛЮЧЕВЫЕ СЛОВА: блокада нервов, блокада плечевого сплетения, блокада шейного сплетения, ультразвуковое исследование, паралич дыхания

* *For correspondence:* Anna A. Ezhevskaya — Dr. Med. Sci., professor of the Department of Anesthesiology, Intensive Care Medicine and Transfusiology, intensive care anesthesiologist Privolzhsky Research Medical University, Nizhny Novgorod, Russia; e-mail: ezhevskaya_a@pimunn.net

* *Для корреспонденции:* Ежевская Анна Александровна — д-р мед. наук, профессор кафедры анестезиологии, реаниматологии и трансфузиологии, врач — анестезиолог-реаниматолог ФГБОУ ВО «ПИМУ» Минздрава России, Нижний Новгород, Россия; e-mail: ezhevskaya_a@pimunn.net

For citation: Adamenko A.N., Ezhevskaya A.A., Zagrekov V.I. Comparative analysis of the development of adverse events of regional anesthesia during clavicle surgery: a randomized controlled trial. Annals of Critical Care. 2026; 1:133–144. https://doi.org/10.21320/1818-474X-2026-1-133-144

Для цитирования: Адаменко А.Н., Ежевская А.А., Загреков В.И. Сравнительный анализ развития нежелательных явлений регионарной анестезии при операциях на ключице: рандомизированное контролируемое исследование. Вестник интенсивной терапии им. А.И. Салтанова. 2026; 1:133–144. https://doi.org/10.21320/1818-474X-2026-1-133-144

Received: 21.05.2025
Accepted: 03.11.2025

Поступила: 21.05.2025
Принята к печати: 03.11.2025

DOI: 10.21320/1818-474X-2026-1-133-144

Introduction

Clavicle fractures account for a significant proportion (up to 44%) of all fractures of the shoulder girdle and require surgical intervention in the presence of fragment displacement, severe pain, marked functional limitations or neurovascular compromise [1–3]. The interscalene block (ISB) technique, proposed by J. Etienne in 1925 and popularized in clinical practice by A.P. Winnie, remains the most common method of regional anesthesia for operations on the shoulder and upper limb. The combination of ISB with superficial cervical plexus block (CPB) provides an adequate level of surgical anesthesia owing to effective anesthesia of the skin in the operative field [4]. At the same time, this method of regional anesthesia is associated with a high risk of neurological complications. According to available data, the incidence of ipsilateral phrenic nerve paresis after ISB ranges from 50 % to 100 %; Horner's syndrome occurs with a frequency of up to 26.7 %; and unintentional recurrent laryngeal nerve block, causing vocal cord paresis with stridor, is observed in 16.7–36.7 % of patients [5, 6]. Numerous studies assessing the influence of local anesthetic volume used for ISB on the development of complications have shown that ipsilateral diaphragmatic paresis, along with other adverse events associated with this block, is most likely an unavoidable consequence of the dose required to achieve surgical anesthesia [7, 8]. Despite the introduction of various ISB strategies aimed at reducing the incidence of diaphragmatic paresis, an approach that completely eliminates this complication has not yet been developed [9, 10].

Currently, several alternative approaches have been proposed for blocking the nerves innervating the shoulder region. One of them is the technique described by Sivashanmugam T. et al. — blockade of the supraclavicular nerves and the upper trunk of the brachial plexus, known as the SCUT-block (block of Supra-Clavicular nerves and Upper Trunk of the brachial plexus) [11]. In recent years, increasing attention has been paid to fascial blocks, the most studied of which is clavipectoral fascia block, described by Valdés-Vilches L.F. in 2017, whose main advantages are technical simplicity, low risk of adverse events and longer duration of postoperative analgesia [12].

Studies aimed at evaluating selective and fascial blocks of the brachial and cervical plexuses will make it possible to assess their safety and effectiveness compared with the traditional combination of ISB + CPB during clavicle surgery.

Objective

To compare the incidence and severity of adverse events during regional anesthesia using fascial block of the supraclavicular nerve group combined with upper trunk block of the brachial plexus (FSCUT-block) and block of the supraclavicular nerves and upper trunk of the brachial plexus (SCUT-block) versus the combination of interscalene brachial plexus block and superficial cervical plexus block (ISSC-block) in patients undergoing clavicle osteosynthesis.

Materials and methods

A single-center prospective randomized study was conducted at the Department of Traumatology and Orthopedics of the University Clinic of the Privolzhsky Research Medical University (Ministry of Health of the Russian Federation) in the period from December 25, 2023 to July 31, 2025. The study was approved by the local Ethics Committee of the Privolzhsky Research Medical University (Protocol No. 14 dated December 22, 2023) and complied with the ethical standards of the Declaration of Helsinki and current regulatory requirements. All patients provided written informed consent to undergo regional anesthesia.

Eligibility criteria

Inclusion criteria:

- planned surgical intervention on the clavicle;
- signed informed consent for regional anesthesia;
- age 18–60 years;
- physical status I–III according to the American Society of Anesthesiologists (ASA) classification.

Non-inclusion criteria:

- concomitant respiratory pathology;
- local infection at the puncture site;
- significant coagulopathy;
- allergy to amide local anesthetics;
- patient refusal of regional anesthesia;
- objective or subjective factors precluding adequate cooperation with the patient.

Exclusion criteria:

- need to convert to general anesthesia (e.g., block failure);
- protocol deviations (patient withdrawal of consent, loss of data or incorrect documentation).

Study groups

A total of 90 patients scheduled for clavicle osteosynthesis were assessed for eligibility. Five patients were excluded prior to randomization according to non-inclusion criteria due to concomitant respiratory pathology (n = 5). Allocation to the study groups was based on a table of random numbers generated in the Statistica 10 software package (StatSoft). Randomization was carried out according to a single-blind design: the anesthesiologist was aware of group allocation, whereas the patients were not. The patients were divided into three groups: Group 1 (n = 25) — fascial blockade of the supraclavicular nerve group and the upper trunk of the brachial plexus (FSCUT-block); Group 2 (n = 30) — blockade of the supraclavicular nerves and the upper trunk of the brachial plexus (SCUT-block); Group 3 (n = 30) — interscalene brachial plexus block with superficial cervical plexus block (ISSC-block) (Figure 1).

The preoperative stage

All enrolled patients underwent ultrasound assessment of diaphragmatic excursion. Ultrasound examination of diaphragmatic movement was performed during quiet breathing in the supine position using a convex high-frequency probe (7–15 MHz) in M-mode on the side of the fracture (with the cranial orientation of the probe on the right and left along the mid-clavicular line in the subcostal space through the acoustic windows of the liver and spleen, respectively) at the point of optimal diaphragm visualization. Movement of the posterior third of the diaphragm, which normally exhibits maximal excursion, was analyzed (Figure 2).

In the operating room, standard anesthetic monitoring was performed using Life Scope TR equipment (Nihon Kohden Corporation, Japan): non-invasive blood pressure, respiratory rate, heart rate, cardiac index, electrocardiography in lead II and pulse oximetry. After monitoring, all patients received intravenous premedication with midazolam 0.1 mg/kg. Patients in all groups then underwent regional anesthesia according to the assigned technique; the degree of sensorimotor block was assessed, and surgery was initiated after a satisfactory block was confirmed. The surgical procedure was identical in all patients. Intraoperative crystalloid infusion volume ranged from 500 to 1000 ml.

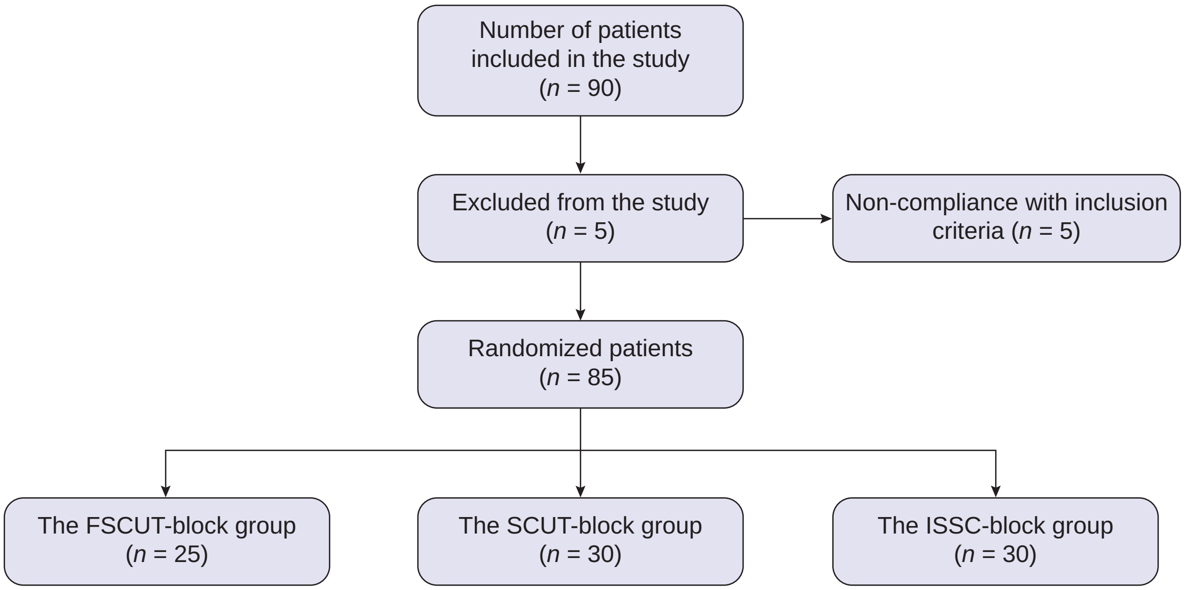

Fig. 1. Block diagram of the study

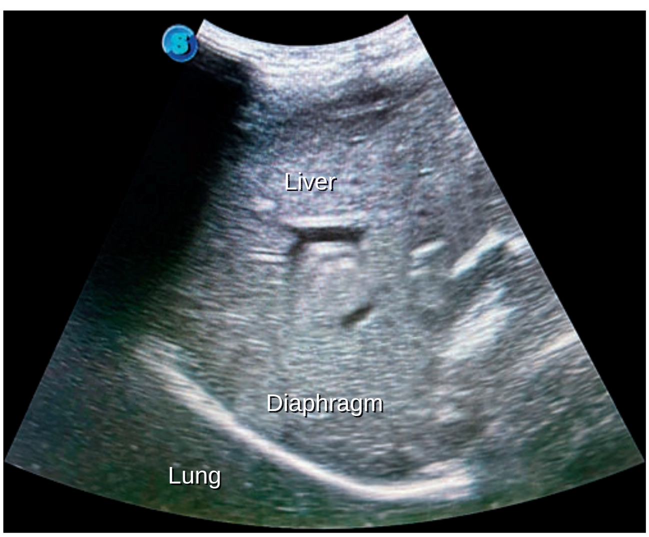

Fig. 2. Sonographic image used to assess excursion of the right hemidiaphragm through the acoustic window of the liver (Credit: authors)

Block techniques in the study groups

Blocks were performed with the patient in the supine position, the ipsilateral upper limb positioned alongside the body, and the head turned to the contralateral side.

A SonoScape S8 Exp ultrasound machine (SonoScape Medical Corp., China) with a linear high-frequency probe S-L743 (SonoScape Medical Corp., China) was used to visualize anatomical structures. Insulated 20G Stimuplex A50 needles (B. Braun Melsungen AG, Germany) were used for injections.

For all blocks, the following ultrasound landmarks were used to determine the level of injection: the prominent anterior tubercle (carotid tubercle) of the C6 vertebra has a well-developed posterior tubercle, whereas C7 practically lacks an anterior tubercle.

In patients of Group 1 (FSCUT-block) to block the upper trunk of the brachial plexus, the ultrasound probe was placed on the side of the fracture laterally on the neck at the C7 level and then moved cranially until the ventral rami of C5 and C6 were visualized and traced distally to their union into the upper trunk of the brachial plexus at approximately the C6 level. An insulated needle was inserted along the lateral border of the probe at an angle of 45° medially, and the needle tip was positioned at the point of optimal visualization. After negative aspiration and a test dose of 1–2 ml of 0.5 % ropivacaine (Fresenius Kabi NORGE, Norway), up to 5 ml of 0.5 % ropivacaine was injected to confirm correct needle placement (Figure 3).

Fascial block of the supraclavicular nerve group was performed from the medial and lateral aspects of the fracture. After placing the linear probe perpendicular to the clavicle, the following landmarks were identified: platysma (superficial cervical muscle), pectoralis major muscle and clavicle. The needle was advanced into the plane between the investing fascia of the platysma and the superficial layer of the cervical fascia, after which 10 ml of 0.5 % ropivacaine was injected on each side under ultrasound visualization of cranial spread of the anesthetic (Figure 4).

In Group 2 (SCUT blockade) the technique for blocking the upper trunk of the brachial plexus was identical to that used in Group 1.

To block the supraclavicular nerves, the probe was positioned parallel to the clavicle and then moved cranially. After visualization, the supraclavicular nerves were traced to the point where they formed a compact bundle (approximately at the C7 level), located lateral to the tapering edge of the sternocleidomastoid muscle between two layers of the deep cervical fascia enveloping the sternocleidomastoid and scalene muscles. An insulated needle was then inserted along the lateral border of the probe at an angle of 45° medially, with the tip positioned near the supraclavicular nerve bundle. After negative aspiration and a test dose of 1–2 ml of 0.5 % ropivacaine, up to 5 ml of 0.5 % ropivacaine was injected to confirm correct needle placement.

In patients Group 3 (ISSC blockade) for ISB, the probe was placed on the side of the fracture laterally on the neck at the C5 level and then moved caudally to the point of optimal visualization of the interscalene groove at the C6–C7 level. The anterior and middle scalene muscles and the brachial plexus in the interscalene space were visualized. An insulated needle was inserted along the inferior border of the probe at an angle of 45° medially, and the tip was positioned at the point of optimal visualization of the brachial plexus. After negative aspiration and a test dose of 1–2 ml of 0.5 % ropivacaine, up to 15 ml of 0.5 % ropivacaine was injected to confirm correct needle position. For the superficial cervical plexus block, 5 ml of 0.5 % ropivacaine was injected along the posterior border of the sternocleidomastoid muscle at the junction of its upper and middle thirds under ultrasound guidance.

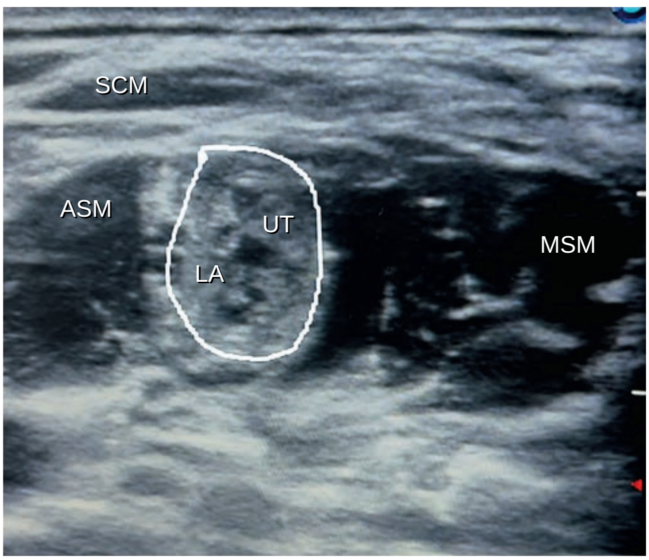

Fig. 3. Sonographic image after upper trunk block of the brachial plexus (Credit: authors)

Note: ASM — anterior scalenus musculus; LA — area of local anesthetic distribution; MSM — medius scalenus musculus; SCM — sternocleidomastoideus muscle; UT — upper trunk of the brachial plexus.

Outcome assessment

Intraoperatively, respiratory and cardiovascular parameters were recorded: blood pressure, respiratory rate and heart rate, as well as pulse oximetry.

In the postoperative period, the duration of analgesia and sensorimotor block was assessed. The extent, distribution and duration of sensory block were evaluated using the PinPrick test. Motor block was assessed using a modified Bromage scale. Diaphragmatic excursion on the side of the block was measured during quiet breathing before the block, 30 minutes after the block, and at 4 and 24 hours thereafter. A reduction in excursion of 25–75 % from baseline was considered diaphragmatic paresis; a reduction of more than 75 % was considered diaphragmatic paralysis.

Statistical analysis

Statistical analysis was performed using Microsoft Excel 2010 (Microsoft Corporation, USA) and Statistica 10 (StatSoft, Inc., USA).

Sample size calculation was based on comparing the incidence of unintentional phrenic nerve block among three independent intervention groups. Literature data indicating that the incidence of this adverse event after ISB approaches 100 % were used as baseline [13].

It was expected that the incidence of complications in the two experimental groups would be significantly lower than in the control group, with an assumed absolute risk re-

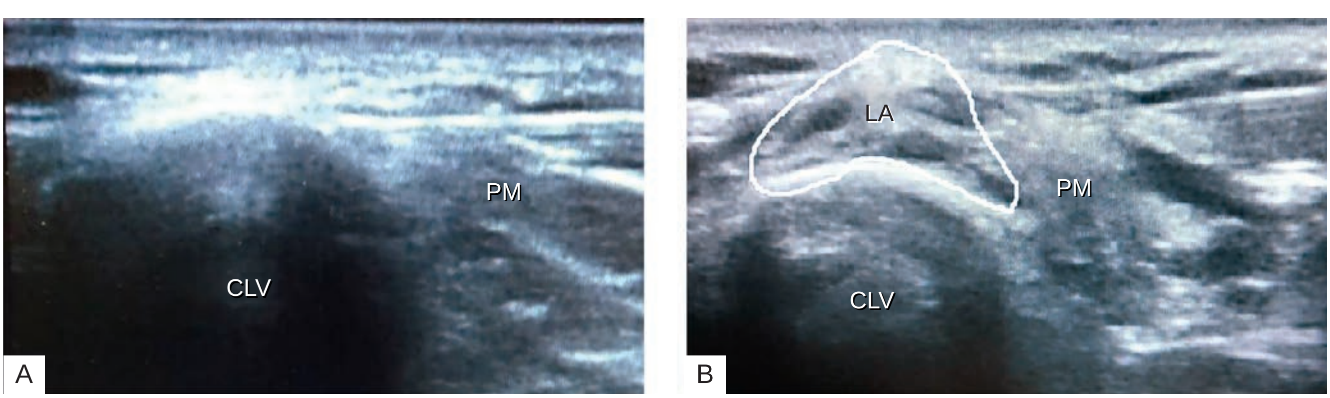

Fig. 4. The image of the sonographic picture during the fascial blockade of the supraclavicular nerve group before the blockade (A) and after the blockade (B) (Credit: authors)

Note: CLV — clavicle; LA — area of local anesthetic distribution; PM — pectoralis major musculus.

duction of 50 %. ISSC-block group: expected complication rate (p1) = 1.0 (100 %). FSCUT and SCUT groups: expected complication rate (p2, p3) = 0.5 (50 %). Statistical parameters: significance level $\alpha = 0.05$; power $(1-\beta) = 80$ %; number of groups = 3.

Pairwise comparisons of each experimental group with the control group were planned. Allocation ratio was 1:1:1. To calculate the minimum required sample size, a two-proportion z-test for independent samples was used with Bonferroni correction for multiple comparisons (adjusted significance level $\alpha/3 = 0.0167$). Calculations were performed in the R software environment (v.4.2.2) using the pwr package.

The calculation showed that 25 patients per group (75 patients in total) were required to detect an absolute decrease in complication rate from 100 % to 50 % with 80 % power at the adjusted significance level.

Taking into account possible drop-outs and the intention to increase model robustness, the sample size was increased to 85 patients. This also improved the precision of estimates (narrower confidence intervals) and increased the power to detect smaller effects.

Quantitative variables were assessed for normality using the Shapiro-Wilk test. Normally distributed variables were described as mean (M) and standard deviation (SD); 95 % confidence intervals (95% CI) were provided for mean values. Non-normally distributed data were described as median (Me) and interquartile range (Q1–Q3). Categorical variables were presented as absolute numbers and percentages; 95% CI for proportions were calculated using the Clopper-Pearson method. Comparison of three or more groups by a quantitative variable with non-normal distribution was performed using the Kruskal-Wallis test, with post-hoc pairwise comparisons using Dunn's test with Holm correction. Comparison of proportions in multi-way contingency tables was performed using Pearson's chi-square test, with post-hoc comparisons using Pearson's chi-square test and Holm correction. For categorical outcomes, relative risk (RR) and its 95% CI were calculated. A p-value of 0.05 was considered statistically significant.

Results

Participants in the three groups were comparable in age, sex, baseline somatic status, and type and duration of surgery (Table 1).

Hemodynamic parameters remained stable in all groups, and no significant between-group differences were observed intraoperatively ($p > 0.05$) (Figure 5).

Baseline diaphragm excursion did not differ significantly between the groups ($p = 0.843$). Analysis of changes in diaphragm excursion 30 minutes after the block revealed statistically significant reductions in the ISSC group, where values were lowest ($p < 0.001$); these changes persisted at 4 hours ($p < 0.001$). Comparative analysis of ultrasound measures of diaphragm excursion 24 hours after the intervention showed restoration of diaphragmatic function, with no statistically significant differences between the groups ($p = 0.427$) (Figure 6, Table 2).

The mean duration of analgesia differed significantly between groups: it was shortest with the SCUT-block and longest with the FSCUT and ISSC blocks ($p < 0.001$). The mean duration of motor block in the SCUT and FSCUT groups was significantly shorter than in the control ISSC group ($p < 0.001$) (Figure 7).

The distribution of sensory block in the groups with selective upper trunk block (Groups 1 and 2) was similar and corresponded to the surgical field (Figure 8). Motor block in these groups was characterized by complete block of the suprascapular, axillary and musculocutaneous nerves and partial block of the radial nerve, whereas ISB in the ISSC group produced near-complete motor block of all major nerves of the brachial plexus.

Assessment of the incidence of diaphragmatic paresis and paralysis showed that these events occurred most fre-

Table 1. General characteristics of the patients

Parameter		FSCUT-block (Group 1)	SCUT-block (Group 2)	ISSC-block (Group 3)	*p*-value
Age, Me [IQR]		34 [26; 46]	43.5 [28.75; 51.75]	40.00 [25.50; 48.75]	0.523*
Duration of surgery (min), M (SD)		68.28 (11.76)	69.27 (13.69)	74.83 (14.10)	0.139*
Gender	Male	19 (76.0 %)	22 (73.3 %)	25 (83.3 %)	0.631**
	Female	6 (24.0 %)	8 (26.7 %)	5 (16.7 %)	
ASA	I	9 (36.0 %)	10 (33.3 %)	11 (36.7 %)	0.587**
	II	16 (64.0 %)	17 (56.7 %)	16 (53.3 %)	
	III	0 (0 %)	3 (10.0 %)	3 (10.0 %)	

Note: ASA — American Society of Anesthesiologists; IQR — interquartile range.
* The Kruskal–Wallis test; ** *p* — Pearson's chi-squared test.
Quantitative data are represented by Me-median. Qualitative data values are presented as absolute number and ρ (percentage).

Table 2. Comparison of the average values of the ultrasound excursion of the diaphragm in the M-mode on the fracture side

Parameter	FSCUT-block (Group 1)	SCUT-block (Group 2)	ISSC-block (Group 3)	*p*-value
Before block, cm, Me [IQR]	1.7 [1.6–1.8]	1.7 [1.6–1.8]	1.7 [1.6–1.8]	0.847
30 min after block, cm, Me [IQR]	1.5 [1.3–1.6]	1.5 [1.35–1.6]	0.6 [0.3–1.0]	< 0.001 p_{3-1} < 0.001 p_{3-2} < 0.001
4 h after block, cm, Me [IQR]	1.5 [1.2–1.6]	1.6 [1.2–1.7]	0.6 [0.3–0.97]	< 0.001 p_{3-1} < 0.001 p_{3-2} < 0.001
24 h after block, cm, Me [IQR]	1.7 [1.7–1.8]	1.7 [1.6–1.8]	1.7 [1.6–1.8]	0.427

Note: cm — centimeters; IQR — interquartile range; *p* — Pearson's chi-squared test.
Quantitative data are represented as a median (Me).

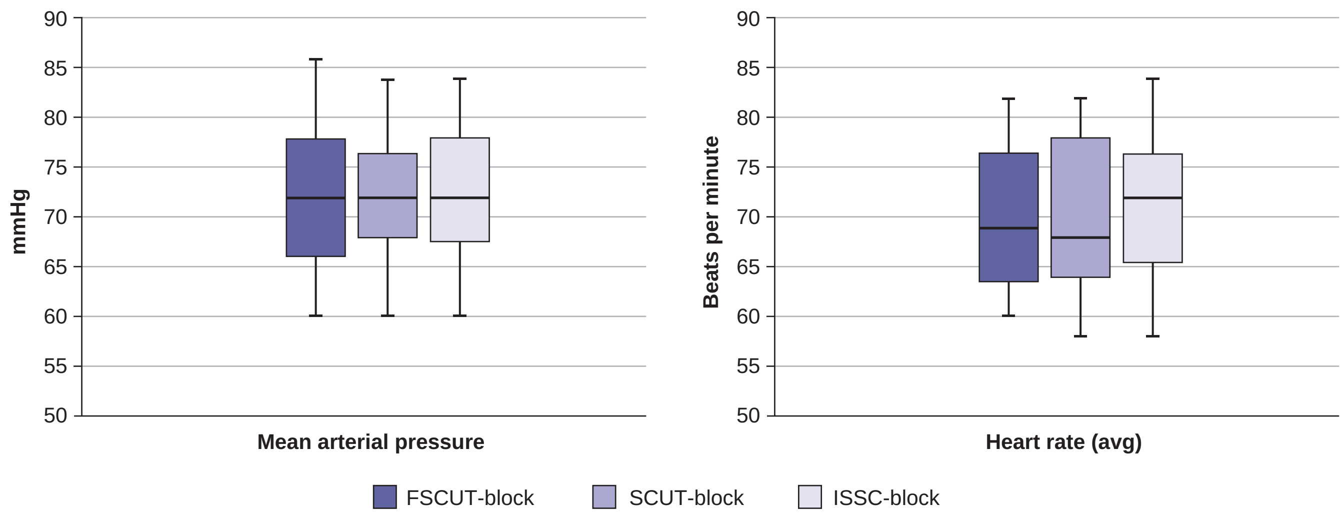

Fig. 5. Comparison of intraoperative hemodynamic parameters

quently in the ISSC group (p = 0.005 and p < 0.001, respectively) (Figure 9).

Mean respiratory rate did not differ significantly among groups in the preoperative period (p = 0.670). Intraoperatively, respiratory rate was significantly higher in the ISSC group (15/min) compared with the SCUT and FSCUT groups (14/min each; p = 0.006).

There were seven cases of ipsilateral eyelid ptosis in the ISSC group, one case in the FSCUT group (odds ratio [OR] 0.113; 95% CI 0.013–0.988) and two cases in the SCUT group (OR 0.227; 95% CI 0.043–1.197). In the ISSC group, four patients (13.3 %) reported transient hoarseness after the block. No other complications were recorded.

Discussion

General anesthesia remains the method of choice for clavicle surgery because of concerns about the high incidence of phrenic nerve block and prolonged motor block of the operated limb associated with the combination of interscalene brachial plexus block and superficial cervical plexus block [6]. In our study, we proposed FSCUT-block as an alternative regional anesthesia technique that demonstrates a more favorable safety profile and is not accompanied by prolonged motor block.

The results obtained are consistent with published data regarding preservation of diaphragmatic function during selective blocks achieved by limiting the volume of local anesthetic (< 10 ml) and by accurate ultrasound-guided needle placement [13]. In the present study, the incidence of unintentional phrenic nerve block ranged from 20 % to 90 %, depending on the technique, which corresponds to previously reported data. Zhang H. et al. demonstrated that a selective approach can reduce the incidence of ipsilateral diaphragmatic paresis from 100 % to 16.7 % (RR 0.17; 95% CI 0.09–0.31; p < 0.001) and that the rate of complete paralysis can be reduced from 93.7 % to 6.3 % [14]. In contrast, Kang R. et al. reported a decrease in the incidence of diaphragmatic paresis from 97.5 % to 76.3 % (p = 0.006) with selective up-

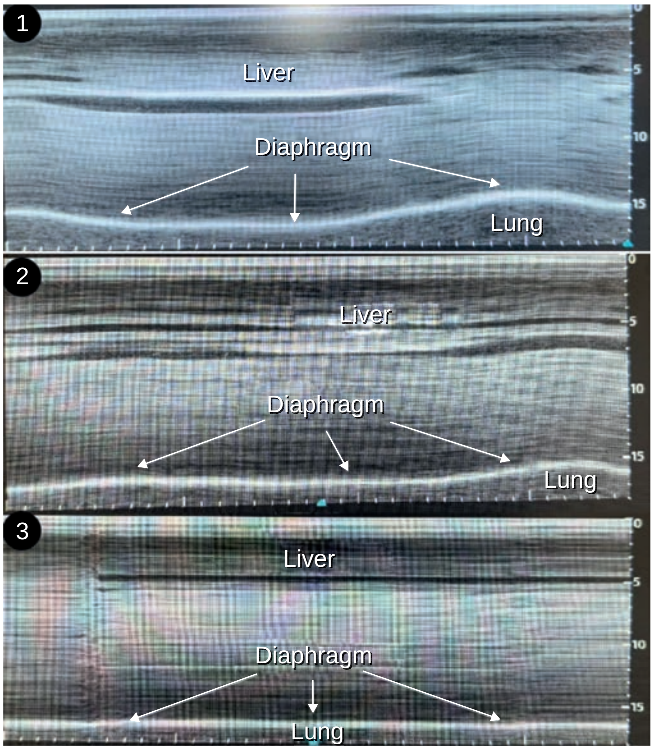

Fig. 6. Ultrasound assessment of diaphragm excursion in M-mode in a patient of Group 3 over time: 1 — before block; 2 — 30 minutes after block; 3 — 4 hours after block (Credit: authors)

Fig. 8. Clinical example of the sensory block distribution in Group 1 (photo from authors' personal archive). The red line outlines the area of sensory block

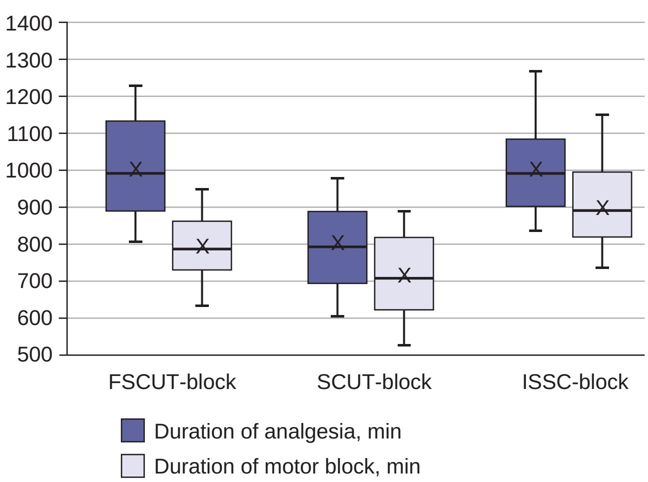

Fig. 7. Comparison of mean duration of analgesia and motor block (min) for different block techniques

Note: min — minutes.

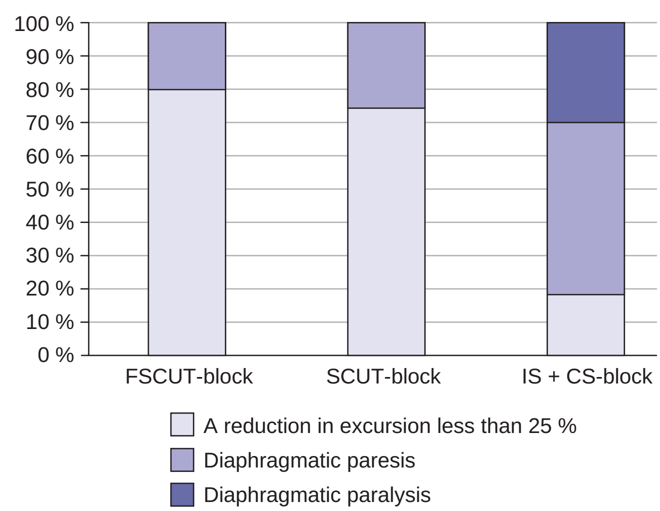

Fig. 9. Incidence of diaphragmatic paresis and paralysis across block techniques

per trunk block, while complete paralysis occurred in 5.3 % of cases versus 72.5 % in the ISB group [14].

When performing superficial cervical plexus block, the spread of anesthetic is limited by the prevertebral fascia, which acts as a hydrophobic barrier [15, 16]; therefore, the incidence of diaphragmatic and recurrent laryngeal nerve paresis during this block is about 2.9 % [17].

The optimal minimum effective volume of local anesthetic for combined brachial and cervical plexus blocks that ensures adequate analgesia while minimizing side effects remains a subject of debate. Riazi S. et al. showed that reducing the volume of anesthetic from 20 ml to 5 ml during ISB does not affect the duration of analgesia but reduces the incidence of complications [7]. According to Falcão L.F. et al., a volume of 2.34–4.29 ml of 0.5 % bupivacaine with epinephrine is sufficient for prolonged and adequate postoperative analgesia [18]. However, in these studies regional anesthesia was mainly used for postoperative analgesia in patients under general anesthesia; such volumes of local anesthetic were insufficient for surgical anesthesia. In the context of our study, these data suggest that differences in analgesia duration are primarily due to technical features of the blocks that determine the distribution of anesthetic within the fascial compartments of the neck.

Ipsilateral diaphragmatic paresis is known to lead to a significant reduction in pulmonary function, manifested as decreased forced expiratory volume in 1 second, forced vital capacity and peak expiratory flow rate. In patients without pre-existing respiratory pathology, these changes are usually clinically silent [19, 20], but they may cause shortness of breath in the supine position, typical of the postoperative period [21]. Cases of prolonged phrenic nerve dysfunction after ISB have been reported, including development of severe restrictive ventilatory defect with respiratory failure requiring nocturnal mechanical ventilation for more than one year in a 64-year-old patient without pulmonary comorbidity [22]. In our study, the time course of complication resolution corresponded to literature data: peak diaphragmatic dysfunction coincided with the period of maximal motor block, and recovery occurred within 24 hours [23].

Large volumes of local anesthetic during ISB are also associated with a high incidence of stellate ganglion block, clinically manifested as Horner's syndrome. This complication can provoke episodes of hypotension and bradycardia during surgery performed in the semi-sitting or "beach chair" position [24]. In our clinic, clavicle osteosynthesis is performed with the patient supine, and no episodes of hypotension were recorded. It should be noted that internationally these operations are often performed in a modified beach-chair position [11, 25], where the incidence of hypotensive episodes reaches 13–28 % due to the Bezold-Jarisch reflex, potentially leading to circulatory arrest [23, 26].

Study limitations

The limitations of this study include the exclusion of patients with concomitant respiratory pathology and the consequent need for further investigation of respiratory impairment caused by diaphragmatic paresis or paralysis in patients with pre-existing respiratory dysfunction.

Conclusion

The proposed combination of fascial block of the supraclavicular nerve group with upper trunk block of the brachial plexus (FSCUT-block) offers significant advantages over other anesthesia techniques for the shoulder region. In particular, it is associated with a low incidence of unintentional phrenic nerve block and other adverse events, thereby improving patient safety compared with traditionally used methods.

Sensory analgesia comparable in duration to interscalene brachial plexus and cervical plexus block, but with less motor block of the operated limb, may enhance patient comfort and accelerate postoperative recovery.

Disclosure. The authors declare that they have no competing interests.

Author contribution. All authors according to the ICMJE criteria participated in the development of the concept of the article, obtaining and analyzing factual data, writing and editing the text of the article, checking and approving the text of the article.

Ethics approval. The study was approved by the local Ethics Committee of the Privolzhsky Research Medical University (protocol No. 14 dated 22.12.2023).

Funding source. The authors received no external funding for this study.

Data Availability Statement. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author's ORCID:

Adamenko A.N. — 0009-0005-4411-9614

Ezhevskaya A.A. — 0000-0002-9286-4679

Zagrekov V.I. — 0000-0001-8235-7705

References

[1] *Postacchini F., Gumina S., De Santis P., Albo F.* Epidemiology of clavicle fractures. J Shoulder Elbow Surg. 2002; 11(5): 452–6. DOI: 10.1067/mse.2002.126613

[2] *Kim D.W., Kim D.H., Kim B.S., Cho C.H.* Current Concepts for Classification and Treatment of Distal Clavicle Fractures. Clin Orthop Surg. 2020; 12(2): 135–44. DOI: 10.4055/cios20010

[3] *Moverley R., Little N., Gulihar A., Singh B*. Current concepts in the management of clavicle fractures. J Clin Orthop Trauma. 2020; 11(Suppl 1): S25–S30. DOI: 10.1016/j.jcot.2019.07.016

[4] *Kaciroglu A., Karakaya M.A., Ahiskalioglu, A., et al.* Ultrasound-guided combined interscalene and superficial cervical plexus blocks for anesthesia management during clavicle fracture surgery. Ain-Shams J Anesthesiol. 2019; 11: 28. DOI: 10.1186/s42077-019-0039-5

[5] *Сафин Р.Р.* Анализ осложнений при различных вариантах блокады плечевого сплетения. М.: Практическая медицина, 2018. [*Safin R.R.* Analysis of complications during different variants of brachial plexus blockade. Moscow: Practical Medicine, 2018. (In Russ)] DOI: 10.32000/2072-1757-2018-7-65-66

[6] *Lee C.C.M., Beh Z.Y., Lua C.B., et al.* Regional Anesthetic and Analgesic Techniques for Clavicle Fractures and Clavicle Surgeries: Part 1-A Scoping Review. Healthcare (Basel). 2022; 10(8): 1487. DOI: 10.3390/healthcare10081487

[7] *Riazi S., Carmichael N., Awad I., et al.* Effect of local anaesthetic volume (20 vs 5 ml) on the efficacy and respiratory consequences of ultrasound-guided interscalene brachial plexus block. Br J Anaesth. 2008; 101(4): 549–56. DOI: 10.1093/bja/aen229

[8] *Sinha S.K., Abrams J.H., Barnett J.T., et al*. Decreasing the local anesthetic volume from 20 to 10 mL for ultrasound-guided interscalene block at the cricoid level does not reduce the incidence of hemidiaphragmatic paresis. Reg Anesth Pain Med. 2011; 36(1): 17–20. DOI: 10.1097/aap.0b013e3182030648

[9] *Lee M.G., Shin Y.J., You H.S., et al*. A Comparison of Anesthetic Quality Between Interscalene Block and Superior Trunk Block for Arthroscopic Shoulder Surgery: A Randomized Controlled Trial. Pain Physician. 2021; 24(3): 235–42. DOI: 10.36076/ppj.2021/24/235

[10] *Kim K.S., Ahn J.H., Yoon J.H., et al*. Hemidiaphragmatic Paresis Following Interscalene Brachial Plexus Block With 2-Point Injection Technique. Pain Physician. 2021; 24(8): 507–15 Accessed July 10, 2025 https://www.painphysicianjournal.com/linkout?issn = &vol = 24&page = 507

[11] *Sivashanmugam T., Areti A., Selvum E., et al*. Selective blockade of supraclavicular nerves and upper trunk of brachial plexus "The SCUT block" towards a site-specific regional anaesthesia strategy for clavicle surgeries — A descriptive study. Indian J Anaesth. 2021; 65(9): 656–61. DOI: 10.4103/ija.ija_255_21

[12] *Valdés-Vilches L.F., Sánchez-del Águila M.J*. Anesthesia for clavicular fracture: selective supraclavicular nerve block is the key. Reg Anesth Pain Med. 2014; 39(3): 258–9. DOI: 10.1097/AAP.0000000000000057.

[13] *Zhang H., Qu Z., Miao Y., et al*. Comparison Between Subparaneural Upper Trunk and Conventional Interscalene Blocks for Arthroscopic Shoulder Surgery: A Randomized Noninferiority Trial. Anesth Analg. 2022; 134(6): 1308–17. DOI: 10.1213/ANE.0000000000005990

[14] *Kang R., Jeong J.S., Chin K.J., et al*. Superior Trunk Block Provides Noninferior Analgesia Compared with Interscalene Brachial Plexus Block in Arthroscopic Shoulder Surgery. Anesthesiology. 2019; 131(6)1316–26. DOI: 10.1097/ALN.0000000000002919

[15] *Seidel R., Schulze M., Zukowski K., et al.* Ultraschallgesteuerte intermediäre zervikale Plexusanästhesie: Anatomische Untersuchung [Ultrasound-guided intermediate cervical plexus block. Anatomical study]. Anaesthesist. 2015; 64(6): 446–50. DOI: 10.1007/s00101-015-0018-6

[16] *Warshafsky D., Goldenberg D., Kanekar S.G*. Imaging anatomy of deep neck spaces. Otolaryngol Clin North Am. 2012; 45(6): 1203–21. DOI: 10.1016/j.otc.2012.08.001

[17] *Abdelghany M.S., Ahmed S.A., Afandy M.E*. Superficial cervical plexus block alone or combined with interscalene brachial plexus block in surgery for clavicle fractures: a randomized clinical trial. Minerva Anestesiol. 2021; 87(5): 523–32. DOI: 10.23736/S0375-9393.21.14865-5

[18] *Falcão L.F., Perez M.V., de Castro I., et al.* Minimum effective volume of 0.5 % bupivacaine with epinephrine in ultrasound-guided interscalene brachial plexus block. Br J Anaesth. 2013; 110(3): 450–5. DOI: 10.1093/bja/aes419

[19] *Urmey W.F., McDonald M.* Hemidiaphragmatic paresis during interscalene brachial plexus block: effects on pulmonary function and chest wall mechanics. Anesth Analg. 1992; 74(3): 352–7. DOI: 10.1213/00000539-199203000-00006

[20] *Zhuo Q., Zheng Y., Hu Z., et al.* Ultrasound-Guided Clavipectoral Fascial Plane Block With Intermediate Cervical Plexus Block for Midshaft Clavicular Surgery: A Prospective Randomized Controlled Trial. Anesth Analg. 2022; 135(3): 633–40. DOI: 10.1213/ANE.0000000000005911

[21] *McCool F.D., Tzelepis G.E*. Dysfunction of the diaphragm. N. Engl. J. Med. 2012; 366(10): 932–42. DOI: 10.1056/NEJMra1007236

[22] *Cugnin N., Le Gaillard B., Souza Neto E.P.* Permanent hemidiaphragmatic paresis after interscalene brachial plexus block: a case report. Braz J Anesthesiol. 2021; 71(2): 175–7. DOI: 10.1016/j.bjane.2021.02.009

[23] *Deruddre S., Vidal D., Benhamou D.* A case of persistent hemidiaphragmatic paralysis following interscalene brachial plexus block. J Clin Anesth. 2006; 18(3): 238–9. DOI: 10.1016/j.jclinane.2005.03.010

[24] *Трухин К.С., Заболотский Д.В., Корячкин В.А., и др.* Влияние блокады плечевого сплетения на частоту артериальной гипотонии и брадикардии при артроскопии плеча у подростков. Ортопедия, травматология и восстановительная хирургия детского возраста. 2020; 8(1): 35–42. [*Trukhin K.S., Zabolotskii D.V., Koriachkin V.A., et al*. Effect of brachial plexus block on the incidence of arterial hypotension and bradycardia events during shoulder arthroscopy in adolescents. Pediatric Traumatology, Orthopaedics and Reconstructive Surgery. 2020; 8(1): 35–42. (In Russ)] DOI: 10.17816/PTORS17538

[25] *Sonawane K., Dharmapuri S., Saxena S., et al*. Awake Single-Stage Bilateral Clavicle Surgeries Under Bilateral Clavipectoral Fascial Plane Blocks: A Case Report and Review of Literature. Cureus. 2021; 13(12): e20537. DOI: 10.7759/cureus.20537

[26] *Kim J.H., Song S.Y., Ryu T., et al*. Changes in heart rate variability after sitting following interscalene block. Clin Auton Res. 2015; 25(5): 327–33. DOI: 10.1007/s10286-015-0312-z