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The Analgesic Efficacy of Prolonged Erector Spinae Fascial Plane Block in Patients with Multiple Rib Fractures

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Summary

Objctive. To evaluate the analgesic efficacy of prolonged erector spinae fascial plane (ESFP) block in patients with multiple rib fractures.

Material and methods. The study included 40 patients with multiple rib fractures. Based on anesthesia methods, patients were divided into 2 groups, where systemic analgesics were used for pain management in the control group (*N*=20), and additional supplementation with prolonged erector spinae fascial plane (ESFP) block in the main group (*N*=20). The study monitored the severity of pain measured by the numeric rating scale (NRS) at rest and during coughing, forced vital capacity (FVC), and the need for injectable narcotic analgesics.

Results. The NRS measures at rest in the main group were statistically significantly superior to the control group results: at stage II — 1.5 points (IQR: 1.0–3.0) vs 3.0 points (IQR: 3.0–4.0); at stage III — 2.0 points (IQR: 1.0–2.0) vs 4.0 points (IQR: 3.0–5.0); at stage IV — 1.5 points (IQR: 0.8–2.2) vs. 4.5 points (IQR: 4.0–5.0); at stage V — 1 point (IQR: 0–2,0) vs. 3.0 points (IQR: 2.8–4.0), respectively ($P<0.001$). Percentages of predicted FVC depending on patient's gender, age, height and weight in the control group were as follows: at stage II — 38± 8% (95%CI: 34–41); stage III — 44± 8% (95%CI: 40–47); stage IV — 41±10% (95%CI: 36–45) and stage V — 49±10% (95%CI: 45–53). In the main group, the following FVC values were obtained: 49±15% at stage II (95%CI: 42–56), 50±13% at stage III (95%CI: 44–57), 53±13% at stage IV (95%CI: 47–59), and 57±11% at stage V (95%CI: 52–63). Therefore, statistically significant FVC reduction in the control group vs the main group came up to 22%, 14%, 24% and 15% at stages II-V, respectively ($P<0.05$). The amounts of injected narcotic analgesics on day 1 and day 2 after initiation of the study were 5.0 mg (IQR: 5–10) and 5.0 mg (IQR: 0–5.0) in the main group vs 10.0 mg (IQR: 5.0–15.0) and 7.5 mg (IQR: 5.0–10.0) in the control group, respectively ($P<0.05$).

Conclusion. The prolonged erector spinae fascial plane block improves the quality of analgesia and FVC values in patients with multiple rib fractures.

Key words: long-term continuous block; erector spinae muscle; fascial plane; anesthesia; multiple fractures; ribs

Conflict of interest. The authors declare no conflict of interest.

Introduction

Rib fractures account for 10–12% of all trauma events and are generally a marker of serious injury [1]. Fractures of three or more ribs are defined as multiple and account for up to 68% of all rib fractures [2]. Despite timely and state-of-the-art medical care, this condition is associated with various severe pleural and pulmonary complications in 33%, including pulmonary atelectasis, pneumonia, ARDS, hydro- and pneumothorax, and pleural empyema, significantly prolonging hospital stay [3]. Pain in multiple rib fractures is very intense, and simple physiological actions such as deep breathing, productive coughing, and changes in body position lead to an increase in pain intensity. As a result, chest stiffness and the likelihood of atelectasis and pneumonia increase [4]. Accordingly, the selection and use of the optimal method of emergency pain management in patients with multiple rib fractures is an essential component of the comprehensive management of these patients [5]. In our opinion, multimodal analgesia with systemic analgesics combined with regional analgesia, such as erector spinae plane block (ESPB), seems to be the best method to treat patients with multiple rib fractures.

The erector spinae plane block was first described by Forero M. et al. in 2016 as a new method of regional block of thoracic nerves for the treatment of neuropathic pain [6]. The target of the block when injecting local anesthetic (LA) is the «fascial plane», which is located along the spine, between the anterior surface of the erector spinae muscle and the posterior part of the transverse processes of the vertebrae. Thus, when LA spreads along the fascia, it affects the posterior branches of the spinal nerves, and when it spreads anteriorly into the paravertebral space, it also affects the anterior branches of the spinal nerves, providing analgesia to the posterior, lateral, and anterior chest wall [6–9]. Available publications report broad indications for the use of ESPB, including pain relief for multiple rib fractures [10–14].

ESPB in a patient with multiple rib fractures was first described by Hamilton et al. who noted a

decrease in pain intensity scores on a numeric rating scale from 6 out of 10 at rest and 10 out of 10 on cough (despite prior multimodal analgesia) to 0 out of 10 at rest and 1 out of 10 on cough after only a few minutes of ESPB [15].

Other papers describing a series of clinical observations have also reported good pain relief after ESPB in patients with multiple rib fractures [16, 17]. A retrospective cohort study without a control group demonstrated the efficacy of pain management in 79 patients with multiple rib fractures after ESPB, as measured by reduced pain intensity, increased inspiratory volume on incentive spirometry, and reduced use of narcotic analgesics [18]. The persistent problem of inadequate pain relief in patients with multiple rib fractures, the search for an optimal method of pain relief, and the need to overcome the shortcomings of previous studies, such as the small number of patients and lack of a control group, provide a rationale for conducting our study.

Aim of the study: To evaluate the efficacy of extended erector spinae plane block in patients with multiple rib fractures.

Materials and Methods

A prospective study was conducted at the Republican Scientific Center for Emergency Medical Care in 2019 on 40 patients admitted for emergency indications with multiple rib fractures in the context of combined or isolated thoracic trauma.

Inclusion criteria: age 18 years and older, two and more rib fractures, conservative therapy.

Exclusion criteria: impaired consciousness (Glasgow Coma Score less than 14 points), Injury Severity Score greater than 25 points, need for mechanical ventilation or surgery under general anesthesia. All patients were divided into two groups according to the type of anesthesia. Patients in the control group (*N*=20) were prescribed with systemic analgesics such as Diclofenac 75 mg intramuscularly (i.m.) twice daily or Ketoprofen 100 mg i.m. or intravenously (i.v.) three times daily, Acetaminophen 1 g, administered i.v., four times daily. In addition, a ketoprofen patch was applied to the injured rib area and changed once a day, while Promedol 20 mg or Morphine 10 mg or Omnopon 20 mg i.m. or i.v. were administered for severe pain. Patients in the main group (*N*=20) received systemic analgesics in the same regimen as in the control group, supplemented by prolonged ESPB on day 1 after admission.

No differences were found between the groups in age, sex, frequency of injury causes, number of ribs injured, injury severity according to the Injury Severity Score (ISS), and injury characteristics (Table 1, $P>0.05$).

Before performing the block, the patients were informed about the upcoming manipulation, and after obtaining the patient's consent, an extended ESPB was performed under aseptic and antiseptic conditions.

Routine monitoring (BP, pulse, ECG, SpO_2) was performed during the first day after the patient's admission to the hospital. The patient's position during the block was chosen according to the patient's activity: lying on the side, opposite to the block, or sitting up. The level of the block was determined by the transverse process of the vertebra corresponding to the underlying injured ribs (Fig. 1).

Ultrasound guidance was performed with a 7–12 MHz linear transducer on a portable ultrasound device (Samsung Medison R3, South Korea). The appropriate transverse process was visualized 2.5–3 cm lateral to the spinous processes in the longitudinal position of the transducer. After determining the appropriate transverse process and marking the point of needle insertion, we performed aseptic preparation of the manipulation field and local infiltration anesthesia of the area of needle insertion with 4–5 mL of 1% lidocaine. A Tuohy 18G

Table 1. The main demographic and clinical parameters in groups of patients.

Parameter	Values in groups		*P*
	Control, *N*=20	Study, N=20	
Age, years (*M*±*SD*; 95%CI)	47.3±14.9; 40.3–54.3	48.8±15.6; 41.4–56.1	0.766
Sex, *N* (%)			
Female	5 (25.0)	5 (25.0)	1.000
Male	15 (75.0)	15 (75.0)	
Number of damaged ribs (*Me*; IQR)	4.0; 4.0–6.0	4.5; 4.0–6.0	0.707
Type of trauma, *N* (%)			
Single	10 (50.0)	9 (45.0)	1.000
Multiple	10 (50.0)	11 (55.0)	
Injury Severity Scale (ISS), points (*Me*; IQR)	14.0; 11.0–14.8	14.0; 11.0–17.0	0.423
Cause of trauma, *N* (%)			
Traffic accident	12 (60.0)	10 (50.0)	0.346
High altitude trauma	3 (15.0)	4 (20.0)	
Occupational injury	1 (5.0)	0 (0.0)	
Domestic injury	2 (10.0)	5 (25.0)	
Beating	0 (0.0)	1 (5.0)	
Other	2 (10.0)	0 (0.0)	

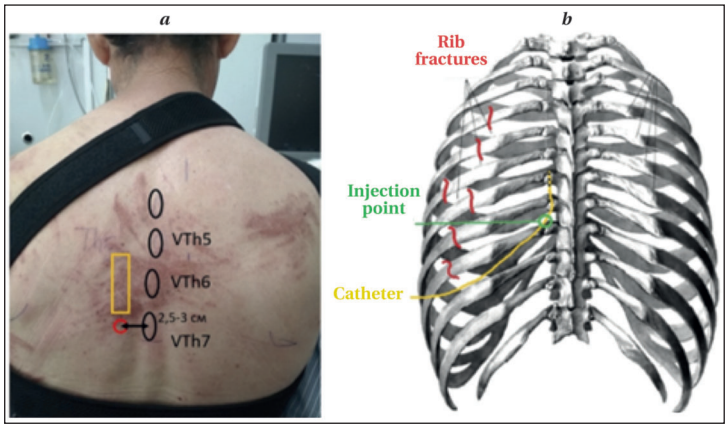

Fig. 1. Selection of injection site for catheter placement based on rib injury.
Note. *a* — clinical case. The red circle indicates the injection point of the needle, the yellow rectangle indicates the location of the base of the linear transducer. *b* — author's scheme of mutual positioning of the catheter tip and bony structures of the thorax (Fig. Bony structures, http://instruktor-fiz.org/wp-content/uploads/image/theory/clip_image023.jpg, Access date 2023.05.03).

needle was inserted in the cranial direction cranially under ultrasound guidance until contact was made with the distal part of the transverse process. The correct position of the needle tip in the fascial plane was determined by injecting up to 5 mL of normal saline, visualizing the linear spread of the solution beyond the erector spinae muscle and its separation from the surface of the transverse process. A 20 G catheter from the epidural kit was then inserted 4–5 cm cranially through the Tuohy needle and secured to the skin with a plaster. A 20 mL bolus of 1% lidocaine with 4 mg dexamethasone was injected through the catheter. For prolonged analgesia, an elastomeric pump was connected to the catheter immediately after the bolus administration, and a continuous infusion of 250 mL of 1% lidocaine was administered at a rate of 5 mL/h. Prolonged analgesia was maintained for three to seven days, depending on the patient's condition.

Pain intensity was assessed by numerical pain rating scale (NPRS) at rest and during coughing, and forced vital capacity (FVC) was measured by a portable spirometer as a percentage of predicted value based on the patient's sex, age, height, and weight. These values were recorded in both groups at several stages of the study: stage 1 — before the study (in both groups primary analgesia with NSAIDs and narcotics was administered), stage 2 — 1 hour later (in the control group after multimodal analgesia, in the main group after multimodal analgesia and block), stage 3 — 6 hours later, stage 4 — 24 hours later, stage 5 — 48 hours after the start of the study. The need for parenteral narcotic analgesics, calculated as the total dose of narcotic analgesics in parenteral morphine equivalent between 0–24 hours and 24–48 hours after the start of the study, was also assessed in the groups. Narcotic analgesic equivalence was calculated as follows: 10 mg Morphine = 20 mg Omnopon = 40 mg Promedol.

The results were analyzed using parametric and non-parametric methods. The collection, adjustment, organization of raw data and visualization of the obtained results were performed in Microsoft Office Excel 2020. Statistical analysis was performed using StatTech v. 2.8.4 (StatTech LLC, Russia). The Shapiro–Wilk criterion was used to assess the normality of the distribution. In case of normal distribution, the data were pooled into variation series, in which the means (*M*) and standard deviations (*SD*) and the 95% confidence interval (95%CI) were calculated. For non-normal distribution, quantitative variables were reported as median (*Me*) and interquartile range (IQR). The Mann–Whitney *U* test was used to compare independent populations when non-normal distribution was present. The nonparametric Friedman criterion with Holm-Bonferroni correction was used to compare more than two dependent samples with distribution different from normal. When the number of expected observations in any cell of the four-way table was less than 5, Fisher's exact test was used to estimate the significance of differences. When comparing means in samples of quantitative variables with normal distribution, Student's *t*-criterion was calculated. The paired Student's *t*-test was used to compare means calculated for paired samples.

Results

Pain intensity at rest as assessed by the NPRS did not differ between groups at stage 1 of the study (Table 2, P=0.128), but significant differences were found at all subsequent stages. The NPRS score at stage 2 was 1.5 points (IQR, 1.0 to 3.0) in the main group vs. 3.0 points (IQR, 3.0 to 4.0) in the control group, at stage 3 it was 2.0 points (IQR, 1.0 to 2.0) versus 4.0 points (IQR, 3.0 to 5.0), at stage 4, 1.5 points (IQR, 0.8 to 2.2) versus 4.5 points (IQR, 4.0 to 5.0), at stage 5, 1.0 point (IQR, 0 to 2.0) versus 3.0 points (IQR, 2.8 to 4.0), respectively (P<0.001). In the control group, there was a significant decrease in NPRS score only at stages 2 and 4 of the study (P<0.001). In the main group, the NPRS score decreased significantly by more than 50% at study stage 2 and remained significantly lower through and including study stage 5, when it reached its lowest point of 1.0 (IQR, 0 to 2.0) (P<0.001).

The NPRS values on cough in stages 2, 3, 4, and 5 of the study in the main group were significantly lower than those in the control group by more than 40% (Table 2, P<0.001). A significant de-

Table 2. Changes in the main parameters.

Group	Values in groups at the study stages					*P*
	1	2	3	4	5	
NPRS at rest, points (*Me*; IQR)						
Control	4.0; 3.0–5.0	3.0; 3.0–4.0	4.0; 3.0–5.0	4.5; 4.0–5.0	3.0; 2.8–4.0	<0.001[2*]
Study	5.0; 4.0–6.2	1.5; 1.0–3.0	2.0; 1.0–2.0	1.5; 0.8–2.2	1; 0–2.0	<0.001[2*] <0.001[3*] <0.001[4*] <0.001[5*]
P	0.128	<0.001*	<0.001*	<0.001*	<0.001*	—
NPRS on coughing, points (*Me*; IQR)						
Control	9.0; 9.0–10.0	9.0; 8.0–10.0	8.0; 8.0–9.0	7.0; 6.0–8.0	8.0; 8.0–8.2	<0.001[3*] <0.008[4*] 0.001[5*]
Study	10.0; 9.0–10.0	6.0; 5.0–7.0	5.0; 5.0–6.2	5.0; 4.0–6.0	5.5; 4.8–6.0	<0.001[2*] 0.001[3*] <0.001[4*] <0.001[5*]
P	0.390	<0.001*	<0.001*	<0.001*	<0.001*	—
FVC, % (*M*±*SD*; 95%CI)						
Control	38.1±8.3; 34.3–42.0	37.6±8.1; 33.8–41.5	43.5±7.7; 39.9–47.2	40.6±9.9; 36.0–45.2	49.0±9.5; 44.6–53.5	0.001[5*]
Study	41.9±11.5; 36.5–47.3	48.5±14.9; 41.6–55.5	50.5±13.1; 44.4–56.6	53.1±13.4; 46.9–59.4	57.4±11.3; 52.1–62.7	<0.001[2*] <0.001[3*] <0.001[4*] <0.001[5*]
P	0.244	0.007*	0.048*	0.002*	0.016*	—

Note. Significant differences, $P<0.05$: * — between groups; [2*] — between stages 1 and 2; [3*] — between stages 1 and 3; [4*] — between stages 1 and 4; [5*] — between stages 1 and 5. NPRS — numerical pain rating scale; FVC — forced vital capacity.

crease in the NPRS on cough in the control group was observed only from stage 3 of the study and reached a minimum in stage 4 of the study ($P<0.001$). In the main group, the reduction in this parameter was more dramatic, starting as early as stage 2, when it decreased by 40% and remained significantly lower until the end of the study ($P<0.001$).

From stage 2 of the study, FVC was significantly lower in the control group than in the main group (Table 2). While the FVC in the main group was 49±15% (95%CI, 42 to 56) at stage 2, 50±13% (95%CI, 44 to 57) at stage 3, 53±13% (95%CI, 47 to 59) at stage 4, and 57±11% (95%CI, 52 to 63) at stage 5, the FVC in the control group was 38±8% (95%CI, 34 to 41) at stage 2, 44±8% (95%CI, 40 to 47) at stage 3, 41±10% (95%CI, 36 to 45) at stage 4, and 49±10% (95%CI, 45 to 53) at stage 5, which were 22%, 14%, 24%, and 15% less than in the main group, respectively ($P<0.05$).

Both groups showed an increase in FVC of 22% in the control group and 27% in the main group from stage 1 to stage 5 of the study ($P<0.05$).

Changes in narcotic analgesic consumption in morphine equivalents are shown in Fig. 2. On day 1 after study initiation, this value was 5.0 mg (IQR, 5–10) in the main group versus 10.0 mg (IQR, 5.0–15.0) in the control group, which was significantly lower by 50% ($P<0.05$). On day 2, it was 5.0 mg (IQR, 0–5.0), also 33% lower than in the control group, where it was 7.5 mg (IQR, 5.0–10.0) ($P<0.05$).

Discussion

The lack of differences in the NPRS at rest and on cough between the groups during stage 1 of the study indicates their comparability. In the subsequent stages of the study, more effective pain relief was achieved with prolonged ESPB used in combination

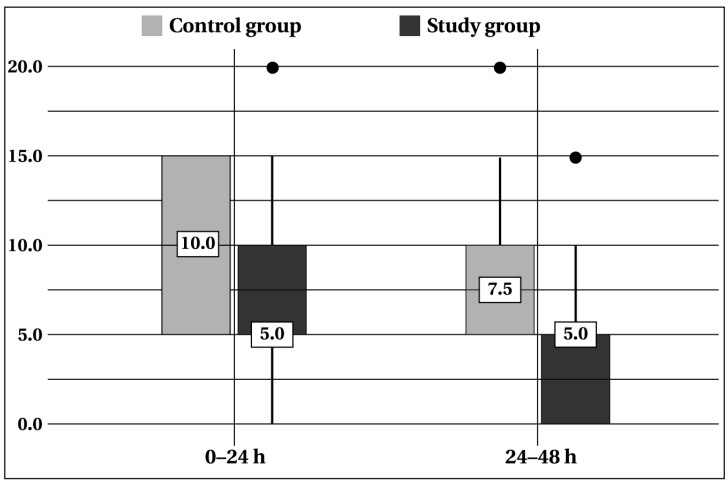

Fig. 2. The use of narcotic analgesics in morphine equivalent on days 1 and 2 after the start of the study.

with the multimodal systemic analgesic therapy. Similar trends in pain severity and respiratory parameters before and after ESPB were found in a study by Adhikari et al. where the NPRS score decreased by 39% in the first 3 hours and inspiratory volume on incentive spirometry increased by a mean of 545 mL (95% CI, 319 to 770 mL) in the first 24 hours after the block [18]. In another study with a smaller number of patients (*N*=10), NPRS at rest and on movement also decreased by 70% and 67%, respectively, within 96 hours [17].

Some authors argue that in fractures of two or less ribs and moderate pain, regional analgesia is not necessary and systemic analgesia alone is sufficient because of the increased risk of various complications associated with regional analgesia [19].

There is no doubt that the individual choice of a specific regional analgesia technique is determined by its efficacy, safety and ease of performance. The risk of complications with epidural analgesia and paravertebral blocks is higher than with fascial blocks. Unstable hemodynamic parameters and prior anticoagulant therapy may limit the use of epidural and paravertebral analgesia, whereas equally effective prolonged ESPB may serve as an alternative [20–22]. No complications of prolonged ESPB were observed in our study.

We used the method of dosed prolonged local anesthetic administration through a catheter connected to a microinfusion pump, the use of which requires staff training, based on literature data suggesting its advantages over fractional or single injection [23–25]. The 1% lidocaine was administered because of a wider therapeutic window compared to bupivacaine or ropivacaine used for fractional or single block, and a lower risk of systemic and cardiac toxicity.

The lack of a pre-specified sample size can be considered a limitation of our study.

Conclusion

Reduced pain perception scores, decreased narcotic analgesic consumption and increased FVC with prolonged erector spinae plane block suggest its efficacy in patients with multiple rib fractures.

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