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Ultrasound-Guided Erector Spinae Plane Block for Thoracoscopic Surgery: Analgesic Efficacy and Safety Evaluation

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Abstract: *Objective:* This study aimed to systematically evaluate the analgesic efficacy and safety of ultrasound-guided erector spinae plane block (ESPB) in patients undergoing thoracoscopic surgery. *Methods:* A prospective randomized controlled trial was conducted. One hundred patients scheduled for elective thoracoscopic surgery were randomly allocated to two groups: an experimental group receiving ESPB combined with general anesthesia (n = 50) and a control group receiving general anesthesia alone (n = 50). Postoperative pain intensity measured by Numerical Rating Scale (NRS) at multiple time points, total opioid consumption, incidence of adverse events, and quality of postoperative recovery were compared between the two groups. *Results:* Resting NRS scores at 2, 6, 12, 24, and 48 hours postoperatively were significantly lower in the experimental group than in the control group ($P < 0.001$). Morphine equivalent consumption over 48 hours was reduced by approximately 47%. The rate of rescue analgesia was markedly lower in the experimental group (18% vs. 52%). Opioid-related adverse events, including nausea, vomiting, and urinary retention, occurred less frequently in the experimental group. Hospital stay was shorter, pulmonary function recovery was superior, and the incidence of chronic pain at 3 months postoperatively was significantly reduced (4% vs. 18%). No serious complications, such as pneumothorax or local anesthetic toxicity, were observed throughout the study. *Conclusion:* Ultrasound-guided ESPB is safe and reliable. It effectively reduces postoperative pain, decreases opioid consumption, and promotes enhanced recovery in patients undergoing thoracoscopic surgery. These findings support its broader clinical application.

Keywords: Erector spinae plane block; Thoracoscopic surgery; Ultrasound guidance; Postoperative analgesia; Opioid sparing; Enhanced recovery after surgery; Randomized controlled trial

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1. Introduction

Thoracoscopic surgery has become the dominant approach in thoracic surgery. Its advantages—minimal invasiveness and rapid recovery—are well established. However, postoperative pain remains a significant clinical concern. Pain after thoracoscopic procedures arises from multiple sources, including intercostal nerve traction, pleural irritation, and incisional tissue damage. Patients commonly experience severe acute pain in the early postoperative period. Inadequate pain management not only delays recovery but may also lead to chronic pain syndrome, substantially impairing quality of life. For these reasons, optimizing perioperative analgesia for thoracoscopic surgery patients has remained an active area of investigation in anesthesiology. Conventional analgesia relies heavily on opioids. However, opioid use carries well-recognized adverse effects, including nausea, vomiting, respiratory depression, and the risk of dependence. These limitations have driven interest in regional anesthesia techniques as core components of multimodal analgesic strategies. The erector spinae plane block (ESPB) is a fascial plane block technique first described by Forero *et al.* in 2016. Under ultrasound guidance, local anesthetic is deposited deep to the erector spinae muscle. The injectate spreads cranially and caudally, penetrating the paravertebral space and interrupting nociceptive transmission in both the dorsal and ventral rami of spinal nerves. Evidence supporting ESPB has accumulated across multiple surgical contexts. In thoracic oncology, ESPB has shown promising analgesic potential for refractory pain management [1–3]. Systematic reviews and meta-analyses have demonstrated that ESPB significantly reduces perioperative opioid consumption in patients undergoing laparoscopic nephrectomy [4–7]. Quantitative assessment of its analgesic efficacy and systematic safety data in this context are still insufficient. The present study therefore aimed to conduct a prospective randomized controlled trial to evaluate the analgesic efficacy and safety of ultrasound-guided ESPB in patients undergoing thoracoscopic surgery. The findings are intended to provide evidence-based guidance for optimizing clinical anesthesia protocols [8].

2. Methods

2.1. Study design

A prospective randomized controlled trial design was adopted in this study, which was performed in the thoracic surgery operating rooms and the Department of Anesthesiology of our hospital from June 2024 to June 2025. Participants who met the inclusion criteria were then randomly allocated via a random number table in a ratio of 1:1 to receive intervention (experimental group, ultrasound-guided ESPB combined with general anesthesia) or control therapy (general anesthesia alone). Standardized thoracoscopic surgical procedure and perioperative care were provided to both groups [9]. Researchers who collected postoperative pain information and performed data analysis were asked not to know about the allocation of patients until they finished their work throughout the whole study course. So the result may be more accurate without interference and the conclusion will have greater credibility. Postoperative NRS score was regarded as the primary outcome, with some secondary outcomes including overall opioid consumption during the first 48 hours following operation, incidence of adverse events, and quality of recovery scores postoperatively [10].

2.2. Study participants

From June 2024 to June 2025, adult patients who were planned to undergo thoracoscopic surgery at our institution were considered for enrollment. Those who fulfilled one or more of the following conditions were excluded from the trial: age < 18 or > 70 years; ASA classification IV/V; BMI < 18.5 or ≥ 30.0 kg/m²; abnormal results found in their routine laboratory examination performed prior to surgery (tests concerning blood coagulation, liver/hepatic function and kidney function); and failure to sign the written informed consent voluntarily. Patients were excluded if they had a known allergy or contraindication to local anesthetics, infection, scarring, or anatomical abnormalities at the intended puncture site, severe cardiopulmonary insufficiency, coagulation disorders, or neurological disease. Long-term opioid use, a history of substance dependence, and pregnancy or lactation were also grounds for exclusion [11]. Sample size was calculated based on pilot data, with postoperative 24-hour NRS score as the primary endpoint. Using a two-sided significance level of $\alpha = 0.05$ and a power $(1 - \beta)$ of 0.80, the formula indicated 45 patients per group. Accounting for an anticipated 10% dropout rate, 50 patients per group were planned, giving a total enrollment of 100 patients [12].

2.3. Interventions

On arrival in the operating room, all patients had peripheral intravenous access established. Standard monitoring included electrocardiography, non-invasive blood pressure, and pulse oximetry. Invasive arterial blood pressure monitoring was established via radial artery cannulation under local anesthesia. Patients in the experimental group received ultrasound-guided ESPB prior to general anesthesia induction. Each patient was positioned in the lateral decubitus position with the operative side up. A high-frequency linear transducer (6–13 MHz) was placed at the level of the T5 transverse process on the operative side. Once the erector spinae muscle, rhomboid muscle, and transverse process were clearly visualized, an in-plane needle technique was used, advancing from medial to lateral. The needle tip was positioned within the fascial plane between the deep surface of the erector spinae muscle and the transverse process. Negative aspiration for blood and air was then performed, followed by injection of 30 mL of 0.375% ropivacaine hydrochloride. In real time, using ultrasound, there was confirmation of adequate spread of injectate within the fascial layer. In the control group, no regional block was performed at all [13]. General anesthesia induction was identical in both groups. Midazolam (0.05 mg/kg intravenously), propofol (1.5–2.0 mg/kg intravenously), sufentanil (0.4 μg/kg intravenously), and cisatracurium (0.2 mg/kg intravenously) were given in sequence to facilitate tracheal intubation. Propofol and remifentanil infusions provided maintenance of anesthesia.

2.4. Outcome measures

Outcome measures were divided into primary and secondary ones. Resting and active NRS pain scores at 2, 6, 12, 24, and 48 hours after operation were counted as the primary outcome. NRS scores range from 0 (no pain) to 10 (worst imaginable pain). Research nurses who had been trained according to the same program made the assessment blind to group allocation. There were many secondary outcomes including the following aspects. In the first aspect, the number of requests for a dose of patient-controlled intravenous analgesia (PCIA), as well as the amount of opioids administered during the first 48 hours after surgery were noted down (opioid dosages were converted to their morphine equivalent value based on conversion ratios). On the other hand, time to first rescue analgesia and the rate of rescue analgesic use were both measured [14].

2.5. Statistical analysis

All data were processed and analyzed by means of SPSS, version 26.0.

3. Results

3.1. Baseline characteristics

In this study, there were altogether 100 patients included, of whom there were 50 cases in each of the two groups. As shown in **Table 1** and **Figure 1** below, there was no significant difference in terms of the baseline characteristics between the two groups, such as age, gender ratio, BMI, ASA classification, and the type of operation performed, as well as whether there were other diseases before surgery (all $P > 0.05$). The results proved that the randomization was sufficient to keep the two groups balanced.

Table 1. Comparison of baseline characteristics between the two groups

Variable	Experimental group (n = 50)	Control group (n = 50)	χ^2/t	P value
Age (years, mean ± SD)	54.3 ± 9.7	55.1 ± 10.2	0.424	0.672
Sex (male/female, n)	28 / 22	30 / 20	0.17	0.681
BMI (kg/m², mean ± SD)	23.6 ± 2.8	24.1 ± 3.1	0.894	0.374
ASA class II (n, %)	36 (72%)	34 (68%)	0.211	0.645
ASA class III (n, %)	14 (28%)	16 (32%)	0.211	0.645
Operative duration (min, mean ± SD)	112.4 ± 24.6	115.8 ± 26.3	0.687	0.493
Intraoperative blood loss (mL, mean ± SD)	85.3 ± 18.7	88.6 ± 20.4	0.882	0.381
Hypertension (n, %)	16 (32%)	18 (36%)	0.178	0.673
Diabetes mellitus (n, %)	8 (16%)	10 (20%)	0.274	0.602

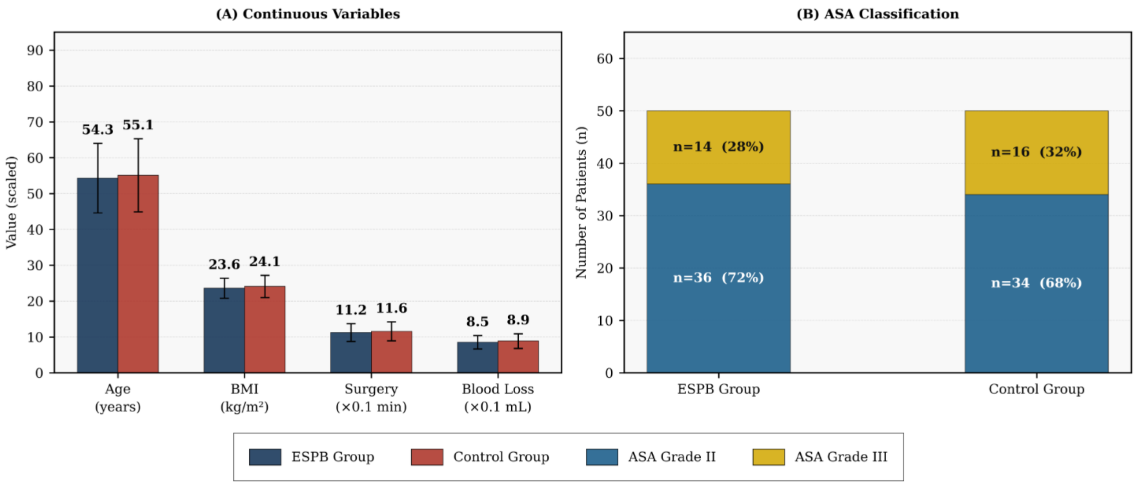

Figure 1. Baseline characteristics comparison between ESPB group and control group

3.2. Postoperative analgesic efficacy

Resting and active NRS pain scores were systematically compared between the two groups at 2, 6, 12, 24, and 48 hours postoperatively. Results are presented in **Table 2**. At every time point, resting NRS scores were significantly lower in the experimental group than in the control group: 2 h (2.1 ± 0.8 vs. 4.3 ± 1.1), 6 h (2.4 ± 0.9 vs. 4.6 ± 1.2), 12 h (2.8 ± 1.0 vs. 4.9 ± 1.3), 24 h (2.2 ± 0.8 vs. 4.1 ± 1.0), and 48 h (1.6 ± 0.7 vs. 3.2 ± 0.9), with all differences reaching statistical significance ($P < 0.001$). Active NRS scores followed the same pattern [15]. The experimental group showed consistently lower scores at all time points compared with the control group ($P < 0.001$). Regarding opioid consumption, total morphine equivalent use within 48 hours was 18.4 ± 5.2 mg in the experimental group, significantly less than 34.7 ± 7.8 mg in the control group ($P < 0.001$). Time to first rescue analgesia was 9.6 ± 2.3 h in the experimental group versus 4.2 ± 1.5 h in the control group ($P < 0.001$) [16]. The rescue analgesia rate was 18% in the experimental group and 52% in the control group ($P < 0.001$). QoR-15 scores at 24 and 48 hours postoperatively were significantly higher in the experimental group ($P < 0.05$). These results are illustrated in **Figure 2**.

Table 2. Comparison of postoperative analgesic outcomes between the two groups

Outcome measure	Experimental group (*n* = 50)	Control group (*n* = 50)	t/χ^2	*P* value
Resting NRS score — 2 h postoperative	2.1 ± 0.8	4.3 ± 1.1	11.82	< 0.001
Resting NRS score — 6 h postoperative	2.4 ± 0.9	4.6 ± 1.2	10.94	< 0.001
Resting NRS score — 12 h postoperative	2.8 ± 1.0	4.9 ± 1.3	9.76	< 0.001
Resting NRS score — 24 h postoperative	2.2 ± 0.8	4.1 ± 1.0	11.03	< 0.001
Resting NRS score — 48 h postoperative	1.6 ± 0.7	3.2 ± 0.9	10.47	< 0.001
48 h morphine equivalent (mg)	18.4 ± 5.2	34.7 ± 7.8	13.26	< 0.001
Time to first rescue analgesia (h)	9.6 ± 2.3	4.2 ± 1.5	14.18	< 0.001
Rescue analgesia rate (%)	18%	52%	13.47	< 0.001
QoR-15 score — 24 h postoperative	128.6 ± 12.4	108.3 ± 14.7	8.04	< 0.001
QoR-15 score — 48 h postoperative	136.2 ± 11.8	114.5 ± 13.2	9.42	< 0.001

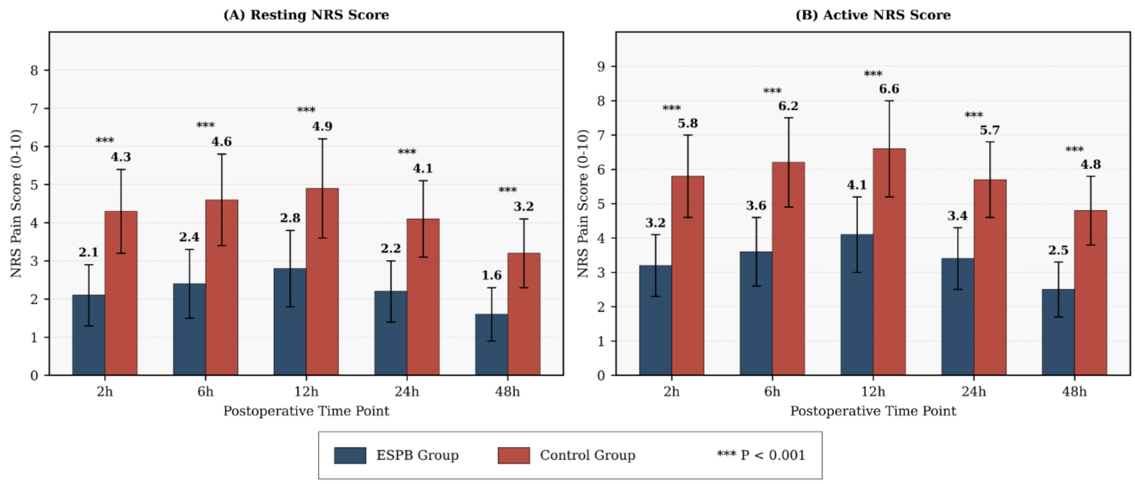

Figure 2. Postoperative NRS pain score comparison between ESPB group and control group

3.3. Safety and adverse event profile

A comprehensive safety assessment was conducted in both groups, covering block-related complications, opioid-related adverse events, and intraoperative hemodynamic parameters. The distribution of adverse events is illustrated in **Table 3** and **Figure 3**.

Table 3. Comparison of adverse events between the two groups

Adverse event	Experimental group (*n* = 50)	Control group (*n* = 50)	χ^2	*P* value
Nausea and vomiting (*n*, %)	6 (12%)	18 (36%)	8.22	0.004
Urinary retention (*n*, %)	3 (6%)	9 (18%)	3.94	0.048
Pruritus (*n*, %)	2 (4%)	7 (14%)	3.02	0.086
Respiratory depression (*n*, %)	0 (0%)	0 (0%)	—	—
Intraoperative hypotension (*n*, %)	4 (8%)	5 (10%)	0.13	0.724
Bradycardia (*n*, %)	3 (6%)	4 (8%)	0.15	0.696
Pneumothorax (*n*, %)	0 (0%)	0 (0%)	—	—
Local anesthetic systemic toxicity (*n*, %)	0 (0%)	0 (0%)	—	—
Overall adverse event rate (%)	13 (26%)	29 (58%)	10.94	< 0.001

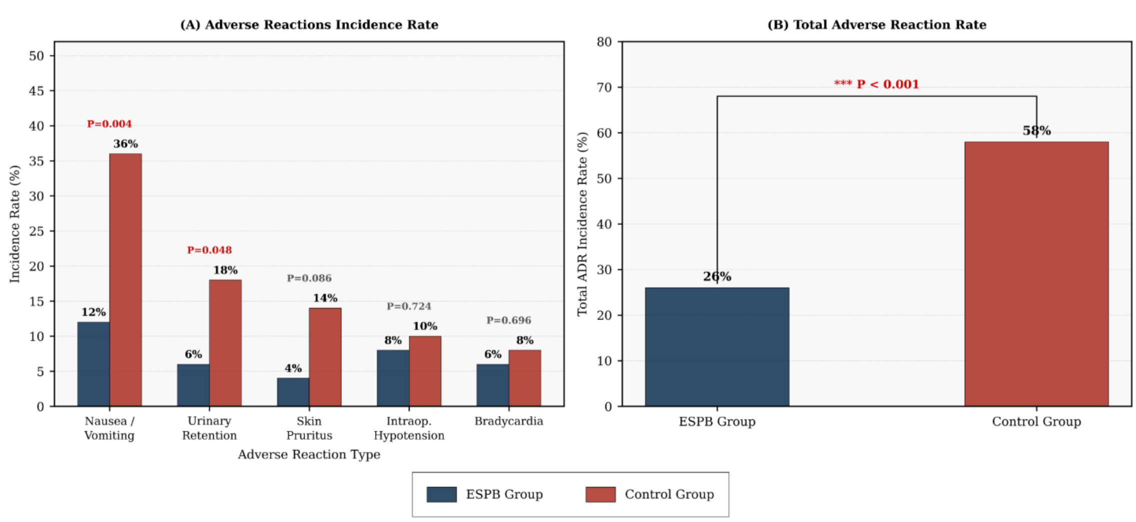

Figure 3. Safety and adverse reaction comparison between ESPB group and control group

3.4. Postoperative recovery quality

Postoperative recovery was evaluated across four dimensions: time to first ambulation, length of hospital stay, pulmonary function recovery, and QoR-15 scores. These findings are illustrated in **Table 4** and **Figure 4**.

Table 4. Comparison of postoperative recovery outcomes between the two groups

Outcome measure	Experimental group ($n = 50$)	Control group ($n = 50$)	t/χ^2	P value
Time to first ambulation (h)	14.2 ± 3.6	22.8 ± 4.9	10.84	< 0.001
Chest drain retention (days)	2.8 ± 0.7	3.6 ± 0.9	5.42	< 0.001
Total hospital stay (days)	6.4 ± 1.3	8.2 ± 1.7	6.37	< 0.001
FVC% — 24 h postoperative (%)	72.4 ± 8.3	62.1 ± 9.7	6.19	< 0.001
FVC% — 48 h postoperative (%)	81.6 ± 7.4	69.8 ± 8.5	7.98	< 0.001
QoR-15 — 24 h postoperative	128.6 ± 12.4	108.3 ± 14.7	8.04	< 0.001
QoR-15 — 48 h postoperative	136.2 ± 11.8	114.5 ± 13.2	9.42	< 0.001
Chronic pain — 1 month (%)	8% (4/50)	26% (13/50)	5.77	0.013
Chronic pain — 3 months (%)	4% (2/50)	18% (9/50)	5.01	0.021

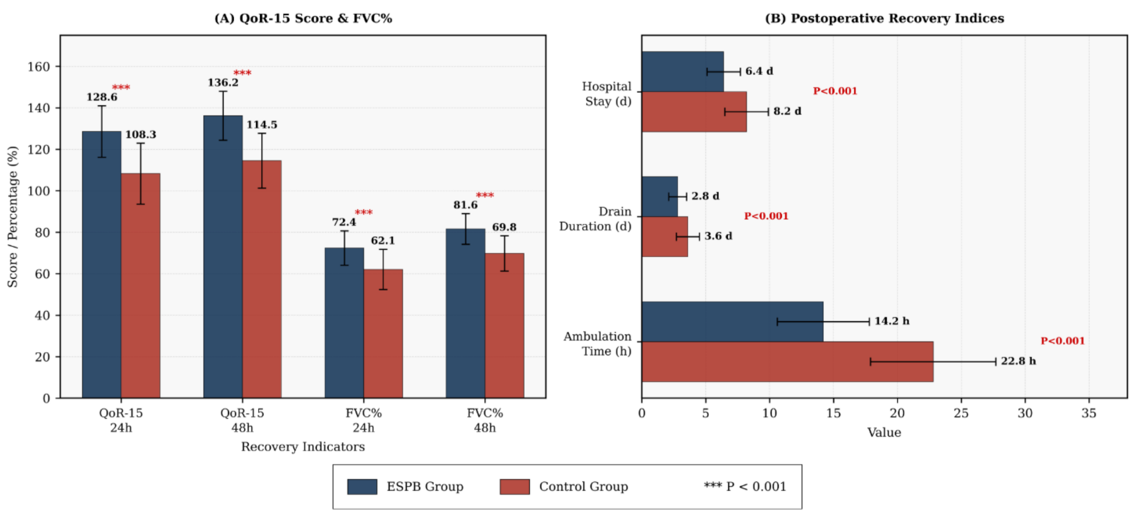

Figure 4. Postoperative recovery quality comparison between ESPB group and control group

4. Discussion

The purpose of this prospective randomized controlled study was to evaluate the analgesic effect and safety of ESPB in patients undergoing thoracoscopic surgery in a systematic manner. As compared with traditional thoracic paravertebral block, ESPB targets one plane deep to the erector spinae muscle, and its anatomical landmarks appear obvious under ultrasound guidance, so that the direction of the puncture needle remains distant from the pleura and even the spinal cord. So the risk of pneumothorax, spinal cord injury, or total spinal anesthesia is much smaller accordingly. In the current study, there were no occurrences of block-related serious adverse events among patients included in the experimental group throughout the entire research process. It once again proved the safety of this technique [17]. In addition, the opioid sparing effect was very significant clinically. Total morphine equivalent consumption within 48 h was reduced by almost 47% compared to the control group among patients included in the experimental group. And what's more importantly is that along with a decreased amount of morphine, the rate of opioid-related adverse reactions such as nausea and vomiting significantly decreased. At last, the incidence of urinary retention also dropped greatly. All these benefits were especially meaningful and valuable for thoracic surgery because early recovery of lung function and enhanced recovery after surgery

(ERAS) principles had become very important goals which surgeons should take into consideration [18]. Also noteworthy is that the incidence rate of chronic pain at both one month and three months following surgery was much smaller in the experimental group relative to the control group. Therefore, effective perioperative regional analgesia might decrease the incidence rate of chronic pain caused by surgery because it can weaken the generation process of central sensitization [19]. There are several limitations of this study. The sample size was relatively small, which makes it impossible to obtain very convincing conclusions; this work was carried out in only one medical center. Besides, the follow-up time was so short that there is no clear evidence of how long the effect of the treatment will last. In conclusion, in order to make results more reliable, multicenter large-sample randomized controlled trials need to be done to verify the results obtained here [20]. And optimization of protocols regarding the concentration and volume of locally applied anesthetics also requires exploration.

5. Conclusion

Erector spinae plane block guided by ultrasound is a relatively recently proposed fascial plane block technique. As the results show in this paper, there is considerable significance in the clinical role of ESPB in perioperative pain management of patients undergoing thoracoscopic surgeries. In combination with general anesthesia, ESPB can reduce pain scores significantly at each time point postoperatively. At the same time, less opioids were consumed. Fewer cases of adverse reactions caused by opioids also occurred among patients receiving ESPB. Pulmonary function recovered more quickly and hospital stays were shorter. Also, the risk of developing chronic pain could decrease to some extent if patients received ESPB treatment. Furthermore, the operation procedure of ESPB is easy to learn. With the guidance of ultrasound, the anatomical position of injection site is very clear and distinct. The safety of ESPB is acceptable too. All these features coincide perfectly with the concepts of ERAS. Therefore, ESPB has great potential to be applied widely among patients who undergo thoracoscopic surgery.

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Disclosure statement

The authors declare no conflict of interest.

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