Article

Clinical Utility of Ultrasound-Guided Erector Spinae Plane Block in Percutaneous Transforaminal Endoscopic Discectomy

Ann. Ital. Chir., 2026 97, 2: 382–391
https://doi.org/10.62713/aic.4138

Xiaoting Zheng[1], Jile Jiang[2], Yuequan Yan[3], Qinghui Chen[1], Guixiang Zheng[1], Bincheng Wang[1], Bin Huang[1], Weihan Chen[1], Qipeng Su[1]

[1]Department of Orthopaedics, Dehua County Hospital, 362500 Quanzhou, Fujian, China
[2]Department of Spine Surgery, Beijing Jishuitan Hospital, 100035 Beijing, China
[3]Department of Anesthesiology, Dehua County Hospital, 362500 Quanzhou, Fujian, China

AIM: To evaluate the feasibility and preliminary effects of ultrasound-guided erector spinae plane block (ESPB) in patients undergoing percutaneous transforaminal endoscopic discectomy (PTED).
METHODS: This exploratory randomized controlled trial enrolled 60 patients with lumbar disc herniation who underwent PTED between May and December 2021 at our institution. Participants were randomly assigned to either a local anesthesia (LA) group or an ESPB group (n = 30). Heart rate (HR), mean arterial pressure (MAP), and visual analogue scale (VAS) scores were recorded at four time points: before anesthesia (T0), during foraminoplasty (T1), during annulus fibrosus manipulation (T2), and at the end of surgery (T3). Additional outcomes included operative time, intraoperative blood loss, length of hospital stay, willingness to undergo reoperation, and outcomes based on the modified Macnab criteria. The Oswestry Disability Index (ODI) and VAS scores were also assessed preoperatively and at 3 and 6 months postoperatively.
RESULTS: All patients successfully completed the procedure. Compared with the LA group, the ESPB group exhibited more stable intraoperative HR and MAP, along with significantly lower VAS scores from T1 to T3 ($p < 0.05$), indicating potential benefits in intraoperative analgesia and hemodynamic control. No significant differences were observed in operative time, blood loss, or length of hospital stay between groups ($p > 0.05$). Both groups showed significant improvements in VAS and ODI scores over time ($p < 0.05$), although intergroup differences at follow-up were not statistically significant ($p > 0.05$).
CONCLUSIONS: Ultrasound-guided ESPB may enhance intraoperative comfort and analgesia compared to local anesthesia in PTED. These findings suggest that ESPB is a feasible and potentially beneficial approach in this setting. However, larger-scale confirmatory studies are required to establish definitive clinical efficacy and long-term benefits.
Clinical Trial Registration: ISRCTN (ISRCTN69505916).

Keywords: percutaneous transforaminal endoscopic discectomy; ultrasound-guided; erector spinae plane block; local anesthesia; lumbar disc herniation

Introduction

Lumbar intervertebral disc herniation (LDH) is recognized as one of the most prevalent conditions encountered in orthopedic clinical practice [1]. Sciatica is the most common clinical presentation, typically characterized by radiating pain from the lower back into the leg, often accompanied by motor or sensory impairment [2]. While numerous patients with LDH recover with conservative management, a subset requires surgical intervention due to treatment failure [3]. Surgical treatment can significantly alleviate pain, restore function, and improve quality of life [4]. As a result, surgical intervention is increasingly prioritized in patient management strategies.

Although conventional open microdiscectomy remains the gold standard for treating LDH [5], the development of spinal endoscopy has led to the increasing adoption of foraminoscopy due to its superior outcomes, including reduced trauma, faster recovery, less bleeding, and shorter hospital stay [6,7]. Traditional foraminoscopic procedures primarily utilize local anesthesia, which offers a high safety profile and allows for real-time communication between the patient and surgeon during the operation [8]. Intraoperative nerve damage can be determined by observing toe movements, making local anesthesia the most commonly used anesthetic approach in this context [8,9].

However, many patients report experiencing significant pain during surgery, particularly in the foraminoscopic procedure performed under local anesthesia, especially in the

Submitted: 28 April 2025 Revised: 16 June 2025 Accepted: 30 June 2025 Published: 9 February 2026
Correspondence to: Xiaoting Zheng, Department of Orthopaedics, Dehua County Hospital, 362500 Quanzhou, Fujian, China (e-mail: 1540635330@qq.com).
Editor: Roberto Cirocchi

posterior interlaminar approach. In some cases, patients are unable to tolerate the intraoperative pain, resulting in premature termination of the procedure. Additionally, being conscious during the operation may aggravate patient anxiety and fear, which can lead to elevated intraoperative blood pressure and vomiting [9].

The erector spinal plane block (ESPB), introduced in 2016, is a novel trunk nerve block technique [10]. By leveraging ultrasound guidance, ESPB enables the precise administration of local anesthetic to the fascial plane superficial to the erector spinae muscle, effectively blocking the erector spinae plane and adjacent peripheral nerves, thereby achieving a strong analgesic effect [11,12]. Research has demonstrated that ESPB provides effective perioperative and postoperative analgesia for lumbar spine surgeries [13–15]. Despite the growing interest in ESPB, its application in foraminoscopic procedures remains limited. Therefore, this study aimed to preliminarily evaluate the feasibility and short-term clinical efficacy of ultrasound-guided ESPB in patients undergoing percutaneous transforaminal endoscopic discectomy (PTED) through a randomized exploratory trial design.

Materials and Methods

Study Participants

Following the ethical standards of the Declaration of Helsinki, this study received approval from the Ethics Committee of Dehua Hospital of Huaqiao University (Approval No.2021L [001]). Written informed consent was obtained from all participants. Clinical Trial Registration: ISRCTN (ISRCTN69505916, https://www.isrctn.com/ISRCTN69505916). This randomized study included 60 patients with lumbar disc herniation who underwent PTED at Dehua Hospital of Huaqiao University between May and December 2021. Patients were randomly assigned to either the local anesthesia (LA) group or the ESPB group (n = 30 each) using a computer-generated random number table. Group allocations were placed in sequentially numbered, sealed, opaque envelopes by an independent investigator. After confirming eligibility and obtaining consent, envelopes were opened to reveal the group assignment. Inclusion criteria: (1) failure of conservative treatment for ≥12 weeks; (2) low back and/or leg pain, numbness, or motor weakness due to LDH; (3) The patient's clinical presentation was corroborated by the MRI and CT scan results, suggesting a clear diagnosis; (4) no history of foraminal surgery; (5) single-level LDH without thickening or calcification of the posterior longitudinal ligament or ligamentum flavum. Exclusion criteria: (1) surgical contraindication; (2) multilevel herniation, vertebral infection, or neoplasm; (3) scoliosis, spinal deformity, lumbar spondylolisthesis, or instability; (4) major systemic disease; (5) participant withdrawal.

Anesthesia and Surgical Procedure

Patients were positioned in the lateral decubitus position with the symptomatic side facing upward, and the skin was disinfected using standard aseptic procedures. In the LA group, 20 mL of 0.375% ropivacaine was administered at the skin puncture site, through the deep fascia, and around the articular processes. In the ESPB group, a high-frequency linear ultrasound probe (6–13 MHz) was aligned sagittally at the L3 vertebral level. Following identification of the spinous processes, the probe was moved laterally to visualize the transverse process and the overlying erector spinae muscle, approximately 3 cm from the midline. Under real-time ultrasound guidance, local anesthetic was precisely delivered into the fascial plane between the erector spinae muscle and the transverse process. An in-plane approach was adopted to insert an echogenic needle from a cranial-to-caudal direction. Needle placement was confirmed by hydrodissection with 2–3 mL of saline, after which 20 mL of 0.375% ropivacaine was injected to complete the block [16]. The L3 segment was selected based on its ability to allow cephalocaudal anesthetic spread across L1–L5 segments [17].

All surgical interventions were conducted by a single experienced surgeon utilizing an Surgi-Max® Ultra adjustable-tip bipolar radiofrequency system (Elliquence LLC, Baldwin, NY, USA), a percutaneous transforaminal endoscopic system (TESSYS®V2.0, Joimax GmbH, Karlsruhe, Germany), and an endoscopic device (MaxMorespine® Endoscope V3.2, MaxMoreSpine GmbH, Unterföhring, Germany).

The surgical intervention consisted of three main steps [18]: (1) Puncture: The cannula entry point was determined preoperatively based on CT scan and MRI findings. The precise location varied depending on individual anatomical characteristics but was typically 8–14 cm lateral to the midline. The puncture needle was directed toward the intersection of the coronal plane of the superior articular process and the horizontal plane of the target intervertebral disc. Using C-arm fluoroscopic guidance and referencing the nucleus pulposus protrusion site on preoperative imaging, the needle was advanced into the target zone. (2) Foraminoplasty: The intervertebral foramen was widened as needed using a bone drill to create an adequate working channel. (3) Discectomy: After positioning the working cannula, the endoscope was introduced. The herniated nucleus pulposus was excised using forceps under direct visualization. The nerve root was then inspected and decompressed until free pulsation synchronous with the heartbeat was observed, indicating successful decompression and completion of the procedure. The PTED surgical procedure is shown schematically in Fig. 1.

Evaluation Parameters

Intergroup differences in mean arterial pressure (MAP), heart rate (HR), and visual analog scale (VAS) scores were

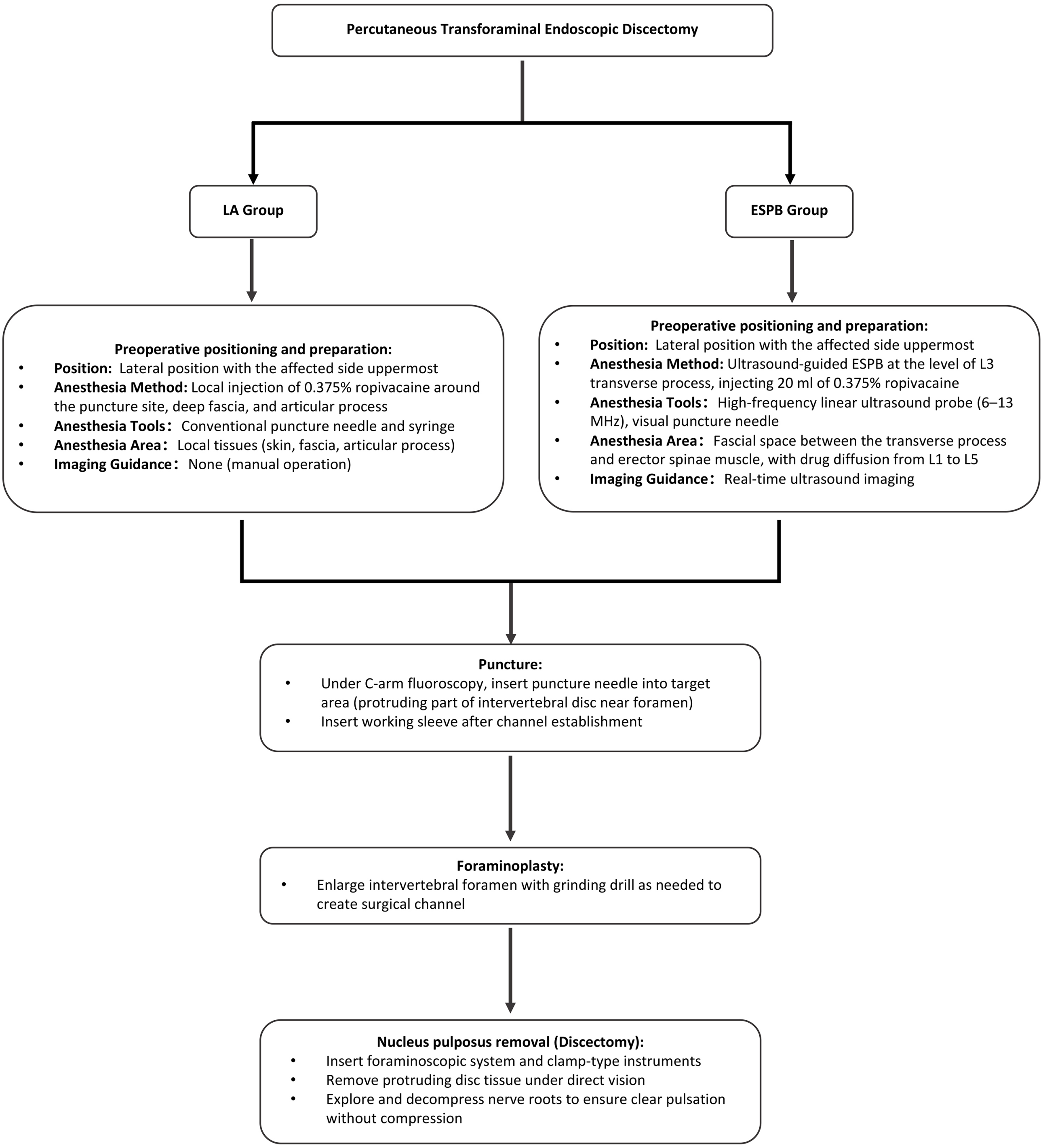

Fig. 1. Flowchart of percutaneous transforaminal endoscopic discectomy surgical procedure. LA, local anesthesia; ESPB, erector spinal plane block.

assessed before anesthesia (T0), during foraminoplasty (T1), during annulus fibrosus manipulation (T2), and at the end of surgery (T3). The VAS was a 10-point scale ranging from 0 (no pain) to 10 (most severe conceivable pain), used to evaluate intraoperative pain at each time point.

Additional variables recorded included the duration of surgery, length of hospital stay, intraoperative blood loss, total hospitalization cost, and patient willingness to undergo reoperation (In this study, "willingness to undergo reoperation" referred to whether the patient would be willing to choose the same procedure again if a similar condition arose in the future or if the same type of treatment was needed). Functional outcomes were assessed three months postoperatively utilizing the modified Macnab criteria [19], which categorize results into four grades: "Excellent" (no pain, no activity limitation), "Good" (intermittent pain, return

Table 1. Baseline characteristics of patients in the ESPB and LA groups.

Variable	ESPB (n = 30)	LA (n = 30)	$t/Z/\chi^2$	p-value
Number of patients	30	30		
Sex (male/female)	19/11	20/10	0.07	0.787
Age (years), median (IQR)	44 (38, 50)	43 (36, 49)	1.10	0.648
BMI (kg/m^2), mean $\pm$ SD	24.05 $\pm$ 3.78	23.62 $\pm$ 3.99	–0.33	0.739
Surgical level			0.07	0.795
L4/5	17	16		
L5/S1	13	14		
Pain duration (months), mean $\pm$ SD	5.67 $\pm$ 1.88	5.00 $\pm$ 1.68	–1.37	0.172
VAS (back) before surgery, median (IQR)	3.37 (2, 4)	3.5 (2, 5)	–0.70	0.485
VAS (leg) before surgery, mean $\pm$ SD	6.70 $\pm$ 1.84	6.47 $\pm$ 1.59	0.53	0.601
ODI before surgery (%), mean $\pm$ SD	56.12 $\pm$ 11.88	52.08 $\pm$ 10.83	–1.30	0.193

Note: Data are presented as mean $\pm$ SD or median (IQR).

Abbreviations: BMI, body mass index; ODI, Oswestry Disability Index; VAS, visual analog scale.

to normal activity), "Fair" (some improvement with residual functional limitation), and "Poor" (no improvement or worsening symptoms) [20].

Additionally, the Oswestry Disability Index (ODI) was employed to evaluate disability associated with lower back pain preoperatively and at 3 and 6 months postoperatively. [21]. The ODI comprises 10 items, each scored from 0 to 5, assessing daily activities such as walking, sitting, lifting, and sleeping. The total score was converted into a percentage (0% representing no disability, 100% indicating maximum disability) to quantify functional impairment and recovery of the patients. Given the nature of the procedures, complete blinding of patients was not feasible. However, patients were not explicitly informed of the specific anesthesia technique administered, and both groups received local anesthetic injections in the lumbar region. To minimize detection bias, all outcome assessments, including data acquisition and analysis, were performed by researchers blinded to group allocation.

Statistical Analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corporation, City, State, Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro-Wilk test. Continuous variables with normal distribution were presented as mean $\pm$ standard deviation ($\bar{x} \pm$ SD). Otherwise, data were presented as median (interquartile range). Categorical variables were described as counts and percentages. Intergroup comparisons were conducted using independent-sample t-tests or the Wilcoxon rank-sum test, depending on data distribution. Intragroup comparisons of preoperative and postoperative VAS and ODI scores were analyzed using paired t-tests or Wilcoxon signed-rank tests as appropriate. Categorical data were compared using chi-squared tests or Fisher's exact tests. Comparisons of modified Macnab outcomes were made using the Mann-Whitney U test. For repeatedly measured outcomes, such as HR, MAP, and VAS scores across time points (T0–T3), repeated measures analysis of variance (ANOVA) was conducted to assess time effects, group effects, and time $\times$ group interactions. When significant effects were observed, Bonferroni-adjusted post hoc tests were applied. Mauchly's test was used to assess sphericity, and the Greenhouse-Geisser correction was applied when sphericity assumptions were violated. A p-value < 0.05 was considered statistically significant.

Table 2. Comparison of HR, MAP, and VAS scores at each intraoperative time point (T0–T3) between ESPB and LA groups.

Items group	HR (bpm)	MAP (mmHg)	VAS score
T0			
ESPB	78.90 $\pm$ 6.81	91.54 $\pm$ 6.92	6.83 $\pm$ 1.62
LA	77.40 $\pm$ 6.79	89.49 $\pm$ 8.21	6.47 $\pm$ 1.59
p-value	0.396	0.299	0.380
T1			
ESPB	81.77 $\pm$ 6.14	93.81 $\pm$ 6.79	2.60 $\pm$ 0.62
LA	91.20 $\pm$ 4.97*	98.48 $\pm$ 7.10*	5.30 $\pm$ 1.02*
p-value	$<$0.001	0.012	$<$0.001
T2			
ESPB	81.60 $\pm$ 6.18	93.68 $\pm$ 6.82	2.23 $\pm$ 0.63
LA	91.53 $\pm$ 4.98*	98.03 $\pm$ 6.98*	4.83 $\pm$ 1.37*
p-value	$<$0.001	0.015	$<$0.001
T3			
ESPB	80.67 $\pm$ 6.62	92.53 $\pm$ 6.82	2.23 $\pm$ 0.63
LA	86.33 $\pm$ 5.44*	96.03 $\pm$ 7.24*	4.83 $\pm$ 1.37*
p-value	$<$0.001	0.059	$<$0.001

Note: Intergroup p-values represent comparisons of MAP, HR, and VAS scores between ESPB and LA groups at each of the four time points (T0–T3). * indicates a statistically significant difference compared to T0 within the same group based on repeated-measures ANOVA with Bonferroni-corrected post hoc testing.

Abbreviations: ESPB, erector spinal plane block; LA, local anesthesia; HR, heart rate; MAP, mean arterial pressure; VAS, visual analog scale.

Table 3. Repeated measures ANOVA for HR, MAP, and VAS scores in the two groups over time (T0–T3).

Variable	Time effect F (p)	Group effect F (p)	Interaction F (p)
HR (bpm)	242.12 (<0.001)	15.49 (<0.001)	108.87 (<0.001)
MAP (mmHg)	93.43 (<0.001)	2.19 (0.144)	34.66 (<0.001)
VAS Score	226.37 (<0.001)	71.99 (<0.001)	31.42 (<0.001)

Note: F and p-values were obtained from repeated measures ANOVA. "Time effect" refers to the main effect across time points (T0–T3), "Group effect" refers to differences between ESPB and LA groups, and "Interaction effect" represents the time × group interaction effect. A p-value < 0.05 was considered statistically significant.

Results

Patient Characteristics

All 60 enrolled patients completed the surgery and follow-up. As presented in Table 1, baseline characteristics, including sex, age, body mass index (BMI), surgical level, pain duration, and preoperative VAS and ODI scores, demonstrated no significant differences between ESPB and LA groups (all $p > 0.05$). The analysis revealed significant main effects of time for all three outcomes (HR, MAP, VAS: F = 242.12, 93.43, and 226.37, respectively; all $p < 0.001$), indicating clear time-dependent changes (Tables 2,3).

Group effects were statistically significant for HR and VAS (F = 15.49 and 71.99; both $p < 0.001$), but not for MAP (F = 2.19, p = 0.144). Significant time × group interactions were observed for all variables (F = 108.87, 34.66, and 31.42; all $p < 0.001$), suggesting that the patterns of change over time differed between the ESPB and LA groups, particularly regarding hemodynamic and analgesic responses. At T0, there were no significant differences between groups in HR, MAP or VAS scores (p = 0.396, 0.299, and 0.380, respectively). However, from T1 to T3, the ESPB group showed significantly lower HR and MAP values than the LA group (HR: all p = 0.001; MAP: p = 0.012, 0.015, and 0.059). Additionally, VAS scores were consistently and notably lower in the ESPB group across T1 to T3 (all $p < 0.001$), indicating greater intraoperative hemodynamic stability and better analgesic effects.

Table 4 shows no notable differences between the two groups in terms of intraoperative blood loss, operative time, length of hospital stay, or total hospitalization costs (all $p > 0.05$). However, a significantly higher proportion of patients in the ESPB group expressed willingness to undergo the same procedure again on postoperative day 1 compared to the LA group (56.67% vs. 26.67%, p = 0.018), suggesting greater intraoperative comfort and patient acceptance.

Table 5 summarizes the three-month clinical findings based on the modified Macnab criteria. Both groups demonstrated high rates of "Excellent" and "Good" outcomes, with no statistically significant differences between them ($p > 0.999$). According to the modified Macnab criteria (see "Materials and Methods" section for definition), outcomes were classified as "Excellent", "Good", "Fair", or "Poor". Table 6 shows VAS and ODI scores at 3 and 6 months postoperatively. Both scores showed significant reductions from preoperative baselines in both groups ($p < 0.05$), indicating functional recovery and pain relief. However, no significant differences were observed between the ESPB and LA groups at any follow-up point (all $p > 0.05$), suggesting that both anesthesia techniques provided comparable short-term clinical efficacy.

Discussion

Lumbar intervertebral disc herniation is commonly encountered in orthopedic outpatient clinics, with a high incidence and a trend toward younger patients. As a result, determining the most appropriate treatment strategy has become an increasingly important area of interest. Although conventional open lumbar surgery remains effective, it is associated with several disadvantages, including extensive tissue disruption, injury to posterior spinal structures, greater intraoperative bleeding, elevated complication rates, and a higher risk of chronic postoperative back pain [22,23]. With the advent of spinal endoscopy, open lumbar surgery has gradually fallen out of favor [24].

Yeung and Tsou [25] introduced the Yeung Endoscopic Spine System (YESS) and pioneered YESS surgical techniques. Since then, spinal endoscopy has been widely adopted in clinical practice. Numerous studies have confirmed that the clinical efficacy of endoscopic lumbar discectomy is comparable to that of traditional open surgery [26,27], while offering added advantages such as reduced surgical trauma, faster postoperative functional rehabilitation, and shorter hospital stays [28]. Local anesthesia (LA) is widely used in PTED due to its favorable safety profile and the benefit of allowing intraoperative communication between the patient and surgeon. However, intraoperative pain remains a common challenge during PTED under LA, particularly during the establishment of the working channel and removal of the herniated nucleus pulposus. Pain stimuli can trigger increased blood pressure, increased heart rate, sweating, and in some instances, signs of neurogenic shock. In severe cases, patients may be unable to tolerate the procedure, leading to its suspension or termination. Furthermore, unrelieved intraoperative pain can compromise surgical performance, especially in complex cases involving disc prolapse or calcification, which often require

Table 4. Comparison of operative time, intraoperative blood loss, length of hospital stay, hospitalization cost, and willingness to undergo reoperation between ESPB and LA groups.

Group	Operative time (minutes) ($\bar{x} \pm$ SD)	Intraoperative blood loss (mL) ($\bar{x} \pm$ SD)	Hospital stay (days), median (IQR)	Hospitalization cost (RMB), median (IQR)	Willingness to undergo reoperation, n (%)
ESPB	73.63 ± 16.18	13.57 ± 3.26	5 (4, 5)	17,916 (17,678, 18,965.25)	17/13 (56.67)
LA	75.87 ± 16.54	13.07 ± 3.04	4.5 (4, 5)	17,965 (17,671.75, 19,067)	8/22 (26.67)
$t/Z/\chi^2$	–0.53	0.62	–0.66	–0.07	5.55
p-value	0.599	0.541	0.507	0.947	0.018

Note: Values are presented as mean ± standard deviation or median (interquartile range). Exchange rate: 1 USD = 7.1 RMB.

Abbreviations: ESPB, erector spinal plane block; LA, local anesthesia.

Table 5. Modified Macnab criteria outcomes at three months postoperatively.

Group	Poor/Total	Fair/Total	Good/Total	Excellent/Total	"Excellent" and "Good" rates (%)
ESPB	0	3	18	9	90.00
LA	1	3	19	7	86.67
χ^2					0.001
p-value					>0.999

Note: Rates are based on modified Macnab criteria.

Abbreviations: ESPB, erector spinal plane block; LA, local anesthesia.

longer operative times. Additionally, awake patients may experience heightened anxiety and fear, further compromising their surgical experience. Therefore, optimizing anesthesia strategies to improve patient comfort and procedural tolerance is a key area of research.

Currently, various anesthesia methods are available for PTED, including general, epidural, local anesthesia, local anesthesia combined with sedation, and erector spinae plane block (ESPB) [22,29]. General anesthesia provides effective analgesia but increases the risk of intraoperative nerve injury [30,31]. When combined with intraoperative neurophysiological monitoring, the risks of neural injury and dural sac compromise can be significantly mitigated [32,33]. However, due to financial constraints, electrophysiological monitoring is not routinely implemented in many institutions, particularly in resource-limited settings, and its preoperative preparation is time-consuming. Kong *et al.* [34] compared PTED under general, local, and epidural anesthesia and found that epidural anesthesia allows for sensory-motor separation, enabling patients to give real-time feedback while maintaining intraoperative comfort. However, epidural anesthesia may block spinal nerve roots, inhibiting motor and sensory functions of the lower back and lower limbs. Although it provides effective pain relief, it carries potential risks such as epidural hematoma, nerve injury, and postoperative muscle weakness [35]. Additionally, epidural anesthesia often requires the patient to assume a knee-chest position, which may be difficult for some individuals to tolerate or sustain. Kerimbayev *et al.* [5] compared PTED under general and local anesthesia and concluded that local anesthesia helps minimize nerve root injury while avoiding common complications associated with general anesthesia, such as headache, nausea, vomiting, sore throat, and dizziness. Moreover, it may yield improved short-term postoperative outcomes.

The use of ESPB in spinal surgery has been relatively underreported. In 2016, Forero *et al.* [10] first described ultrasound-guided administration of local anesthetics into the erector spinae plane adjacent to the transverse processes, effectively blocking multiple ipsilateral spinal nerves and producing visceral analgesic effects through extensive diffusion of the drug within the fascial plane [36]. The erector spinae muscle extends across the entire lower back, with its deep thoracolumbral fascia extending from thoracic to lumbar spinal levels [37], which facilitates the cephalocaudal spread of local anesthetics [38,39]. Lumbar spinal nerves exit the intervertebral foramina and give rise to the posterior ramus, which traverses the foramen, enters the erector spinae muscle, and subsequently branches out to innervate the facet joints, skin, and other structures behind the waist. Because the ESPB puncture site is superficial and located away from major organs and blood vessels, complications such as pneumothorax and hematoma are rare [40]. For this reason, ESPB is frequently employed in abdominal procedures like laparoscopic cholecystectomy, and in breast and thoracic surgeries [41,42].

Duan *et al.* [43] demonstrated that ESPB significantly reduced resting and movement-associated pain within the first 24 hours postoperatively while lowering rescue analgesic use and total analgesic consumption in spinal surgery patients. Similarly, Ma *et al.* [44] and Finnerty *et al.* [45] reported that ESPB effectively reduced postoperative pain and analgesic requirements compared to no block or placebo. Taşkaldıran [46] reported that ESPB resulted in lower VAS scores and decreased opioid utilization in the early postoperative phase. Breebaart *et al.* [47] also

Table 6. Comparison of preoperative and postoperative VAS and ODI scores between ESPB and LA groups.

Group	VAS-leg and pain			ODI		
	Before surgery	3 months post-surgery	6 months post-surgery	Before surgery	3 months post-surgery	6 months post-surgery
ESPB	5 (3, 7)	1 (1, 1)*	1 (0, 1)*	56.12 ± 11.88	13.9 (12.20, 18.40)*	8.5 (7.30, 9.63)*
LA	5 (3, 7)	1 (1, 2)*	1 (0, 1)*	52.08 ± 10.83	15.6 (12.20, 18.40)*	8.5 (7.30, 9.60)*
t/*Z*	–0.22	–0.73	–0.73	–1.30	–0.304	–0.401
p-value	0.830	0.464	0.465	0.193	0.761	0.688

* represents that the difference was statistical when compared to pre-operative scores. VAS, visual analog scale; ESPB, erector spinal plane block; LA, local anesthesia; ODI, Oswestry Disability Index. Data are expressed as mean ± SD or median and IQR.

demonstrated the efficacy of ESPB in reducing perioperative use of analgesics and muscle relaxants. However, the clinical value and risk-benefit ratio of ESPB for lumbar spine surgery remain controversial. Systematic reviews suggest that current evidence is inadequate to fully support widespread adoption of ESPB in this context [48].

In the present study, all procedures were completed successfully in both groups, without any complications such as nerve injury, dural sac rupture, vascular damage, or hematoma. Additionally, no obvious postoperative complications, such as wound infections, delayed hematoma, or neurologic deterioration, were observed in either group. Therefore, postoperative complications were not included in the Results section. However, we acknowledge that such data are critical to evaluating the overall safety of ESPB, and future studies with larger samples should incorporate detailed tracking of postoperative adverse events. The ESPB group exhibited significantly lower pain scores across perioperative time points compared to the LA group, indicating enhanced intraoperative patient cooperation. MAP and HR levels from T1–T3 were also more stable in the ESPB group, suggesting that ultrasound-guided ESPB contributes to maintaining hemodynamic stability during PTED and may reduce cardiovascular stress, especially in elderly patients. These observations offer potential benefits in anesthetic management. Several factors may explain these findings: (1) Effective pain control reduces the surgical stress response and local inflammation, thereby improving perioperative comfort. (2) The concentration of local anesthetics may play a role. Studies have shown that lower concentrations of ropivacaine help maintain a stable heart rate and blood pressure. (3) Ultrasound guidance allows real-time visualization of needle placement, improving accuracy and efficacy.

The greater willingness to undergo repeat surgery in the ESPB group further supports its role in improving intraoperative comfort. This may be attributed to the ability of local anesthetics in ESPB to diffuse into dorsal and ventral branches of spinal nerves, potentially extending into the paravertebral space, where they inhibit nociceptive transmission from both peripheral and visceral nerves [49]. This diffusion reduces local inflammatory responses, desensitizes nerve endings, and effectively alleviates intraoperative and postoperative pain. Some scholars [50,51] argue that ESPB, analogous to epidural analgesia, provides both visceral and somatic analgesic effects. Thus, ESPB not only enhances perioperative comfort but also contributes to improved procedural safety.

In this study, both groups exhibited significant postoperative improvements in VAS and ODI scores compared to baseline, accompanied by high patient satisfaction, as evidenced by “Excellent” and “Good” rates on the modified Macnab criteria. However, no statistically significant differences were reported between the two groups in long-term outcomes, indicating that the primary benefits of ESPB are limited to the perioperative period, with comparable overall efficacy to local anesthesia. Although intraoperative anesthesia costs were higher in the ESPB group, the reduced need for postoperative analgesics resulted in comparable overall hospitalization costs between the groups.

Notably, the ultrasound-guided ESPB requires specialized skills and may involve a procedural learning curve. Operator experience can influence the accuracy of the block and its analgesic efficacy. In this study, all ESPB procedures were conducted by a single experienced anesthesiologist, minimizing variability. However, in routine clinical practice, differences in operator expertise may influence clinical outcomes. Future research should incorporate multiple practitioners to explore how the learning curve may impact ESPB performance.

Moreover, full blinding of patients was not feasible due to differences in technique and injection site between ESPB and local infiltration anesthesia. However, since patients were not informed of their group assignment and both procedures involved local anesthetic administration to the lumbar region, it is unlikely that most participants were fully aware of their allocation. Despite this, we recognize that subjective outcomes, such as intraoperative VAS scores and willingness to undergo reoperation, may have been influenced by patient expectations. Future studies may consider using sham procedures or standardized preoperative briefings to reduce potential bias.

Limitation of Study

Several limitations in this study warrant acknowledgement. As an exploratory randomized controlled trial, this study was primarily designed to evaluate the feasibility and short-term clinical effects of ultrasound-guided erector spinae plane block rather than to establish definitive evidence regarding its efficacy or safety. In addition, the follow-up period was relatively limited, and postoperative safety and complication outcomes were not systematically collected or quantitatively analyzed, which restricts a comprehensive assessment of long-term outcomes and procedural safety. As a single-center randomized controlled trial, the sample size was relatively limited and was based on the number of eligible patients during the study period rather than a priori power calculation. Although several key outcome indicators demonstrated statistically significant differences, the limited sample size may affect the generalizability of specific conclusions. Additionally, preoperative baseline data, such as heart rate, blood pressure, comorbidities (e.g., hypertension, cardiovascular disease), and the use of medications that could influence hemodynamic status, were not systematically collected or analyzed. While patients with significant organ dysfunction were excluded according to the inclusion criteria, and no notable differences in pre-anesthesia hemodynamic parameters were observed between the two groups, the absence of comprehensive preoperative clinical data may limit the interpretation of perioperative hemodynamic outcomes. Future studies should aim to expand the sample size, enhance preoperative clinical data collection, and incorporate subgroup analyses to more comprehensively evaluate the analgesic efficacy and safety of ESPB in patients with varying baseline cardiovascular profiles.

Conclusions

In summary, ultrasound-guided ESPB during percutaneous endoscopic lumbar discectomy improves intraoperative patient comfort and analgesia. These preliminary findings suggest that ESPB may have short-term clinical benefits in this setting. However, its impact on long-term outcomes, including chronic low back pain and recurrence, warrants further investigation through larger, multicenter, and confirmatory trials.

Availability of Data and Materials

The data used to support the findings of this study are available from the corresponding author upon request.

Author Contributions

XTZ and JLJ: Conceptualization; Methodology; Project administration; Data curation; Formal analysis; Writing—Original Draft; Writing—Review & Editing. YQY and QHC: Conceptualization; Methodology; Resources; Investigation; Writing—Review & Editing. GXZ and BCW: Resources; Validation; Visualization; Writing—Review & Editing. BH, WHC and QPS: Data acquisition; Software; Supervision; Writing—Review & Editing. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Ethics Committee of Dehua Hospital of Huaqiao University (Approval No.2021L [001]). All subjects signed the consent form before participation in the study. The study conformed to the provisions of the Declaration of Helsinki.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Harada GK, Siyaji ZK, Mallow GM, Hornung AL, Hassan F, Basques BA, *et al*. Artificial intelligence predicts disk re-herniation following lumbar microdiscectomy: development of the “RAD” risk profile. European Spine Journal. 2021; 30: 2167–2175. https://doi.org/10.1007/s00586-021-06866-5.

[2] Ropper AH, Zafonte RD. Sciatica. The New England Journal of Medicine. 2015; 372: 1240–1248. https://doi.org/10.1056/NEJMra1410151.

[3] Bush K, Cowan N, Katz DE, Gishen P. The natural history of sciatica associated with disc pathology. A prospective study with clinical and independent radiologic follow-up. Spine. 1992; 17: 1205–1212. https://doi.org/10.1097/00007632-199210000-00013.

[4] Pearson AM, Lurie JD, Tosteson TD, Zhao W, Abdu WA, Weinstein JN. Who should undergo surgery for degenerative spondylolisthesis? Treatment effect predictors in SPORT. Spine. 2013; 38: 1799–1811. https://doi.org/10.1097/BRS.0b013e3182a314d0.

[5] Kerimbayev T, Kenzhegulov Y, Tuigynov Z, Aleinikov V, Urunbayev Y, Makhambetov Y, *et al*. Transforaminal Endoscopic Discectomy Under General and Local Anesthesia: A Single-Center Study. Frontiers in Surgery. 2022; 9: 873954. https://doi.org/10.3389/fsurg.2022.873954.

[6] Gadjradj PS, Rubinstein SM, Peul WC, Depauw PR, Vleggeert-Lankamp CL, Seiger A, *et al*. Full endoscopic versus open discectomy for sciatica: randomised controlled non-inferiority trial. BMJ. 2022; 376: e065846. https://doi.org/10.1136/bmj-2021-065846.

[7] Depauw PRAM, Gadjradj PS, Soria van Hoeve JS, Harhangi BS. How I do it: percutaneous transforaminal endoscopic discectomy for lumbar disk herniation. Acta Neurochirurgica. 2018; 160: 2473–2477. https://doi.org/10.1007/s00701-018-3723-5.

[8] Teli M, Lovi A, Brayda-Bruno M, Zagra A, Corriero A, Giudici F, *et al*. Higher risk of dural tears and recurrent herniation with lumbar

micro-endoscopic discectomy. European Spine Journal. 2010; 19: 443–450. https://doi.org/10.1007/s00586-010-1290-4.

[9] Wan Q, Zhang D, Li S, Liu W, Wu X, Ji Z, *et al*. Posterior percutaneous full-endoscopic cervical discectomy under local anesthesia for cervical radiculopathy due to soft-disc herniation: a preliminary clinical study. Journal of Neurosurgery. Spine. 2018; 29: 351–357. https://doi.org/10.3171/2018.1.SPINE17795.

[10] Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain. Regional Anesthesia and Pain Medicine. 2016; 41: 621–627. https://doi.org/10.1097/AAP.0000000000000451.

[11] Elsharkawy H, Pawa A, Mariano ER. Interfascial Plane Blocks: Back to Basics. Regional Anesthesia and Pain Medicine. 2018; 43: 341–346. https://doi.org/10.1097/AAP.0000000000000750.

[12] Tseng V, Xu JL. Erector Spinae Plane Block for Postoperative Analgesia in Lumbar Spine Surgery: Is There a Better Option? Journal of Neurosurgical Anesthesiology. 2021; 33: 92. https://doi.org/10.1097/ANA.0000000000000631.

[13] Ueshima H, Inagaki M, Toyone T, Otake H. Efficacy of the Erector Spinae Plane Block for Lumbar Spinal Surgery: A Retrospective Study. Asian Spine Journal. 2019; 13: 254–257. https://doi.org/10.31616/asj.2018.0114.

[14] Melvin JP, Schrot RJ, Chu GM, Chin KJ. Low thoracic erector spinae plane block for perioperative analgesia in lumbosacral spine surgery: a case series. Canadian Journal of Anaesthesia. 2018; 65: 1057–1065. https://doi.org/10.1007/s12630-018-1145-8.

[15] Liang X, Zhou W, Fan Y. Erector spinae plane block for spinal surgery: a systematic review and meta-analysis. The Korean Journal of Pain. 2021; 34: 487–500. https://doi.org/10.3344/kjp.2021.34.4.487.

[16] Yi-Han W, Rong T, Jun L, Min W, Yan Z, Yi L, *et al*. Dexmedetomidine combined with ropivacaine for erector spinae plane block after posterior lumbar spine surgery: a randomized controlled trial. BMC Musculoskeletal Disorders. 2022; 23: 235. https://doi.org/10.1186/s12891-022-05198-9.

[17] Yayik AM, Cesur S, Ozturk F, Ahiskalioglu A, Ay AN, Celik EC, *et al*. Postoperative Analgesic Efficacy of the Ultrasound-Guided Erector Spinae Plane Block in Patients Undergoing Lumbar Spinal Decompression Surgery: A Randomized Controlled Study. World Neurosurgery. 2019; 126: e779–e785. https://doi.org/10.1016/j.wneu.2019.02.149.

[18] Li P, Yang F, Tong Y, Chen Y, Song Y. Comparison of Percutaneous Transforaminal Endoscopic Decompression and Transforaminal Lumbar Interbody Fusion in the Treatment of Single-Level Lumbar Disc Herniation with Modic Type I Changes. Journal of Pain Research. 2021; 14: 3511–3517. https://doi.org/10.2147/JPR.S338342.

[19] Macnab I. Negative disc exploration. An analysis of the causes of nerve-root involvement in sixty-eight patients. The Journal of Bone and Joint Surgery. American Volume. 1971; 53: 891–903.

[20] Yu T, Wu JP, Zhang J, Yu HC, Liu QY. Comparative evaluation of posterior percutaneous endoscopy cervical discectomy using a 3.7 mm endoscope and a 6.9 mm endoscope for cervical disc herniation: a retrospective comparative cohort study. BMC Musculoskeletal Disorders. 2021; 22: 131. https://doi.org/10.1186/s12891-021-03980-9.

[21] Fairbank JC, Pynsent PB. The Oswestry Disability Index. Spine. 2000; 25: 2940–52; discussion 2952. https://doi.org/10.1097/00007632-200011150-00017.

[22] Yang L, Pan YL, Liu CZ, Guo DX, Zhao X. A retrospective comparative study of local anesthesia only and local anesthesia with sedation for percutaneous endoscopic lumbar discectomy. Scientific Reports. 2022; 12: 7427. https://doi.org/10.1038/s41598-022-11393-4.

[23] Dunn LK, Durieux ME, Nemergut EC. Non-opioid analgesics: Novel approaches to perioperative analgesia for major spine surgery. Best Practice & Research. Clinical Anaesthesiology. 2016; 30: 79–89. https://doi.org/10.1016/j.bpa.2015.11.002.

[24] Postacchini F, Postacchini R. Operative management of lumbar disc herniation: the evolution of knowledge and surgical techniques in the last century. Acta Neurochirurgica. Supplement. 2011; 108: 17–21. https://doi.org/10.1007/978-3-211-99370-5_4.

[25] Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: Surgical technique, outcome, and complications in 307 consecutive cases. Spine. 2002; 27: 722–731. https://doi.org/10.1097/00007632-200204010-00009.

[26] Nellensteijn J, Ostelo R, Bartels R, Peul W, van Royen B, van Tulder M. Transforaminal endoscopic surgery for symptomatic lumbar disc herniations: a systematic review of the literature. European Spine Journal. 2010; 19: 181–204. https://doi.org/10.1007/s00586-009-1155-x.

[27] Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study. Spine. 2008; 33: 931–939. https://doi.org/10.1097/BRS.0b013e31816c8af7.

[28] Kambin P, Casey K, O'Brien E, Zhou L. Transforaminal arthroscopic decompression of lateral recess stenosis. Journal of Neurosurgery. 1996; 84: 462–467. https://doi.org/10.3171/jns.1996.84.3.0462.

[29] Fang G, Ding Z, Song Z. Comparison of the Effects of Epidural Anesthesia and Local Anesthesia in Lumbar Transforaminal Endoscopic Surgery. Pain Physician. 2016; 19: E1001–4.

[30] Ye XF, Wang S, Wu AM, Xie LZ, Wang XY, Chen JX, *et al*. Comparison of the effects of general and local anesthesia in lumbar interlaminar endoscopic surgery. Annals of Palliative Medicine. 2020; 9: 1103–1108. https://doi.org/10.21037/apm-20-623.

[31] Wu K, Zhao Y, Feng Z, Hu X, Chen Z, Wang Y. Stepwise Local Anesthesia for Percutaneous Endoscopic Interlaminar Discectomy: Technique Strategy and Clinical Outcomes. World Neurosurgery. 2020; 134: e346–e352. https://doi.org/10.1016/j.wneu.2019.10.061.

[32] Chen Y, Luo C, Wang J, Liu L, Huang B, Li CQ, *et al*. Roles of multimodal intra-operative neurophysiological monitoring (IONM) in percutaneous endoscopic transforaminal lumbar interbody fusion: a case series of 113 patients. BMC Musculoskeletal Disorders. 2021; 22: 989. https://doi.org/10.1186/s12891-021-04824-2.

[33] Thuet ED, Winscher JC, Padberg AM, Bridwell KH, Lenke LG, Dobbs MB, *et al*. Validity and reliability of intraoperative monitoring in pediatric spinal deformity surgery: a 23-year experience of 3436 surgical cases. Spine. 2010; 35: 1880–1886. https://doi.org/10.1097/BRS.0b013e3181e53434.

[34] Kong M, Gao C, Cong W, Li G, Zhou C, Ma X. Percutaneous Endoscopic Interlaminar Discectomy with Modified Sensation-Motion Separation Anesthesia for Beginning Surgeons in the Treatment of L5-S1 Disc Herniation. Journal of Pain Research. 2021; 14: 2039–2048. https://doi.org/10.2147/JPR.S306319.

[35] Zhu Y, Zhao Y, Fan G, Sun S, Zhou Z, Wang D, *et al*. Comparison of 3 Anesthetic Methods for Percutaneous Transforaminal Endoscopic Discectomy: A Prospective Study. Pain Physician. 2018; 21: E347–E353.

[36] Hamilton DL, Manickam BP. Is the erector spinae plane (ESP) block a sheath block? Anaesthesia. 2017; 72: 915–916. https://doi.org/10.1111/anae.13912.

[37] Wang J, Lu Y. Application of ultrasound-guided bilateral erector spinae plane block in lumbar spinal surgery. Annals of Palliative Medicine. 2020; 9: 1282–1284. https://doi.org/10.21037/apm-20-287.

[38] Urits I, Charipova K, Gress K, Laughlin P, Orhurhu V, Kaye AD, *et al*. Expanding Role of the Erector Spinae Plane Block for Postoperative and Chronic Pain Management. Current Pain and Headache Reports. 2019; 23: 71. https://doi.org/10.1007/s11916-019-0812-y.

[39] Tulgar S, Aydin ME, Ahiskalioglu A, De Cassai A, Gurkan Y. Anesthetic Techniques: Focus on Lumbar Erector Spinae Plane Block. Local and Regional Anesthesia. 2020; 13: 121–133. https://doi.org/10.2147/LRA.S233274.

[40] Kot P, Rodriguez P, Granell M, Cano B, Rovira L, Morales J, *et al*. The erector spinae plane block: a narrative review. Korean Journal of Anesthesiology. 2019; 72: 209–220. https://doi.org/10.4097/kja.d.19.00012.

[41] Leong RW, Tan ESJ, Wong SN, Tan KH, Liu CW. Efficacy of erector spinae plane block for analgesia in breast surgery: a systematic review and meta-analysis. Anaesthesia. 2021; 76: 404–413. https://doi.org/10.1111/anae.15164.

[42] Koo CH, Hwang JY, Shin HJ, Ryu JH. The Effects of Erector Spinae Plane Block in Terms of Postoperative Analgesia in Patients Undergoing Laparoscopic Cholecystectomy: A Meta-Analysis of Randomized Controlled Trials. Journal of Clinical Medicine. 2020; 9: 2928. https://doi.org/10.3390/jcm9092928.

[43] Duan M, Xu Y, Fu Q. Efficacy of Erector Spinae Nerve Block for Pain Control After Spinal Surgeries: An Updated Systematic Review and Meta-Analysis. Frontiers in Surgery. 2022; 9: 845125. https://doi.org/10.3389/fsurg.2022.845125.

[44] Ma J, Bi Y, Zhang Y, Zhu Y, Wu Y, Ye Y, *et al*. Erector spinae plane block for postoperative analgesia in spine surgery: a systematic review and meta-analysis. European Spine Journal. 2021; 30: 3137–3149. https://doi.org/10.1007/s00586-021-06853-w.

[45] Finnerty D, Ní Eochagáin A, Ahmed M, Poynton A, Butler JS, Buggy DJ. A randomised trial of bilateral erector spinae plane block vs. no block for thoracolumbar decompressive spinal surgery. Anaesthesia. 2021; 76: 1499–1503. https://doi.org/10.1111/anae.15488.

[46] Taşkaldıran Y. Is Opioid-free Anesthesia Possible by Using Erector Spinae Plane Block in Spinal Surgery? Cureus. 2021; 13: e18666. https://doi.org/10.7759/cureus.18666.

[47] Breebaart MB, Van Aken D, De Fré O, Sermeus L, Kamerling N, de Jong L, *et al*. A prospective randomized double-blind trial of the efficacy of a bilateral lumbar erector spinae block on the 24h morphine consumption after posterior lumbar inter-body fusion surgery. Trials. 2019; 20: 441. https://doi.org/10.1186/s13063-019-3541-y.

[48] Qiu Y, Zhang TJ, Hua Z. Erector Spinae Plane Block for Lumbar Spinal Surgery: A Systematic Review. Journal of Pain Research. 2020; 13: 1611–1619. https://doi.org/10.2147/JPR.S256205.

[49] Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. Anaesthesia. 2017; 72: 452–460. https://doi.org/10.1111/anae.13814.

[50] Celik M, Tulgar S, Ahiskalioglu A, Alper F. Is high volume lumbar erector spinae plane block an alternative to transforaminal epidural injection? Evaluation with MRI. Regional Anesthesia and Pain Medicine. 2019. https://doi.org/10.1136/rapm-2019-100514. (online ahead of print)

[51] Greenhalgh K, Womack J, Marcangelo S. Injectate spread in erector spinae plane block. Anaesthesia. 2019; 74: 126–127. https://doi.org/10.1111/anae.14523.