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Comparison of the effects of ultrasound-guided thoracic paravertebral block and erector spinae plane block on postoperative acute and chronic pain in patients undergoing video-assisted thoracoscopic surgery

Musa Zengin[1], Gülay Ülger[1], Ramazan Baldemir[1], Hilal Sazak[1], Koray Aydoğdu[2], Ali Alagöz[1]

[1]University of Health Sciences, Ankara Atatürk Chest Diseases and Thoracic Surgery Training and Research Hospital, Anesthesiology and Reanimation Clinic, Ankara, Turkey
[2]University of Health Sciences, Ankara Atatürk Chest Diseases and Thoracic Surgery Training and Research Hospital, Thoracic Surgery Clinic, Ankara, Turkey

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ABSTRACT

Aim: The aim of the study was to compare the effects of ultrasound (US)-guided Erector spinae plane block (ESPB) and thoracic paravertebral block (TPVB) on postoperative acute and chronic pain.

Material and Method: Patients aged range of 18 to 80 years and underwent video-assisted thoracoscopic surgery (VATS) were included in a single-blinded randomized trial. All patients were informed about the study and their written consent was obtained. The primary outcome was determined as acute postoperative visual analog scale (VAS) scores, and secondary outcomes were postoperative morphine consumption and the incidence of chronic pain. US-guided ESPB and TPVB were performed to all patients and they were assigned randomly to ESPB (Group 1) and TPVB (Group 2) groups according to the analgesia protocol.

Results: Visual analog scale (VAS) resting and VAS cough scores at the 1st, 2nd, 4th, 8th, and 16th hours were found to be statistically significantly higher in the TPVB group than in the ESPB group ($p<0.05$) Morphine consumption (p:0.042) and additional analgesic (p:0.037) use were found to be statistically significantly higher in the TPVB group compared to the ESPB group. As complications, only nausea and vomiting were observed with no significant difference between the groups ($p>0.05$). There was no significant difference in terms of postoperative 30th and 90th day pain characteristics between the groups ($p>0.05$).

Conclusion: ESPB was superior to TPVB in terms of acute postoperative pain management, morphine consumption, and side effects, but the incidence of chronic pain in the first and third months after surgery was similar in both groups.

Keywords: Acute pain, chronic pain, erector spinae plane block, thoracic paravertebral block, video-assisted thoracoscopic surgery

INTRODUCTION

In thoracic surgery, video-assisted thoracoscopic surgery (VATS) procedures are gaining popularity due to the minimally invasive approach resulting in limited tissue trauma, shorter recovery time, and lesser postoperative pain (1,2). Even though VATS is less invasive than open thoracotomy, moderate to severe acute pain is common after VATS, and is also associated with significant chronic pain (1,3).

In the early postoperative period, poorly managed acute pain has significant adverse effects on respiratory mechanics and mobilization and increased risk of postoperative pulmonary complications (4).

The mechanism of chronic pain after thoracic surgery is still under debate. One of the possible mechanisms of chronic pain is intercostal nerve damage during surgery. Previous studies have shown chronic pain in 40% to 80% of patients after thoracotomy and in 20% to 40% after VATS (5).

Thoracic epidural analgesia (TEA) remains the gold standard in the treatment of postoperative pain in thoracic surgery (6-8). However, TEA may cause side effects such as hypotension, urinary retention, nausea, and vomiting (8,9).

Corresponding Author: Musa Zengin, musazengin@gmail.com
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Therefore, in recent years, peripheral blocks have been preferred more for postoperative analgesia following VATS applications. There are also studies showing that peripheral blocks and TEA provide similar postoperative analgesia after VATS (7,8,10).

Thoracic paravertebral block (TPVB) has been employed to prevent postoperative pain after thoracic surgery (11). Erector spinae plane block (ESPB), a novel plane block first introduced by Forero et al. (12) in 2016, provide analgesia for different surgeries such as lung surgery, laparoscopy, mastectomy, and pediatric surgery, and may also be effective for the management of chronic pain (12). The possible mechanism of action of ESPB is related to the distribution of the local anesthetic solution into the paravertebral and epidural space (13) and subsequently blocking the dorsal and ventral branches of the spinal nerve. Although many studies have been conducted on the effectiveness of ESPB in the prevention of acute pain after VATS, studies evaluating its effects on chronic pain are very limited.

We hypothesized that the application of ESPB before surgical incision may prevent acute and chronic pain after VATS. In this study, the primary outcome was determined as acute postoperative visual analog scale (VAS) scores, and secondary outcomes were postoperative morphine consumption and the incidence of chronic pain. Our aim is to compare the effects of ultrasound-guided ESPB and TPVB on postoperative acute and chronic pain.

MATERIAL AND METHOD

Study Design and Patients

The study was carried out with the permission of Ankara Keçiören Training and Research Hospital Ethics Committee (Date:13.04.2021, Decision No: 2012-KAEK-15:2232). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The study was conducted with a prospective, randomized, single-blind design.

The VATS patients, in the age range of 18 to 80 years, with the American Society of Anesthesiologists (ASA) physical status 1-3 and body mass index (BMI) of 18-30 kg/m² were included in the study. In a high-volume tertiary thoracic surgery center, patients were informed about the study, and their written consent was obtained. During the preoperative evaluation, the patients were informed about pain assessment and patient-controlled analgesia (PCA). Patients with preoperative acute or chronic pain and a history of opioid therapy were excluded. Moreover, patients with bleeding disorders, infection at the injection site, or allergy to local anesthetics and patients who underwent emergency surgery, and conversion to thoracotomy were excluded from the study.

Patients were assigned to ESPB (Group 1) and TPVB (Group 2) groups according to the analgesia protocol. 71 patients were included in the study. Randomization was performed using computer-generated random numbers. Blinding was performed by concealing information in closed opaque envelopes.

General anesthesia

Patients were monitored in the operating room in accordance with the ASA standards. Patients were administered 0.03 mg/kg midazolam for premedication. Following preoxygenation, anesthesia was induced with 2 mg/kg propofol, 1.5 mcg/kg fentanyl, and 0.1 mg/kg vecuronium. After the intubation with a left-sided double-lumen endobronchial tube, anesthesia was maintained by administering sevoflurane in oxygen and air mixture and by administering remifentanil infusion at a dose of 0.01-0.20 mcg/kg/min. Before the commencement of the surgical procedure, blocks were performed under ultrasonography (US) guidance.

Block procedures

Block procedures were performed under general anesthesia before the skin incision to prevent anxiety and ensure patient comfort. Thus, a preemptive effect was achieved. Following the anesthesia induction, blocks were performed under US guidance when patients were in the lateral decubitus position. After strict skin antisepsis, the needle insertion area was covered with sterile drapes. In all patients, a high-frequency 6-18 MHz linear probe (MyLab six, Esaote, Genoa, Italy) in a sterile cover was placed 2-3 cm laterally to the spinous process of the fifth thoracic (T5) vertebrae. Anatomical structures including muscles up to the transverse process, the transverse process, the paravertebral space, the internal intercostal membrane, and the pleura were visualized. A US-compatible 22-Gauge and 8-mm nerve block needle (Pajunk, SonoPlexSTIM, Germany) was used in all groups. The following procedures were performed in the study groups:

ESPB group (n:30): Following the visualization of the anatomical structures, the nerve block needle was advanced via the in-plane technique beneath the erector spinae muscles until the interfascial space was reached (**Figure 1a**). After hydrodissection with 2 ml normal saline, 20 ml 0.25% bupivacaine was injected into the area (**Figure 1b**).

TPVB group (n:30): After the visualization of the anatomical structures, the needle was advanced via the in-plane technique until reaching the paravertebral space (**Figure 1c**). A volume of 20 ml of 0.25% bupivacaine was injected into the area (**Figure 1d**).

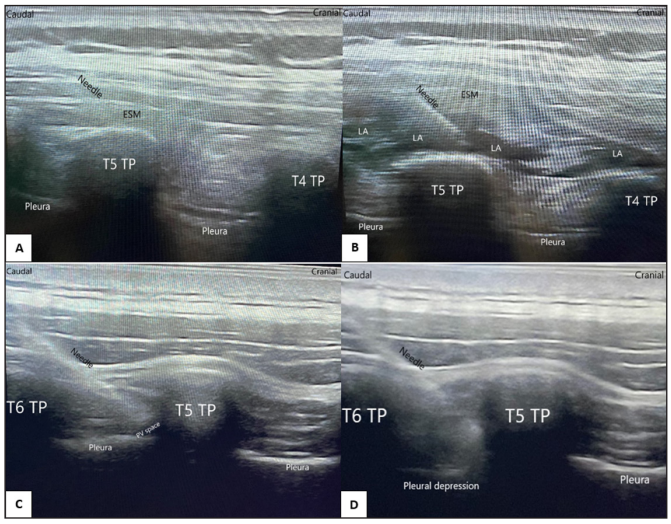

Figure 1. Anatomical view during Erector Spina Plane Block (A,B) and Thoracic Paravertebral Block (C,D). A: The view of the block needle above the transverse process and below the erector spinae muscle. B: 20 ml of 0.25% bupivacaine was administered beneath the erector spinae muscle. The local anesthetic spread caudally and cranially beneath the erector spinae muscle.C: The view of the block needle in the paravertebral space before the block. D: 20 ml of 0.25% bupivacaine was administered and pleural depression was observed. (ESM: Erector spinae muscles; LA: local anesthetic; PV space: Paravertebral space; T: Thoracic; TP: Transverse process)

Analgesia Protocol

During the skin closure, patients received intravenously administered dexketoprofen and tramadol. Metoclopramide was administered intravenously to avoid nausea and vomiting. In the postoperative surgical intensive care unit, intravenous morphine was administered via patient-controlled analgesia (PCA) pump for 24 hours. Pain intensity was evaluated using a 10- point (0: No pain and 10: Unbearable pain) visual analog scale (VAS). The PCA pump's dose delivery was limited to administer a bolus dose of 1 mg morphine and deliver a maximum dose of 12 mg morphine in total within 4 hours with lockout intervals of 15 minutes. Paracetamol 1 g every 8 hours and dexketoprofen 50 mg twice daily were administered intravenously for multimodal analgesia. As a rescue analgesic agent, 0.5 mg/kg tramadol was given to patients intravenously when a score of VAS at rest was ≥ 4. The patients were transferred to the ward in the postoperative 24th hour. Tramadol 50 mg capsules every 8 hours, paracetamol 500 mg tablets, and dexketoprofen 25 mg tablets every 12 hours were given from the second day. VAS scores at rest and while coughing were recorded in the postoperative 1st hour, 2nd hour, 4th hour, 8th hour, 12th hour, and 24th hour. The need for additional analgesics and side effects including allergic reactions, respiratory depression, sedation, urinary retention, nausea-vomiting, and itching were recorded. In two groups, patients' hemodynamic data, age, BMI, gender, diagnosis, the type of surgery, intraoperative and postoperative complications, postoperative VAS scores, and postoperative additional analgesic use were recorded. The block was applied to all patients by the same attending anesthesiologist. VAS follow-ups were performed by a pain management nurse who was blinded to the type of block applied to the patient.

The chronic pain findings of the patients were questioned by phone call. On the 30th and 90th days, the patients were called by phone and questioned whether they had burning, throbbing, numbness, electrical shock sensation, allodynia, hyperalgesia, and hypoesthesia in the surgical site. In addition, patients were asked on the 30th and 90th days whether there were pain-related limitations in activities of daily living.

Sample size and power analyses

The number of patients to participate in the study was calculated using the G*power 3.1.9.4 program, and the results of a pilot study showed that the resting 1st mean of the TPVB and ESB groups were 2.81 and 2.35, respectively, and 0.6 standard deviations (SD) in both groups. Using a bilateral t-test, 56 patients were asked to reach a power of 80% with an alpha value of 0.05 to detect differences between them, and 60 patients (30 in each group) were eligible to participate in the study. The post hoc power was calculated using G*Power© software version 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). The power was calculated for the Mann Whitney U test, which was used for testing the main hypothesis (VAS rest 16th) of the present study. Depending on previous research results with two-sided (two tails) type I error 0.05 and effect size (d) factor .01, post hoc power calculated as %96.5.

Statistical Analyses

Data analyses were performed by using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov Smirnov test. Levene test was used for the evaluation of homogeneity of variances. Unless specified otherwise, continuous data were described as mean±SD for normal distributions, and median (Q1: first quartile - Q3: third quartile) for skewed distributions. Categorical data were described as a number of cases (%). Statistical analysis differences in normally distributed variables between two independent groups were compared by Student's t-test, Mann Whitney U tests were applied for comparisons of the not normally distributed data. Categorical variables were compared using Pearson's Chi-square test or Fisher's exact test. It was accepted p-value < 0.05 as a significant level on all statistical analyses.

RESULTS

After ethics committee approval, the data of a total of 71 patients were analyzed. Eleven patients were excluded from the study due to conversion from VATS to open thoracotomy (**Figure 2**).

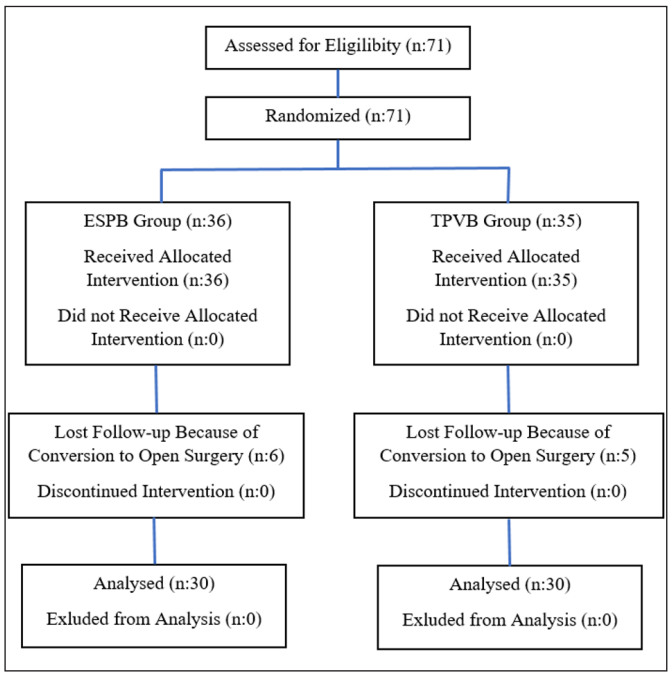

Figure 2. Flow Chart. ESPB: Erector Spinae Plane Block, TPVB: Thoracic Paravertebral Block

There was no statistically significant difference between the groups in terms of demographic characteristics, surgical features, and patient satisfaction (p>0.05) (**Table 1**).

Table 1. Demographic characteristics and surgical features of patients

	ESPB (n:30)	TPVB (n:30)	p
Age, year	57.5 (44-62)	57.5 (33-62)	0.807Φ
Gender			0.292β
Female	14 (46.7%)	10 (33.3%)	
Male	16 (53.3%)	20 (66.7%)	
BMI, kg/m²	25.78±2.77	25.59±3.24	0.929*
ASA			0.683β
1	4 (13.3%)	5 (16.7%)	
2	9 (30.0%)	12 (40.0%)	
3	17 (56.7%)	13 (43.3%)	
Surgery			0.943β
Wedge Resection	20 (66.7%)	19 (53.3%)	
Segmenthectomy	5 (16.7%)	5 (16.7%)	
Lobectomy	5 (16.7%)	6 (20.0%)	
Duration of surgery, min	150 (135-210)	175 (120-240)	0.899Φ

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3) and categorical variables are expressed as either frequency (percentage). Student t Test *, Mann whitney u Test Φ, Chi square Test β, p=Level of Significance, p<0,05, ASA: American Society of Anesthesiologists, BMI: Body mass index, ESPB: Erector spinae plane block, TPVB: Thoracic paravertebral block

No statistically significant difference was observed between the groups in terms of mean arterial pressure, heart rate, and SpO_2 (p>0.05).

When the groups were evaluated in terms of VAS resting scores, the 1st, 2nd, 4th, 8th, and 16th-hour VAS resting results were found to be statistically significantly higher in the TPVB group than in the ESPB group (p<0.05) (**Table 2**). VAS cough scores were statistically significantly higher in the TPVB group at the 1st, 2nd, 4th, 8th, and 16th hours (p<0.05) (**Table 2**).

Table 2. Resting and coughing VAS scores of the patients during the postoperative 24 hours

	ESPB (n:30)	TPVB (n:30)	p
	Med (Q1 – Q3)	Med (Q1 – Q3)	
VAS resting			
1st hour	3 (2-4)	4 (3-5)	0.019
2nd hour	3 (2-3)	3,5 (3-5)	0.006
4th hour	2 (2-3)	3 (3-4)	0.006
8th hour	2 (2-3)	3 (2-3)	0.001
16th hour	2 (1-2)	3 (2-3)	<0.001
24th hour	2 (1-2)	2 (2-3)	0.102
VAS coughing			
1st hour	4 (3-5)	5 (4-6)	0.008
2nd hour	4 (3-5)	5 (4-6)	0.001
4th hour	3 (3-4)	4 (4-5)	0.006
8th hour	3 (3-4)	4 (3-4)	0.001
16th hour	3 (2-3)	4 (3-4)	<0.001
24th hour	3 (2-3)	3 (3-4)	0.143

*Mann whitney u test, p=Level of Significance, p<0,05, ESPB: Erector spinae plane block, TPVB: Thoracic paravertebral block, VAS: Visuel analog skala

Morphine consumption (p:0.042) and additional analgesic (p:0.037) use were found to be statistically significantly higher in the TPVB group compared to the ESPB group. As complications, only nausea and vomiting were observed with no significant difference between the groups (**Table 3**).

Table 3. Morphine consumption during postoperative 24 hours, need for additional analgesics, and complication rates

	ESPB (n:30)	TPVB (n:30)	p
Morphine consumption (mg)	13.77±8.80	18.53±8.98	0.042*
Additional analgesic use n (%)	9 (30.0%)	17 (56.7%)	0.037β
Complication (Nausea) n (%)			0.195β
No	29 (96.7%)	25 (83.3%)	
Yes	1 (3.3%)	5 (16.7%)	

Continuous variables were expressed as mean±standard deviation (SD). Categorical variables are expressed as frequency (percentage). Student t Test *, Chi square Test β, p=Level of Significance, p<0.05 ESPB: Erector spinae plane block, mg: milligram, TPVB: Thoracic paravertebral block

When the patients were evaluated in terms of the overall incidence of chronic pain and the incidence of individual chronic pain symptoms on the 30th and 90th days; no statistically significant difference was observed between the ESPB and TPVB groups (p>0.05) (**Table 4**).

Table 4. Chronic pain findings on the 30th and 90th day of the VATS

	ESPB (n:30)		TPVB (n:30)		p
	n	(%)	n	(%)	
30th day pain symptoms	18	(60.0%)	16	(53.3%)	0.602
30th day daily activity restriction	11	(36.7%)	8	(26.7%)	0.405
Burning	8	(26.7%)	6	(20.0%)	0.542
Throbbing	3	(10.0%)	7	(23.3%)	0.166
Numbness	11	(36.7%)	8	(26.7%)	0.405
Electric shock sensation	3	(10.0%)	2	(6.7%)	0.999
Allodynia	2	(6.7%)	0	(0%)	0.492
Hyperalgesia	8	(26.7%)	8	(26.7%)	0.999
Hypoestesia	6	(20.0%)	5	(16.7%)	0.739
90th day pain symptoms	5	(16.7%)	8	(26.7%)	0.347
90th day daily activity restriction	3	(10.0%)	2	(6.7%)	0.999
Burning	2	(6.7%)	5	(16.7%)	0.424
Throbbing	1	(3.3%)	3	(10.0%)	0.612
Numbness	2	(6.7%)	6	(20.0%)	0.254
Electric shock sensation	1	(3.3%)	1	(3.3%)	0.999
Allodynia	0	(0%)	0	(0%)	-
Hyperalgesia	0	(0%)	2	(6.7%)	0.492
Hypoestesia	0	(0%)	4	(13.3%)	0.112

ESPB: Erector spinae plane block, TPVB: Thoracic paravertebral block

DISCUSSION

In this randomized, prospective, single-blinded trial, the authors aimed to clarify the analgesic effects of TPVB and ESPB for acute and chronic pain in VATS procedures. The previous trials on this area included different results and inadequate data, particularly on the ESPB. In the present study, ESPB was superior to TPVB for acute postoperative pain, but the incidence of chronic pain was similar in both groups. When the side effects were evaluated, the number of patients who developed nausea and vomiting in the TPVB group was higher, although not statistically significant. This may be related to the higher dose of morphine and additional analgesic needed in the postoperative period in the TPVB group compared to ESPB.

In recent years, comparative studies of ESPB with other methods such as TPVB and intercostal block have been conducted, and various results have emerged with regard to analgesic efficacy (14,15). When evaluated in terms of its mechanism of action, clinical and cadaveric studies show that the local anesthetic distribution after ESPB is similar to that of TPVB (16,17). The possible mechanism of action of ESPB is related to the distribution of the local anesthetic solution into the paravertebral and epidural space and subsequently blocking the dorsal and ventral branches of the spinal nerve (13,18). However, when compared to TPVB, the fact that the ESPB application point is more accessible and far from the pleural area can both increase the success of the application and the complication rates may be more limited (19). The use of ESPB for analgesia in the early postoperative period after VATS seems to be advantageous compared to TPVB. In addition, ESPB's ease of application compared to TPVB and its distance from pleura and vascular structures may cause complications to suggest that it is a more appropriate block method.

In studies comparing TPVB and TEA, side effects such as hypotension, nausea/vomiting, itching, urinary retention are more limited in TPVB applications (8,10). This circumstance can be explained by the limited sympathetic and neuraxial block due to TPVB. In ESPB, the ease of application, depending on the anatomical structure, and the fact that local anesthetics do not cause central block effects, limits the side effects and complications that may occur. Although not statistically significant in our study, side effects were limited in ESPB, and nausea/vomiting was observed in only one patient.

Chronic pain causes a significant burden for patients, affects the quality of life, and is related to the risk of morbidity. Thoracic surgery is one of the procedures in which the development of chronic pain is most common. Trauma due to thoracotomy and VATS applications, especially in the intercostal nerves, is assumed to be an important factor in the development of chronic pain after thoracic surgery (5,20). Previous studies have shown the presence of chronic pain in 40% to 80% of patients after thoracotomy and in 20% to 40% after VATS (1,5,21). ESPB application was first performed by Forero et al. (12) for neuropathic pain. Although there are studies on the application of ESPB in the treatment of chronic pain (22,23), studies on the effectiveness of preoperatively applied ESPB on chronic pain are quite limited. According to our study results, patients with persistent pain symptoms on the 30th day were 53.3% in the TPVB group, while it was 60% in the ESPB group. On the 90th day, the rates were found to be 26.7% in the TPVB group and 16.7% in the ESPB group. Although there was no statistically significant difference, it was observed that the 90th-day pain rates were higher in patients who underwent TPVB. Larger series of studies on this subject will contribute to more clearly revealing the effectiveness of ESPB in preventing chronic pain.

The present study has some limitations. The study was conducted at a single center. We assessed pain scores only during the 24 hours after surgery. However, none of our patients required rescue analgesia in the ward, and the administration of routine oral analgesic medication regimens was sufficient for patients in the ward after the 24th postoperative hour. Finally, we only evaluated the incidence of chronic pain after the first and third months of surgery. Longer duration assessments may yield more descriptive results for the development of chronic pain.

CONCLUSION

ESPB was superior to TPVB in terms of acute postoperative pain control, and morphine consumption, but the incidence of chronic pain the first and third months after surgery was similar in both groups. Randomized controlled trials with larger series, using TPVB and ESPB for the prevention of postoperative pain, may be helpful in explaining the chronic pain incidence after VATS.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ankara Keçiören Training and Research Hospital Ethics Committee (Date:13.04.2021, Decision No: 2012-KAEK-15:2232).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Bayman EO, Parekh KR, Keech J, et al. Preoperative patient expectations of postoperative pain are associated with moderate to severe acute pain after vats. Pain Med 2019; 20: 543-54.
2. Kwon ST, Zhao L, Reddy RM, et al. Evaluation of acute and chronic pain outcomes after robotic, video-assisted thoracoscopic surgery, or open anatomic pulmonary resection. J Thorac Cardiovasc Surg 2017; 154: 652-9.
3. Zengin M, Baldemir R, Ulger G, et al. Postoperative analgesic efficacy of thoracic paravertebral block and erector spinae plane block combination in video-assisted thoracic surgery. Cureus 2021; 13: e15614.
4. Hanley C, Wall T, Bukowska I, et al. Ultrasound-guided continuous deep serratus anterior plane block versus continuous thoracic paravertebral block for perioperative analgesia in videoscopic-assisted thoracic surgery. Eur J Pain 2020; 24: 828-38.
5. Steegers MA, Snik DM, Verhagen AF, et al. Only half of the chronic pain after thoracic surgery shows a neuropathic component. J Pain 2008; 9: 955-61.
6. Barbera C, Milito P, Punturieri M, et al. Serratus anterior plane block for hybrid transthoracic esophagectomy: a pilot study. J Pain Res 2017; 10: 73-7.
7. Komatsu T, Kino A, Inoue M, et al. Paravertebral block for video-assisted thoracoscopic surgery: analgesic effectiveness and role in fast-track surgery. Int J Surg 2014; 12: 936-9.
8. Zengin M, Alagoz A. Comparison of thoracic epidural analgesia and thoracic paravertebral block applications in the treatment of acute pain after thoracotomy in geriatric patients. Cureus 2021; 13: e18982.
9. Yeap YL, Wolfe JW, Backfish-White KM, et al. Randomized prospective study evaluating single-injection paravertebral block, paravertebral catheter, and thoracic epidural catheter for postoperative regional analgesia after video-assisted thoracoscopic surgery. J Cardiothorac Vasc Anesth 2020; 3: 1870-6.
10. Scarci M, Joshi A, Attia R. In patients undergoing thoracic surgery is paravertebral block as effective as epidural analgesia for pain management? Interact Cardiovasc Thorac Surg 2010; 10: 92-6.
11. Xu ZZ, Li X, Zhang Z, et al. Ultrasound-guided erector spinae plane block versus thoracic paravertebral block on postoperative analgesia after laparoscopic nephroureterectomy: study protocol of a randomized, double-blinded, non-inferiority design trial. Trials 2021; 22: 249.
12. Forero M, Adhikary SD, Lopez H, et al. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med 2016; 41: 621-7.
13. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. Can J Anaesth 2021; 68: 387-408.
14. Turhan Ö, Sivrikoz N, Sungur Z, et al. Thoracic paravertebral block achieves better pain control than erector spinae plane block and intercostal nerve block in thoracoscopic surgery: a randomized study. J Cardiothorac Vasc Anesth 2021; 35: 2920-7.
15. Zhao H, Xin L, Feng Y. The effect of preoperative erector spinae plane vs. paravertebral blocks on patient-controlled oxycodone consumption after video-assisted thoracic surgery: A prospective randomized, blinded, non-inferiority study. J Clin Anesth 2020; 62: 109737.
16. Altiparmak B, Toker MK, Uysal Aİ, et al. Eficácia do bloqueio do plano do músculo eretor da espinha guiado por ultrassom para analgesia após colecistectomia laparoscópica: um estudo controlado randômico [Efficacy of ultrasound-guided erector spinae plane block for analgesia after laparoscopic cholecystectomy: a randomized controlled trial]. Braz J Anesthesiol 2019; 69: 561-8.
17. Yang HM, Choi YJ, Kwon HJ, et al. Comparison of injectate spread and nerve involvement between retrolaminar and erector spinae plane blocks in the thoracic region: a cadaveric study. Anaesthesia 2018; 73: 1244-50.
18. Ivanusic J, Konishi Y, Barrington MJ. A cadaveric study investigating the mechanism of action of erector spinae blockade. Reg Anesth Pain Med 2018; 43: 567-71.
19. El-Boghdadly K, Pawa A. The erector spinae plane block: plane and simple. Anaesthesia 2017; 72: 434-8.
20. Wildgaard K, Ravn J, Kehlet H. Chronic post-thoracotomy pain: a critical review of pathogenic mechanisms and strategies for prevention. Eur J Cardiothorac Surg 2009; 36: 170-80.
21. Maguire MF, Ravenscroft A, Beggs D, et al. A questionnaire study investigating the prevalence of the neuropathic component of chronic pain after thoracic surgery. Eur J Cardiothorac Surg 2006; 29: 800-5.
22. Urits I, Charipova K, Gress K, et al. Expanding role of the erector spinae plane block for postoperative and chronic pain management. Curr Pain Headache Rep 2019; 23: 71.
23. Pabón-Muñoz FE, Luna-Montúfar CA, Paredes MR. The ultrasound-guided erector spinae plane (ESP) block in chronic pain due to bone metastasis: case report. Colombian Journal of Anesthesiology 2019; 47: 128-131.