Original Article

A Comparative Study Between Ultrasound-Guided Erector Spinae Plane Block and Paravertebral Block in Thoracic Surgeries For Postoperative Analgesia

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Abstract

Background: Regional analgesia has an important role in the multimodal analgesia approach for postoperative pain management. Recently, the use of PVB is increased for providing effective analgesia. ESP block is a comparatively newer modality, established as a good analgesic technique. This study aimed to compare the postoperative analgesic efficacy of ultrasound-guided ESP block and PVB in thoracic surgeries.

Materials and Methods: This prospective randomized comparative double-blinded study involved 60 patients who underwent different thoracic surgeries and were randomized to receive ultrasound-guided ESP block (group A) or PVB (group B) with 20 ml 0.25% bupivacaine before induction of general anesthesia. Postoperatively, all patients received 1gm intravenous paracetamol injection every 8 hours. The primary outcome was to compare VAS scores at 0, 1, 3, 6, 12, and 24h, and secondary outcomes were assessed in terms of analgesic consumption and hemodynamic stability postoperatively

Results: Group A had a significantly lower VAS score at 0h, 1h, 3h, and 6h postoperatively (p=0.026, 0.003, 0.003, and 0.002, respectively) than group B. Thereafter, comparable VAS scores were found at 12 and 24h. However, the mean VAS in either of the group was <4 postoperatively. Rescue analgesic consumption was found comparable (p>0.05) in both groups. All patients exhibited stable hemodynamic profiles postoperatively.

Conclusion: Ultrasound-guided ESP block along with round-the-clock NSAIDs can be a better and safe alternative to PVB in thoracic surgeries with reduced analgesic consumption and hemodynamic stability.

Keywords: Ultrasound, erector spinae plane block, paravertebral block, thoracic surgery, postoperative pain

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Introduction

Post-operative pain management after thoracic surgery is a challenging task. Chronic pain after thoracic surgery has been defined as "pain that recurs or persists along a thoracotomy scar at least two months following surgical procedure by the International Association for the Study of Pain (1). Inadequate analgesia increases patients' suffering and quality of life and affects post-operative recovery (2). Several studies have described

numerous modalities to improve post-thoracic surgery pain, including prescribing patient-controlled analgesia and various analgesic methods. Thoracic Epidural Analgesia (TEA) is considered a gold standard technique for pain management in thoracotomies (3). However, it is associated with side effects like hypotension, urinary retention, and pruritis. Thoracic paravertebral block (PVB) is a technique in which local anesthesia (LA) is injected adjacent to the thoracic vertebra from where the spinal nerves emerge from the intervertebral foramina (4). Recently, the use of paravertebral block increased as an option to give equivalent analgesia to thoracic epidurals without significant side effects (5-7).

Forero et al. (8) described ultrasound-guided erector spinae plane block (ESPB) for the first time. It was an interfascial plane block documented as good post-operative analgesia with safety and simplicity. Ultrasonographic imaging characteristics of muscle layers and transverse processes are easy to recognize and locate (8). ESPB is injected away from the pleura and neural and vascular structures into the fascial plane, deep into the erector spinae muscle. This local anesthetic solution extends into the paravertebral space (9), blocking the spinal nerve's dorsal, ventral, and traffic branches. Penetration of the inter-transverse connective tissues also blocks the lateral cutaneous branches of the intercostal nerves (7, 10). Several studies have reported the effectiveness of ESPB. Initially, it was used in treating thoracic neuropathic pain; later, it has been reported to be utilized frequently in treating post-operative pain from surgical procedures in shoulder, breast, bariatric and hip surgery (7, 11-13). Insufficient studies compare the analgesic potential of PVB and ESPB in thoracic surgeries. Therefore, this study was designed to find the efficacy of the ultrasound-guided ESPB and PVB by using 0.25% bupivacaine combined with general anesthesia (GA) in postoperative pain management and enhancing the quality of recovery after thoracic surgeries.

Methods

The study occurred in the Department of Anesthesiology, King George Medical University, Lucknow, Uttar Pradesh, India, between January 2020 and December 2020.

Based on the Inclusion-Exclusion criteria (Table 1), subjects were recruited for the study. The written informed consent was taken from all patients. Patients were taught to self-assess the pain severity using a 10 cm visual analog scale (VAS) (where 0 = no pain and 10 cm = most severe pain).

Ethical considerations: This single-center, prospective, randomized, double-blind comparative study was approved by the institutional ethics committee (Registration No. ECR/262/Inst/UP/2013/RR-19). We strictly followed the good clinical practice guidelines and the Declaration of Helsinki (as revised in 2013) during the

Table 1: Inclusion and exclusion criteria of the study.

Inclusion Criteria	Exclusion Criteria
Patient giving consent.	Patients with chronic pain or receiving chronic analgesic therapy.
Age ≥18 years.	Patients have known allergies to Local Anaesthetic medication.
Patients belonging to the American Society of Anesthesiologists (ASA) physical status Grade I, II, and III.	The patient has bleeding disorders.
Adult patients of either sex undergoing thoracic surgery (eg. thoracotomy,decortication)	Mentally compromised patients may vaguely measure postoperative pain following surgeries.
-	Patients with a history of drug abuse or who are dependent on opioid drugs

study period.

Sample size calculation: The sample size was calculated based on maximum variation in VAS during the post-operative period among the study groups (based on the reference paper by Nagaraja et al. (14). A sample size of 60 (30 in each group) was established by keeping the type I error of 5% and a power of 0.8. We enlisted 65 patients into the study, while five patients did not match the inclusion criteria; hence the total number of patients included in the study was 60.

Randomization and blinding: For randomization, CONSORT guidelines were followed. The patients were randomized using a computer-generated random number table. The random sequence was sealed in consecutively numbered opaque envelopes and kept by the study coordinator. Participants will be randomly divided into two groups according to the 1:1 ratio of groups A and B (n=30 in each group). Patients in group A received erector spinae plane block (ESPB), while group B comprised patients who received paravertebral block (PVB) (Fig 1). A study coordinator was nominated to allocate and preserve the result of randomization. The coordinator has opened the envelopes for allotment according to the order of enrolment. The study participants were blinded to the allocation, and the post-operative assessor was blinded to grouping.

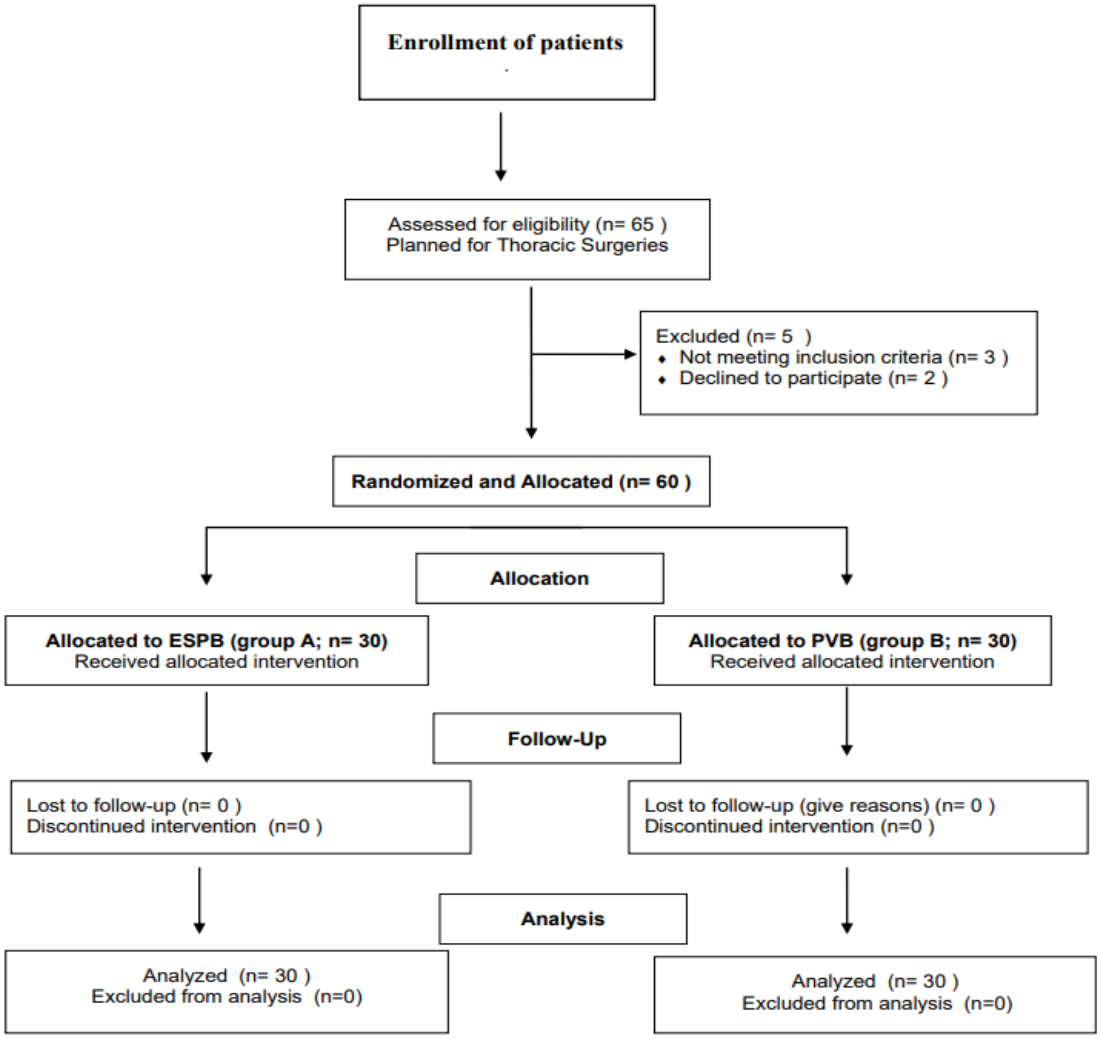

Figure 1. Consort FLOW Diagram; ESPB: Erector Spinae Plane Block; PVB: Para Vertebral Block

0.25% injection. Bupivacaine has been given into the

Table 2: Comparison of Demographic Profile and Baseline Characteristics of patients in two study groups.

SN	Characteristic	Total (n=60)	Group A (n=30)	Group B (n=30)	Statistical significance
1.	Mean Age±SD (Range) in years	41.83±9.78 (23-60)	41.03±9.0 (29-60)	42.63±10.54 (23-60)	't'=0.630; p=0.531
2.	Mean Weight±SD (Range) kgs.	58.18±6.32 (46-71)	58.37±6.77 (48-70)	58.00±5.94 (46-71)	't'=0.223; p=0.824
3.	Mean Height±SD (Range) cms.	162.40±5.99 (148-172)	162.23±6.28 (148-171)	162.57±5.80 (153-172)	't'=-0.214; p=0.832
4.	Mean BMI±SD (Range) kg/m^2.	21.97±1.44 (19.3-25.8)	22.10±1.43 (19.3-24.5)	21.85±1.46 (19.4-25.8)	't'=0.660; p=0.512
5.	ASA Grade				
	I	8 (13.3%)	5 (16.7%)	3 (10.0%)	χ^2=0.634; p=0.728
	II	43 (71.6%)	21 (70.0%)	22 (73.3%)	
	III	9 (15.0%)	4 (13.3%)	5 (16.7%)	

Anesthesia Management: On the day of surgery, standard monitors were attached after confirming the patients' adequate nil per oral (NPO) status. Before general anesthesia (GA) induction, blocks were given by using PAJUNK® 21G sonographic needle with a single dose of 20 ml, 0.25% Bupivacaine injection in a sitting position. Blocks were performed using a high-frequency (5–13 MHz) linear ultrasound probe covered in a sterile sheath. Standard disinfection was applied to the operative site, and the block was performed with the below-mentioned technique.

ESPB: Under strict aseptic precautions, a high-frequency linear ultrasound probe was placed in a longitudinal plane 2.5-3 cm lateral to the T6 spinous process corresponding to the T5 transverse process in Group A patients. The transducer was slid horizontally until the transverse process tip was seen. Superficial to the hyper-echoic transverse process, identification of three muscles was done: trapezius (uppermost), rhomboid major (middle), and erector spinae muscle (lowermost). A PAJUNK® 21G sonographic needle was inserted in the plane from caudal to cephalad direction until the needle approached the plane below the erector spinae; after negative aspiration, 20 ml of erector spinae plane between the erector spinae muscle and the transverse process. Proper placement of local anesthetic was confirmed by upward displacement of erector spinae muscle (7).

PVB: A linear array, high-frequency ultrasound probe was placed in a longitudinal parasagittal plane 2.5-3 cm. lateral to the vertebral column at T5/T6 level with all aseptic precautions in group B patients. The ultrasound probe was adjusted to lay the targeted paravertebral space at the center. A PAJUNK® 21G sonographic needle was introduced from the lower border of the probe and proceeded to the cranial and anterior by keeping the aim for the junction of the upper transverse process and pleura. The needle tip entered the space piercing the superior costotransverse ligament. 20 ml of 0.25% injection Bupivacaine was injected just superior to the hyper-echoic pleural line after negative aspiration. The proper local anesthetic injection was confirmed by anterior displacement of the pleura (16).

All patients underwent their proposed thoracic surgical procedure (the surgeries included in the study were thoracotomy, decortication, VATS (video-assisted thoracoscopic surgery), MODS (multiple open

Table 3: Comparison of Post-operative Visual Analog Scale (VAS) Score between study Groups. ESP: Erector Spinae Plane; PV: Paravertebral

SN	Time Interval	Group A (ESP block) (n=30)			Group B (PV block) (n=30)			Mann-Whitney U Test	
		Median	Mean	SD	Median	Mean	SD	'z'	'p'
1-	Immediate Post-Op	2.00	2.20	0.48	2.50	2.50	0.51	-2.227	0.026
2-	1 hours	2.00	2.27	0.52	3.00	2.73	0.58	-2.989	0.003
3-	3 hours	3.00	2.73	0.69	3.00	3.27	0.58	-2.998	0.003
4-	6 hours	3.00	2.87	0.57	3.00	3.33	0.48	-3.110	0.002
5-	12 hours	3.00	3.13	0.73	3.00	3.40	0.62	-1.292	0.197
6-	24 hours	3.00	3.23	0.63	3.00	3.43	0.50	-1.194	0.232

drainage system), and thoracomyoplasty) under standardized GA protocol with ESP or PV block. GA was induced with intravenous 2 µg kg-1 fentanyl, 2 mg kg-1 propofol, and endobronchial intubation was performed with a double-lumen tube after achieving muscle relaxation with 0.1 mg kg-1 vecuronium. Maintenance of anesthesia was achieved by O2 and N2O mixture and isoflurane or sevoflurane along with periodic vecuronium for muscle relaxation. Intraoperatively, the patient was given a 1 g injection of paracetamol and 4 mg of Ondansetron before surgery. The reversal of neuromuscular blockade was done with 50 µg kg-1 neostigmine and 10 µg kg-1 glycopyrrolate at the end of the surgery. Patients were extubated upon returning to consciousness and shifted to the post-operative ward.

The postoperative pain assessment was performed using a 10 cm visual analog scale (VAS) at 0 (immediate post-op), 1, 3, 6, 12, and 24 hours. Postoperatively, all patients have received an injection of paracetamol 1 gm IV 8 hourly. Rescue analgesia with inj. Tramadol 100 mg IV infusion in 100 ml normal saline was administered if the VAS score was more than 4 at rest or on the patient's demand. Then, 2nd rescue analgesia was considered as 1 µg/Kg Fentanyl injection, if the VAS score remained more than 4 after 30 minutes of the first rescue analgesia. Both groups' hemodynamic parameters (HR, BP, SpO2, RR, ECG changes) were recorded postoperatively. Hypotension is defined as a fall in MBP of >20% from baseline, and bradycardia is defined as HR<50 bpm. Any complications related to the method or drug-like nausea and vomiting, pneumothorax, hematoma, vascular puncture, and local anesthetic toxicity were also recorded in both groups. Injection of ondansetron 4 mg IV was given to treat any case of nausea and vomiting.

The primary objective was to compare the VAS scores in both groups postoperatively at 0 (Imm. Post-op), 1, 3, 6, 12, and 24 hours. Secondary objectives were to assess rescue analgesic consumption and to compare hemodynamic stability in both groups.

Statistical Analysis: The results were compiled and statistically analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. Chi-square test, independent samples t-test, Paired t-test, and Mann-Whitney U test were used to compare the data. 'p-value

Table 4: Comparison of two study groups for Requirement of Rescue Analgesia; ESP: Erector Spinae Plane; PV: Para Vertebral

SN	Requirement of Rescue Analgesia	Total (N=60)	Group A (ESP block) (N=30)		Group B (PV block) (N=30)	
			No.	%	No.	%
1-	Not Required	54 (90%)	28	93.3	26	86.7
2-	Required	6(10%)	2	6.7	4	13.3
		χ^2= 0.741; p= 0.389				

less than 0.05 was considered significant. An independent sample t-test was used for inter-group comparison to compare the distribution concurrence normality assumption. If the distribution is skewed and not independent at different time points, the difference was determined by the Mann-Whitney U test.

Results

Out of 65 patients enlisted, 60 were finally included in the study, while five did not match the inclusion criteria. Patients were divided into groups A and B, as described earlier. The demographic profile and baseline characteristics are described in Table 2. Study patients had a mean age of 41.83±9.78 years (age range 23-60 years), of whom 65% were male (39 of the 60 patients). There was no statistically significant difference in the patient's age, weight, height, and BMI. The distribution of patients according to ASA grade. Out of 60 patients, 8 (13.3%) belong to ASA grade I, of whom 5 were from group A, and three were from group B. Maximum of 43 patients (71.6 %) belong to ASA grade II. A total of 21 (70%) belonged to group A and 22 (73.3%) to group B. Totally, 9 (15%) patients were from ASA grade III, of which 4 (13.3%) were from group A, and 5 (16.7 %) from Group B. Again, there was no statistically significant difference in the distribution pattern of patients according to ASA status in both the groups.

Figure 2 shows the type of thoracic surgeries and their comparison between the two study groups. Decortication, MODS (Multiple Open Drainage

Table 5: Comparison of Time (Hrs) for First Dose of Rescue Analgesia among those who required rescue analgesia and Post-operative Complications between groups between two Group; ESP: Erector Spinae Plane; PV: Para Vertebral

SN		Total (N=60)	Group A (ESP block) (N=30)	Group B (PV block) (N=30)
1-	Mean time (in hrs) required for first dose of rescue analgesia	6(10%)	2(6.7%) 14.50±0.70	4(13.3%) 13.50±1.29
	Post-operative complications [n (%)]	7(11.6%)	3 (10.0%)	4 (13.3%)
		χ^2= 0.741; p= 0.389		

System); VATS (Video Assisted Thoracoscopic Surgery), and Thoracomyoplasty in both groups. In comparing the type of thoracic surgeries between the groups, statistically, no significant difference was found (Fig. 2).

Table 3 shows the comparison of post-operative VAS scores between both groups. The pain score of group A patients was lower than that of group B post-op during all the proposed observational periods. Immediately after the surgery, the score was lower in group A compared to B; immediate postoperative significance was statistically significant (P value= 0.026). The statistically highly significant differences (p>0.005) were observed from 1 to 6 hours post-operative in group A after that at 12, and 24 hours. Though the lower VAS score was observed in group A as compared to B, the difference was non-significant. A comparison of the two study groups was also made for the requirement of rescue analgesia post-operation. Of the 60 patients, 54 (90%) did not require rescue analgesia, and only 6 (10%) patients were on analgesia. The patients who did not require analgesia were 28 (93.9%) from group A while 26 (86.7%) were from group B. When both the groups were compared based on the requirement of rescue analgesia, there was a higher proportion of patients in group B (13.3%) than that in group A (6.7%), but this difference was not found to be significant statistically. Among those who needed rescue analgesia, in group A, the mean time required for the first dose of rescue analgesia (14.50±0.70 hours) was higher as compared to (13.50±1.29 hours) in group B; however, on comparing the two groups statistically, no significant difference was found between groups. A higher proportion of patients in group B (13.3%) compared to group A (10.0%) had postoperative complications but were found statistically insignificant (Table 4).

We also postoperatively compared hemodynamic parameters (HR, MBP, RR, and SpO2). No significant differences were observed in all these parameters between the groups.

Discussion

The present study compares the efficacy of managing post-operative pain of ultrasound-guided ESPB and PVB in different thoracic surgeries. These surgeries include thoracotomy, decortication, VATS, MODS, and thoracomyoplasty. To the best of our knowledge, the studies compared these blocks in one particular type of thoracic surgery like in VATS (16, 18, 19) or thoracotomy (17). USG guidance improved the procedure's ease, increased success, and reduced block complications and onset time (9).

The single injection ESPB had a significantly

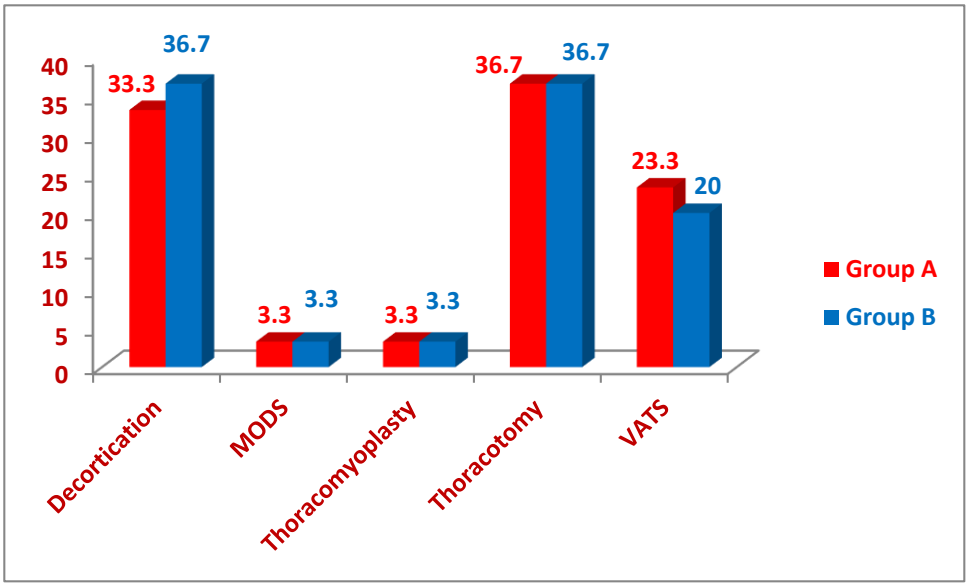

Figure 2. Comparison of type of thoracic surgery between the study groups (In Percentage); MODS: Multiple open drainage system; VATS: Video assisted thoracoscopic surgery. $\chi 2=0.125$ (df=4); p=0.998

lower VAS score in the initial 6 hours postoperatively than single injection PVB in our study subjects. It has been reported that ESPB provided better analgesia than TPVB after VATS without adverse side effects (18). However, Fang et al. (17) found ESPB equivalent to TPVB concerning pain scores and analgesic use after thoracotomy. They observed that post-operative complications are relatively less in the ESPB group. Comparatively fewer post-operative complications in the EPSB group were also observed in our study.

Similarly, Taketa et al. (19) demonstrated the equivalency of ESPB to TPVB for pain control after VATS. They found similar pain scores on movement in both groups and significantly lower pain scores at rest in the TPVB group at 1, 2, and 24 hours. In our study, the median VAS score remained less than 4 at all times in both groups up to 24 hours postoperatively. It shows that both blocks had provided satisfactory analgesia for up to 24 hours. In some recent studies, Shim et al. (20) compared the effect of EPSB with the control group. They found that a single preoperative injection of ESPB with ropivacaine improved acute post-operative analgesia and emergence agitation in patients undergoing VATS. Another recent study (21) on patients undergoing modified radical mastectomy concluded that ESPB might be a simple and safe alternative to the parasagittal in-plane PVB to provide postoperative analgesia, especially in novice practitioners. EPSB provides a comparable profile of postoperative analgesia with less time consumption to execute the block.

Though most of the studies agree with our findings, the findings of a few studies do not favor our study. Another study reported that ultrasound-guided multiple-injection PVB provided better analgesia than single-injection ESPB after thoracoscopic surgery (22). They found significantly lower VAS scores in the PVB group. They might have compared the multiple-injection PVB with single-injection ESPB; the multiple-injection PVB covered more dermatomes to provide better analgesia than single-injection ESPB. But finding comparable to our study was that they also reported the median VAS score was <4 in all the groups up to 24 hours postoperatively.

The requirement for rescue analgesia was observed to be reduced in both the groups in our study. Only 6.7% of patients in the ESPB group and 13.4% in the PVB group required a single dose of rescue analgesia (injection of Tramadol, 100 mg IV infusion in 100 ml normal saline). None of the patients required 2nd dose of rescue analgesia. Group A (ESPB) not only required less intervention of rescue analgesia postoperatively, but the time required for rescue was also higher compared to group B (PVB). However, no significant difference was found in comparing the two groups statistically regarding rescue analgesia. Therefore, the ESP block can be regarded as equal to PVB post-operatively. Our study results were consistent with Zhao et al. (16), who recorded similar post-operative rescue analgesia oxycodone in two groups. They concluded that single-shot bi-level ESP blocks applied before VATS were non-inferior in analgesic effect compared with PVB on the same levels regarding pain score, analgesic rescue consumption, and quality of recovery. At the same time, Shim et al. (20) found the consumption of post-operative rescue pethidine significantly lower in the ESPB group than in the control group in VATS. A recent study by Xu et al. (23) explored whether ESPB would have similar analgesia to TPVB in laparoscopic nephroureterectomy. It claimed the ESPB group to be better than the TPVB group. If superiority is identified on at least either cumulative 24 h opioid consumption or pain NRS (Numeric rating score), the primary outcome is the joint endpoint of opioid consumption and pain NRS score.

The mechanism of action of PVB suggests that it can cause unilateral somatic and sympathetic nerve block through spinal nerve roots (24). Saad et al. (25) demonstrated that thoracic PVB provides adequate analgesia with reduced analgesic consumption following thoracotomy. Giang et al. (26) also reported that PVB is an efficient method to provide adequate pain control following VATS lobectomy with fewer side effects. Many other studies suggested that similar analgesia to epidural with lesser side effects can be achieved by thoracic PVB (4).

The LA in ESP block acts on the dorsal and ventral rami of the spinal nerves and is considered a peri-paravertebral technique. Tulgar et al. (27) demonstrated that in ESP, block diffusion of LA occurs into paravertebral, intercostal, and epidural space and spreads across 2-5 levels affecting thoracic spinal nerves. Nath et al. (28) demonstrated that ESP block

provides good analgesia in open posterolateral thoracotomy. Nagaraja et al. (14) reported that ESP block is an excellent alternative to TEA for post-operative analgesia after cardiac surgery.

In our study, the patients were given 1 g injection of paracetamol and 4 mg of injection of Ondansetron before surgery. This multimodal analgesia approach has provided adequate pain control. In addition, in the present study, blocks were given preoperatively before induction of GA with the concept of pre-emptive analgesia. The sensitization of a nociceptive stimulus can reduce the introduction of analgesics before the stimulus and improvises further treatment. As well as, post-operative distortion of anatomy can prevent proper identification of landmarks.

Postoperatively, all hemodynamic parameters in both groups remained in range compared to baseline parameters. And no case of hypotension and bradycardia was reported. The only postoperative complication seen in this study was nausea and vomiting. No other block or drug-related complication was observed.

There are certain limitations of our study. VAS score is a subjective parameter for assessing pain; this could have caused some bias in assessing postoperative analgesia. To understand the patient's pain threshold, quantitative sensory testing must also be measured. We did not compare VAS scores during coughing or on movement. Our study sample size was small from a single center, and a multicentric study is needed to verify the effects.

Conclusion

Ultrasound-guided ESP block and PVB block provide adequate pain relief up to 24 hours postoperatively in thoracic surgeries. The methods reduced opioid analgesic consumption, hemodynamic stability, and minimal side effects. However, the ultrasound-guided ESP block has a better analgesic profile in the initial 6 hours postoperatively in terms of pain scores as compared to PVB. Thus, we concluded from this study that ultrasound-guided erector spinae plane (ESP) block in combination with round-the-clock NSAIDs could be a better and safe option for paravertebral block (PVB) as a part of multimodal analgesia for post thoracic surgery pain.

Acknowledgment

None.

Conflicts of Interest

The authors declare that they have no conflict of interest.

References

1. 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(1):170-80.
2. Boisen ML, Rolleri N, Gorgy A, Kolarczyk L, Rao VK, Gelzinis TA. The Year in Thoracic Anesthesia: Selected Highlights From 2018. J Cardiothorac Vasc Anesth. 2019;33(11):2909-19.
3. Kaplowitz J, Papadakos PJ. Acute pain management for video-assisted thoracoscopic surgery: an update. J Cardiothorac Vasc Anesth. 2012;26(2):312-21.
4. Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs epidural blockade for thoracotomy--a systematic review and meta-analysis of randomized trials. Br J Anaesth. 2006;96(4):418-26.
5. Yeung JH, Gates S, Naidu BV, Wilson MJ, Gao Smith F. Paravertebral block versus thoracic epidural for patients undergoing thoracotomy. Cochrane Database Syst Rev. 2016;2(2):Cd009121.
6. Abd-Elshafy SK, Abdallal F, Kamel EZ, Edwar H, Allah EA, Maghraby HHM, et al. Paravertebral Dexmedetomidine in Video-Assisted Thoracic Surgeries for Acute and Chronic Pain Prevention. Pain Physician. 2019;22(3):271-80.
7. Chhabra A, Roy Chowdhury A, Prabhakar H, Subramaniam R, Arora MK, Srivastava A, et al. Paravertebral anaesthesia with or without sedation versus general anaesthesia for women undergoing breast cancer surgery. Cochrane Database Syst Rev. 2021;2(2):Cd012968.
8. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain. Reg Anesth Pain Med. 2016;41(5):621-7.
9. Willard FH, Vleeming A, Schuenke MD, Danneels L, Schleip R. The thoracolumbar fascia: anatomy, function and clinical considerations. J Anat. 2012;221(6):507-36.
10. De Cassai A, Tonetti T. Local anesthetic spread during erector spinae plane block. J Clin Anesth. 2018;48:60-1.
11. Chin KJ. Thoracic wall blocks: From paravertebral to retrolaminar to serratus to erector spinae and back again - A review of evidence. Best Pract Res Clin Anaesthesiol. 2019;33(1):67-77.
12. Bonvicini D, Tagliapietra L, Giacomazzi A, Pizzirani E. Bilateral ultrasound-guided erector spinae plane blocks in breast

cancer and reconstruction surgery. J Clin Anesth. 2018;44:3-4.
13. Chin KJ, Malhas L, Perlas A. The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. Reg Anesth Pain Med. 2017;42(3):372-6.
14. Nagaraja PS, Ragavendran S, Singh NG, Asai O, Bhavya G, Manjunath N, et al. Comparison of continuous thoracic epidural analgesia with bilateral erector spinae plane block for perioperative pain management in cardiac surgery. Ann Card Anaesth. 2018;21(3):323-7.
15. Krediet AC, Moayeri N, van Geffen GJ, Bruhn J, Renes S, Bigeleisen PE, et al. Different Approaches to Ultrasound-guided Thoracic Paravertebral Block: An Illustrated Review. Anesthesiology. 2015;123(2):459-74.
16. 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.
17. Fang B, Wang Z, Huang X. Ultrasound-guided preoperative single-dose erector spinae plane block provides comparable analgesia to thoracic paravertebral block following thoracotomy: a single center randomized controlled double-blind study. Ann Transl Med. 2019;7(8):174.
18. Hamilton C, Alfille P, Mountjoy J, Bao X. Regional anesthesia and acute perioperative pain management in thoracic surgery: a narrative review. J Thorac Dis. 2022;14(6):2276-96
19. Taketa Y, Irisawa Y, Fujitani T. Comparison of ultrasound-guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia after video-assisted thoracic surgery: a randomized controlled non-inferiority clinical trial. Reg Anesth Pain Med. 2019.
20. Shim JG, Ryu KH, Kim PO, Cho EA, Ahn JH, Yeon JE, et al. Evaluation of ultrasound-guided erector spinae plane block for postoperative management of video-assisted thoracoscopic surgery: a prospective, randomized, controlled clinical trial. J Thorac Dis. 2020;12(8):4174-82.
21. Moustafa MA, Alabd AS, Ahmed AMM, Deghidy EA. Erector spinae versus paravertebral plane blocks in modified radical mastectomy: Randomised comparative study of the technique success rate among novice anaesthesiologists. Indian J Anaesth. 2020;64(1):49-54.
22. Chen N, Qiao Q, Chen R, Xu Q, Zhang Y, Tian Y. The effect of ultrasound-guided intercostal nerve block, single-injection erector spinae plane block and multiple-injection paravertebral block on postoperative analgesia in thoracoscopic surgery: A randomized, double-blinded, clinical trial. J Clin Anesth. 2020;59:106-11.
23. Xu ZZ, Li X, Zhang Z, Liu ZY, Song LL, Li XY, 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(1):249.
24. Karmakar MK. Thoracic paravertebral block. Anesthesiology. 2001;95(3):771-80.
25. Saad FS, El Baradie SY, Abdel Aliem MAW, Ali MM, Kotb TAM. Ultrasound-guided serratus anterior plane block versus thoracic paravertebral block for perioperative analgesia in thoracotomy. Saudi J Anaesth. 2018;12(4):565-70.
26. Giang NT, Van Nam N, Trung NN, Anh LV, Cuong NM, Van Dinh N, et al. Patient-controlled paravertebral analgesia for video-assisted thoracoscopic surgery lobectomy. Local Reg Anesth. 2018;11:115-21.
27. Tulgar S, Kapakli MS, Senturk O, Selvi O, Serifsoy TE, Ozer Z. Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: A prospective, randomized, controlled clinical trial. J Clin Anesth. 2018;49:101-6.
28. Nath S, Bhoi D, Mohan VK, Talawar P. USG-guided continuous erector spinae block as a primary mode of perioperative analgesia in open posterolateral thoracotomy: A report of two cases. Saudi J Anaesth. 2018;12(3):471-4.