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# Comparison of erector spinae plane block and serratus anterior plane block for pain management in thoracoscopic surgery

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## ABSTRACT

**Aims:** This study was designed to compare the efficacy and safety of erector spinae plane block and serratus anterior plane block in VATS (video assisted thoracoscopic surgery) patients.

**Methods:** This prospective, single-blinded, randomized controlled trial included fifty patients aged 18 to 70 years, classified as American Society of Anesthesiologists (ASA) physical status I-III, who were scheduled to undergo elective video-assisted thoracoscopic surgery (VATS) between February 2022 and February 2023. Patients were randomly assigned to receive either an erector spinae plane block (ESPB) or a serratus anterior plane block (SAPB). In the ESPB group, a catheter was inserted at the T5 vertebral level, and 30 ml of 0.25% bupivacaine was administered. In the SAPB group, the catheter was placed into the superficial fascia overlying the serratus anterior muscle at the level of the fifth rib, and the same volume and concentration of local anesthetic was used. Postoperatively, when the Numeric Rating Scale (NRS) pain score was ≥3, a patient-controlled analgesia (PCA) device delivering 0.125% bupivacaine was connected to the catheter, and continuous infusion was initiated. Intraoperative fentanyl consumption, time to PCA connection, NRS scores, and postoperative morphine use were recorded. Data were analyzed using R version 4.0.0. Appropriate parametric or non-parametric tests were used based on data distribution. Repeated measures were evaluated with the Friedman test, and a p-value <0.05 was considered statistically significant.

**Results:** Intraoperative fentanyl consumption was significantly lower in the ESPB group (p<0.05). There was no significant difference between the groups in time to PCA connection, NRS scores, or postoperative morphine use (p>0.05). NRS scores decreased over time in both groups. No complications occurred.

**Conclusion:** ESPB is superior for intraoperative analgesia, while both blocks are equally effective for postoperative pain management.

**Keywords:** Video assisted thoracic surgery, postoperative pain; regional anesthesia, nerve block, erector spinae plane block, serratus anterior plane block

## INTRODUCTION

Surgical interventions involving the chest wall can cause significant pain in patients. Despite advancements in understanding pain mechanisms and the implementation of effective multimodal analgesia techniques, postoperative pain management remains a significant challenge in thoracic surgery cases. Inadequate treatment of postoperative pain in these patients can disrupt chest wall mechanics, leading to atelectasis and ventilation/perfusion mismatches in the lungs, which may result in hypoxemia. Effective pain management increases functional residual capacity, facilitates secretion clearance through effective coughing, and reduces the risk of complications.[1]

Video-assisted thoracoscopic surgery (VATS) is a minimally invasive surgical technique that is currently the standard approach for both minor and major lung operations.[2] Thoracic epidural analgesia (TEA) and paravertebral block are widely used for analgesia after VATS. Erector spinae plane block (ESPB) and serratus anterior plane block (SAPB) are interfascial plane blocks that are simpler to perform and associated with lower complication rates compared to these techniques.[3]

The primary aim of the study was to compare intraoperative and postoperative opioid consumption in patients receiving ESPB and SAPB. The secondary aim was to evaluate postoperative pain scores, perineural patient-controlled analgesia (PCA) device connection times, and complication rates.

## METHODS

This prospective study was approved by the relevant the Pamukkale University Non-interventional Clinical Researches Ethics Committee (Date: 08.02.2022, Decision No: 168664). Fifty patients aged 18-70 years, with American Society of Anesthesiologists (ASA) physical status scores of I-III, scheduled for elective thoracoscopic surgery between

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February 2022 and February 2023, were included in the study after providing verbal and written informed consent. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Exclusion criteria included patients with infections at the procedure site, a body-mass index (BMI) less than 20 or greater than 30, bleeding diathesis, anticoagulant medication use, a history of allergic reactions to local anesthetics or opioids, chronic analgesic use, impaired liver or kidney function, or those requiring a change in the planned surgical approach. All VATS procedures were initiated using a standardized two-port technique. However, in certain cases, based on intraoperative anatomical or technical challenges, a third port was added at the discretion of the surgical team. Unfortunately, the exact number of ports used in each case was not systematically recorded. All patients received a single chest tube.

Patients were randomized into two groups using a computerized randomization method: the erector spinae plane block (ESPB, n=25) group and the serratus anterior plane block (SAPB, n=25) group.

After routine monitoring, induction was performed with 2 mg/kg propofol, 1.5 mcg/kg fentanyl, and 0.6 mg/kg rocuronium, and the patients were intubated with an appropriate double-lumen endobronchial tube. General anesthesia was maintained with 2 L/min fresh gas flow containing 40% $FiO_2$ and sevoflurane at a minimum alveolar concentration (MAC) of 1.0 (±20%). Neuromuscular blockade was maintained with 0.15 mg/kg rocuronium bromide, and if a ≥20% increase in heart rate or blood pressure was observed from the baseline values at the start of the surgery, a 0.5 mcg/kg fentanyl bolus was administered. All blocks were performed by the same person.

Both blocks were performed in a sterile manner in the lateral decubitus position after induction and before surgery.

In the ESPB group, the linear ultrasound (US) probe was placed 2-3 cm lateral to the T5 spinous process in the parasagittal plane. After visualizing the T5 transverse process with the in-plane technique, an 18G Tuohy needle was advanced at a 45° angle from the skin in the caudo-cranial direction, passing through the trapezius, rhomboid, and erector spinae muscles. Once the needle reached the transverse process, it was slightly withdrawn, and hydrodissection with 5 ml of saline was performed between the erector spinae muscle fascia and the transverse process to confirm the correct placement. An epidural catheter was then inserted, leaving 5 cm of the catheter in the interfascial space. After confirming no blood or air return with negative aspiration, the catheter was secured with a suture. Subsequently, 30 ml of 0.25% bupivacaine was injected in divided doses of 5 ml each.

In the SAPB group, the latissimus dorsi, serratus anterior, and intercostal muscles were determined at the level of the fifth rib by placing the linear US probe in the parasagittal plane on the midaxillary or posterior axillary line on the side to be blocked. Using the in-plane technique, an 18G Tuohy needle was advanced at a 45° angle from the skin in the caudo-cranial direction. A catheter was placed in the plane between the latissimus dorsi and serratus anterior muscles using the same procedure and the same dose of local anesthetic was applied.

Thirty minutes before the end of the surgery, both groups of patients received 50 mg of dexketoprofen and 1 g of intravenous paracetamol.

After surgery, the patients were extubated and transferred to the anesthesia intensive care unit. For postoperative analgesia, patients in both groups were given 1 gram of intravenous paracetamol every 8 hours and 50 mg of intravenous dexketoprofen every 12 hours. In the postoperative period, a PCA device with a 15 ml loading dose, 4 ml/h basal infusion and 4 ml bolus dose and a 30-minute locking time was connected to the perineural catheters of patients with a NRS score of ≥3 at rest, and 0.125% bupivacaine solution infusion was started. Additionally, 0.05 mg/kg morphine was administered intravenously as a push as rescue analgesia to patients who were connected to a perineural PCA device and had received a bolus dose within the last 20 minutes but had a resting NRS score of ≥4. Demographic characteristics, comorbidities, ASA scores, intraoperative fentanyl requirements, anesthesia and surgery times of the patients were recorded. For both groups, NRS scores at rest and during coughing at 30 minutes and 1, 2, 4, 8, 16, and 24 hours postoperatively, need for rescue analgesia, total morphine consumption in 24 hours, time to connect to perineural PCA device, and possible complications were recorded. Postoperative pain assessments were performed by ward nurses who were blinded to the group allocation and were unaware of which block technique had been used.

It was observed that the effect size obtained in a reference study was at a strong level (Cohen's d=1.26). However, as a result of the power analysis performed with the expectation that a lower effect size could be obtained; when the effect size is accepted as d=1.1, it was calculated that a total of 30 participants, at least 15 in each group, were required to detect a significant difference at a 95% confidence level and with 80% statistical power. Accordingly, a total of 50 patients were included in the study, 25 in each group, in order to increase the statistical power.[4]

### Statistical Analysis

Descriptive statistics were presented as numbers and percentages for categorical variables and as mean±standard deviation or median (minimum-maximum) for continuous variables. Whether the data distribution was normal was evaluated using histograms, Q-Q plots and normal distribution tests. Categorical variables were analyzed with Pearson's chi-square test or Fisher's exact test, and continuous variables were analyzed with independent groups T test or Mann-Whitney U test. Friedman test was used for repeated measures of continuous variables in the dependent group. A two-sided p-value of <0.05 was considered statistically significant. Statistical calculations and visualizations were performed using R version 4.0.0.

## RESULTS

It was found that there was no statistically significant difference between the ESPB and SAPB groups in terms of demographic factors such as age, height, weight, BMI, gender, ASA score, duration of surgery, duration of anesthesia and type of surgery. The average total intraoperative fentanyl dose in the ESPB group was 138±40.4 mcg, while in the SAPB group, this value was recorded as 166±41.8 mcg. The statistical analysis results indicated that the SAPB group consumed a significantly higher intraoperative fentanyl dose compared to the ESPB group ($p=0.02$) (Table 1).

When the two groups were compared in terms of the time to connection with the PCA device, no statistically significant difference was found ($p=0.50$). The median time to connection with the PCA device was 30 minutes (30.0-390 minutes) in the ESPB group and 30 minutes (30-60 minutes) in the SAPB group. One patient in the ESPB group did not require connection to a PCA device. There was no significant difference between the groups in terms of rescue analgesia (morphine) use ($p>0.99$). The mean total morphine consumption within the first 24 hours was 4.44±2.07 mg in the ESPB group and 5.67±3.12 mg in the SAPB group. No statistically significant difference was observed between the two groups regarding morphine consumption during the first 24 hours ($p=0.43$). Furthermore, no procedure-related complications were observed in either group (Table 2).

**Table 1. Comparison of demographic characteristics and intraoperative opioid consumption between ESPB and SAPB groups**

| | Total n=50 | ESPB n=25 | SAPB n=25 | p |
|---|---|---|---|---|
| **Age, mean±SD** | 55.7±15.9 | 57.4±14.6 | 54.1±17.2 | 0.40[a] |
| **Height (m), mean±SD** | 1.71±0.07 | 1.70±0.07 | 1.72±0.07 | 0.55[a] |
| **Weight (kg), mean±SD** | 73.2±11.1 | 70.2±8.56 | 76.1±12.7 | 0.10[a] |
| **BMI (kg/m²), mean±SD** | 25.0±3.25 | 24.3±2.72 | 25.6±3.63 | 0.21[a] |
| **Sex, n (%)** | | | | 0.74[b] |
| Female | 12 (24.0) | 5 (20.0) | 7 (28.0) | |
| Male | 38 (76.0) | 20 (80.0) | 18 (72.0) | |
| **ASA score, n (%)** | | | | 0.06[b] |
| 1 | 12 (24.0) | 6 (24.0) | 6 (24.0) | |
| 2 | 33 (66.0) | 14 (56.0) | 19 (76.0) | |
| 3 | 5 (10.0) | 5 (20.0) | 0 (0.00) | |
| **Duration of surgery (min), mean±SD** | 158±72.8 | 168±80.7 | 147±64.1 | 0.36[a] |
| **Duration of anesthesia (min), mean±SD** | 215±79.3 | 228±89.0 | 202±67.5 | 0.26[a] |
| **Type of surgery, n (%)** | | | | 0.30[b] |
| Lobectomy | 20 (40.0) | 12 (48.0) | 8 (32.0) | |
| Segmentectomy | 2 (4.00) | 1 (4.00) | 1 (4.00) | |
| Thymectomy | 7 (14.0) | 1 (4.00) | 6 (24.0) | |
| Mediastinal mass excision | 2 (4.00) | 1 (4.00) | 1 (4.00) | |
| Wedge resection | 19 (38.0) | 10 (40.0) | 9 (36.0) | |
| **Intraoperative fentanyl count, n (%)** | | | | 0.22[b] |
| 0 | 15 (30.0) | 10 (40.0) | 5 (20.0) | |
| ≥1 | 35 (70.0) | 15 (60.0) | 20 (80.0) | |
| **Intraoperative total fentanyl dose (mcg), mean±SD** | 152±43.1 | 138±40.4 | 166±41.8 | 0.02*[a] |

*p<0.05: statistically significant. a: Mann-Whitney U test, b: Chi-square test, ESPB: Erector spinae plane block, SAPB: Serratus anterior plane block, SD: Standard deviation, ASA: American Society of Anesthesiologists, kg: kilogram, m: meter, mcg: microgram, min: minute

**Table 2. Comparison of perineural PCA connection time, postoperative rescue analgesia usage, and complication rates between ESPB and SAPB groups**

| | Total, n=50 | ESPB, n=25 | SAPB, n=25 | p |
|---|---|---|---|---|
| **Time to connect to perineural PCA device (min), median (minimum-maximum), n=49†** | 30 (30-390) | 30 (30.0-390) | 30 (30-60) | 0.50[a] |
| **Use of rescue analgesia, n (%)** | | | | >0.99[b] |
| No | 32 (64.0) | 16 (64.0) | 16 (64.0) | |
| Yes | 18 (36.0) | 9 (36.0) | 9 (36.0) | |
| **Postoperative morphine count, n (%)** | | | | 0.65[b] |
| 0 | 32 (64.0) | 16 (64.0) | 16 (64.0) | |
| 1 | 12 (24.0) | 7 (28.0) | 5 (20.0) | |
| ≥2 | 6 (12.0) | 2 (8.00) | 4 (16.0) | |
| **Total morphine consumption in the first 24 hours (mg), mean±SD, n=18** | 5.06±2.65 | 4.44±2.07 | 5.67±3.12 | 0.43[a] |
| **Complications, n (%)** | 0 (0) | 0 (0) | 0 (0) | - |

*p<0.05: statistically significant. PCA: Patient-controlled analgesia, ESPB: Erector spinae plane block, SAPB: Serratus anterior plane block, SD: Standard deviation, a: Mann-Whitney U test, b: Chi-square test, mg: milligram, min: minute, †: One patient in the ESPB group did not require perineural PCA connection; therefore, the analysis was performed on 49 patients

In the postoperative period, no significant difference was observed between the ESPB and SAPB groups in terms of NRS scores at rest and during coughing. In both groups, postoperative NRS scores related to rest and coughing significantly decreased over time (p<0.001) (**Figure**).

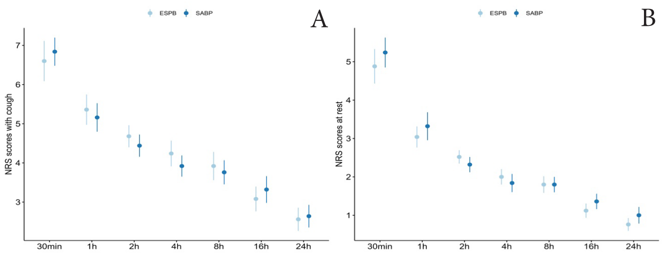

**Figure.** Change in NRS score over time with cough (A) and rest (B)

NRS: Numeric Rating Scale

## DISCUSSION

Currently, there are limited studies comparing ESPB and SAPB for postoperative analgesia in VATS patients, and most of the existing research has utilized single-injection techniques. In this study, unlike previous studies, ESPB and SAPB were continued in the postoperative period through the maintenance of local anesthetic infusion via a patient-controlled analgesia device. In the ESPB group, intraoperative opioid consumption was found to be statistically significantly lower. However, no significant differences were found between the two groups in terms of postoperative opioid consumption, postoperative NRS scores during the first 24 hours, time to connection to the perineural PCA device, and the use of rescue analgesia. Over time, NRS scores decreased in both groups. Additionally, no technical failure or complications were observed in either group.

SAPB was first described by Blanco et al.[5] in 2013 as an interfascial plane block performed under ultrasound guidance. SAPB targets the lateral cutaneous branches of the intercostal nerves that emerge from and penetrate the serratus anterior muscle.[6] In the literature, SAPB has been reported to be applied using superficial (superficial SAPB, SSAPB), deep (deep SAPB, DSAPB), and combined approaches.[7,8] Moon et al.[9] demonstrated that SSAPB and DSAPB provided similar intraoperative analgesic efficacy during VATS lobectomy. Lan Qiu et al.[7] reported that SAPB provides effective analgesia and that SSAPB may produce a longer-lasting effect compared to DSAPB. Zengin et al.[10] showed that combined SAPB offers superior analgesic efficacy compared to DSAPB. The technique used is a key factor influencing analgesic efficacy, as it directly affects the spread of the local anesthetic and the targeted nerve areas. In our study, the SSAPB technique was preferred because it is commonly performed in our clinic and the practitioners have substantial experience with it. Additionally, this method was considered appropriate due to its potential for prolonged analgesic effect as reported in the literature.

The efficacy of ESPB arises from the local anesthetics blocking the dorsal and ventral branches of the spinal nerves, in addition to their spread to the paravertebral and epidural spaces.[11] ESPB, first described by Forero et al.[12] in 2016, is an interfascial plane block performed under ultrasound guidance. Çiftçi et al.[13] demonstrated the efficacy of ESPB in patients undergoing VATS.

In the literature, SAPB and ESPB are generally performed using 20 or 30 ml of local anesthetic; in some studies, the block is maintained via continuous infusion through catheter placement.[4,14,15] Catheters can be placed either under ultrasound guidance or surgically.[10,16] Zengin et al.[17] demonstrated that using 30 ml of local anesthetic in ESPB is more effective and safer compared to 20 ml. Increasing the volume may enhance analgesic efficacy by providing a broader dermatomal spread. However, this must be carefully evaluated due to the potential risk of systemic toxicity. In our study, following a 30 ml local anesthetic bolus, postoperative infusion was continued using a PCA method, and no cases of local anesthetic toxicity were observed. This finding supports that safe analgesia can be achieved even with high volumes, provided that appropriate dosing and administration techniques are used.

In our study, intraoperative opioid consumption in the ESPB group was found to be significantly lower compared to the SAPB group. This finding was consistent with the results in the study by Ekinci et al.[18] In the study by Gaballah et al.[19] ESPB and SAPB were compared in VATS patients and it was reported that none of the patients in the two groups required extra intraoperative opioids except for fentanyl administered at induction. However, in our study, additional intraoperative opioid requirements were observed in 15 patients in the ESPB group and 20 patients in the SAPB group after induction. This discrepancy might be related to the lower dose of opioids administered during induction in our study. In the study by Elsabeeny et al.[4] which compared TEA, ESPB, and SAPB in patients undergoing thoracotomy, no significant difference was found between the ESPB and SAPB groups in terms of intraoperative opioid consumption. This situation may be attributed to differences in the surgical techniques applied to the patients or the type of SAPB used.

In our study, postoperative opioid consumption in the ESPB group was observed to be lower compared to the SAPB group; however, this difference was not statistically significant. Various studies comparing ESPB and SAPB in thoracic surgery patients have reported lower postoperative opioid consumption in the ESPB groups.[4,14,15,18] Finnerty et al.[20] compared the efficacy of single-dose ESPB and SAPB in minimally invasive thoracic surgery and found no significant difference in postoperative opioid consumption between the two groups. Similarly, Zengin et al.[8] compared ESPB and combined SAPB in patients undergoing VATS and reported no significant difference in postoperative opioid consumption.

Although the difference in postoperative opioid consumption between the ESPB and SAPB groups was not statistically significant in our study, the numerical trend favored the ESPB group. Considering this trend and previous literature supporting the superiority of ESPB, it is plausible that a statistically significant difference might emerge in a larger sample size. Therefore, future studies with higher sample sizes are needed to clarify this potential difference.

In our study, no significant difference in pain scores was observed between the two groups. Studies comparing ESPB and SAPB in thoracic surgery patients have shown that pain scores either show an advantage in favor of ESPB or are similar between the two techniques.[4,8,14,18,19,21] Scimia and Ricci[22] reported that in a case in which patient-controlled ESPB was applied for VATS, the postoperative pain score was below 4 without the need for opioids. In our study, the fact that pain scores were found to be high in both groups in the first postoperative hours indicates that both blocks applied with a single dose of 30 ml bupivacaine 0.25% injection before thoracoscopic surgery did not provide adequate analgesia in the early postoperative period, despite being combined with dexketoprofen and acetaminophen.

Except for one patient in the ESPB group, all patients required connection to a perineural PCA pump in the early postoperative period. No additional features were detected in the history of the patient in the ESPB group who did not require connection to the PCA pump, and this may be associated with a high pain threshold. Pain experience varies greatly between individuals, shaped by complex interactions of genetic, psychosocial, and demographic factors, and is crucial for the development of personalized pain management.[23] After being connected to the perineural patient-controlled analgesia pump, the pain scores of the patients participating in our study decreased and 9 patients from each group needed opioids at least once. The initial opioid requirement in patients receiving rescue analgesia occurred within the first postoperative hour in both groups. These findings suggest that, when using patient-controlled ESPB and SAPB techniques for postoperative analgesia management in thoracoscopic surgery, starting local anesthetic infusion before awakening the patient while carefully adhering to toxic dose limits and incorporating opioids into the analgesia regimen in the early postoperative period as needed are critical considerations.

Consistent with previous studies, our research demonstrated that there were no significant complications related to nerve blocks or catheters in either the ESPB or SAPB groups.[4,15] The proximity of the SAPB catheter site to the surgical field may restrict the movements of the surgical team. In this respect, ESPB is more advantageous.

### Limitations

The main limitations of this study include the relatively small sample size, the lack of dermatomal block assessment, and the undocumented number of ports used per case. Detailed data from the PCA devices such as the number of bolus attempts and the total dose of local anesthetic were not collected, as these parameters were not included in the original study protocol. Although observer blinding was implemented, the involvement of multiple assessors and the subjective nature of pain scoring may have introduced variability.

## CONCLUSION

ESPB and SAPB are both safe and effective methods for multimodal analgesia management following VATS. ESPB has been found to be superior in terms of intraoperative analgesia. Further large-scale studies are needed to optimize the application of these techniques.

## ETHICAL DECLARATIONS

### Ethics Committee Approval

The study was carried out with the permission of the Pamukkale University Non-interventional Clinical Researches Ethics Committee (Date: 08.02.2022, Decision No: 168664).

### Informed Consent

All patients signed and 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.


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