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ORIGINAL RESEARCH

Comparison of Ultrasound-Guided Thoracic Paravertebral Block Versus Thoracic Paravertebral Block Combined With Serratus Anterior Plane Block or Erector Spinae Block Following Video-Assisted Thoracoscopic Lobectomy

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Purpose: Compared the efficacy of ultrasound-guided thoracic paravertebral block (TPVB) and thoracic paravertebral combined with serratus anterior plane block (SAPB) or erector spinae block (ESPB) following video-assisted thoracoscopic lobectomy(VATL).

Patients and Methods: This retrospective study analyzed the medical records of 295 patients who underwent VATL surgery between August 2021 and January 2023. Patients were divided into three groups: TPVB (92 patients), TPVB combined with SAPB (106 patients), and TPVB combined with ESPB (97 patients). The primary outcomes were postoperative pain levels, measured using an 11-point visual analogue scale (VAS) both at rest and during coughing at 2, 6, 12, 24, and 48 hours postoperatively, as well as cumulative oxycodone consumption within 24 and 48 hours postoperatively.

Results: Postoperative cumulative oxycodone consumption within 24 and 48 hours was significantly lower in the TPVB+SAPB and TPVB+ESPB groups compared to the TPVB group ($P < 0.001$), with no significant difference between the TPVB+SAPB and TPVB +ESPB groups. The TPVB group exhibited higher VAS pain scores both at rest and during coughing at 2 and 6 hours postoperatively compared to the other two groups ($P < 0.005$). Within 24 hours postoperatively, the Area Under Curve (AUC) for VAS scores at rest was significantly lower in the TPVB+SAPB group than in the other two groups ($P < 0.05$), while the AUC for coughing pain was significantly lower in the TPVB+ESPB group compared to the TPVB group ($P = 0.049$). Nausea or vomiting occurred more frequently in the TPVB group compared to the other groups ($P = 0.016$).

Conclusion: TPVB combined with SAPB or ESPB provides superior analgesic effects compared to TPVB alone after video-assisted thoracoscopic lobectomy, with both techniques showing comparable analgesic efficacy. However, TPVB+SAPB may offer slightly better analgesia at rest, while TPVB+ESPB may have a potential advantage in reducing postoperative nausea and vomiting.

Keywords: thoracic paravertebral block, TPVB, serratus anterior plane block, SAPB, erector spinae plane block, ESPB, video-assisted thoracoscopic lobectomy, VATL, postoperative analgesia

Introduction

Lung cancer is one of the most common malignant tumors worldwide, characterized by a high recurrence rate and mortality rate.[1,2] Once lung cancer is diagnosed, surgical resection should be carried out as far as possible to extend patient survival. Currently, the primary surgical treatment for lung cancer resection in China is video-assisted

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thoracoscopic lobectomy (VATL).[3,4] Compared to traditional thoracotomy, VATL offers several advantages, including reduced trauma, shorter hospital stays, and increased patient comfort.[5] However, patients often still experience moderate-to-severe pain following VATL. Inadequate management of acute postoperative pain can lead to persistent postoperative pain,[6] which may increase healthcare costs, negatively affect quality of life and sleep, and delay the resumption of normal daily activities.[7,8] Implementing multimodal analgesic strategies can enhance postoperative pain control, reduce opioid consumption, and subsequently lower the risk of developing persistent postoperative pain.[9]

Some researchers regard thoracic epidural analgesia (TEA) as the gold standard for postoperative pain management in thoracic surgery. However, due to its significant side effects, TEA is contraindicated in patients taking anticoagulant or antiplatelet medications, and its failure rate has been reported to exceed 10%.[10] In contrast, thoracic paravertebral block (TPVB) is less invasive and has gained wider acceptance. Nonetheless, it is important to recognize that a single administration of TPVB typically provides only short-term analgesia (4–8 hours) and is often followed by rebound pain. Although continuous paravertebral block techniques are being developed, further research is necessary to optimize factors such as the duration of blockade, drug selection, catheter placement, and complication management.[11,12] To enhance postoperative analgesia in thoracic surgery, various dual nerve blockade techniques have been proposed,[13] such as the thoracic paravertebral combined with serratus anterior plane block (SAPB) or erector spinae block (ESPB). The SAPB, which blocks the lateral cutaneous branches of the intercostal nerves, provides analgesia for 6–12 hours and is frequently used in thoracoscopic procedures. The ESPB, offering 8–16 hours of pain relief, allows local anesthetics to diffuse directly into the paravertebral space, thereby blocking the dorsal, ventral, and communicative branches of the spinal nerves.[14] Given the extended duration of analgesia provided by both SAPB and ESPB, combining these techniques may reduce opioid consumption and address the issues associated with the short duration of TPVB and rebound pain. While different nerve block strategies can offer varying degrees of pain relief, it remains uncertain which approach provides superior pain management following video-assisted thoracic lobectomy (VATL).

This retrospective study evaluated the impact of various nerve block techniques, including TPVB alone, TPVB combined with SAPB and TPVB combined with ESPB, on analgesic outcomes in lung cancer patients undergoing VATL.

Materials and Methods

Study Design

This retrospective cohort study included lung cancer patients who underwent VATL. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethic committee of Zhongda Hospital, School of Medicine, Southeast University (NO.: 2022ZDSYLL085-P01) and was registered with Chinese Clinical Trials Registry (Registration No.: ChiCTR2200063686). Individual consent for this retrospective analysis was waived. Patient enrollment and allocation were guided by the CONSORT flow diagram (Figure 1).

Data were extracted from several key systems: the DoCare Anesthesia Clinical Information System V6.0, the primary platform for documenting anesthesia records; the Analgesic Pump Management System V1.2.0.2.1.0 (Jiangsu Renxian Medical Technology Co., Ltd)., the main system for managing postoperative acute pain; and the Hospital Information System (Neusoft Medical Information Management System -RealOne), used as the central platform for documenting surgical and postoperative care records. This retrospective study identified adult patients from the Southeast University Zhongda Hospital Medical Database who underwent VATL at our hospital between August 2021 and January 2023. The inclusion criteria were as follows: (1) age between 18 and 80 years; (2) received one of three specific nerve block techniques—TPVB alone, TPVB combined with ESPB, or TPVB combined with SAPB—with postoperative pain management provided through intravenous analgesia pumps; (3) availability of complete clinical data and follow-up information. Exclusion criteria included: (1) failure to meet the inclusion criteria; and (2) a history of opiate abuse. Patient data were collected by two investigators, covering demographic and clinical details, such as age, sex, body mass index (BMI), ASA physical status (1, 2, or 3), and comorbidities (such as, hypertension, diabetes, chronic heart disease, liver and kidney dysfunction). Intraoperative data included VATL duration, anesthesia duration, blood loss, intraoperative sufentanil consumption, and any block-related complications. The length of hospital stay was also recorded. Additionally,

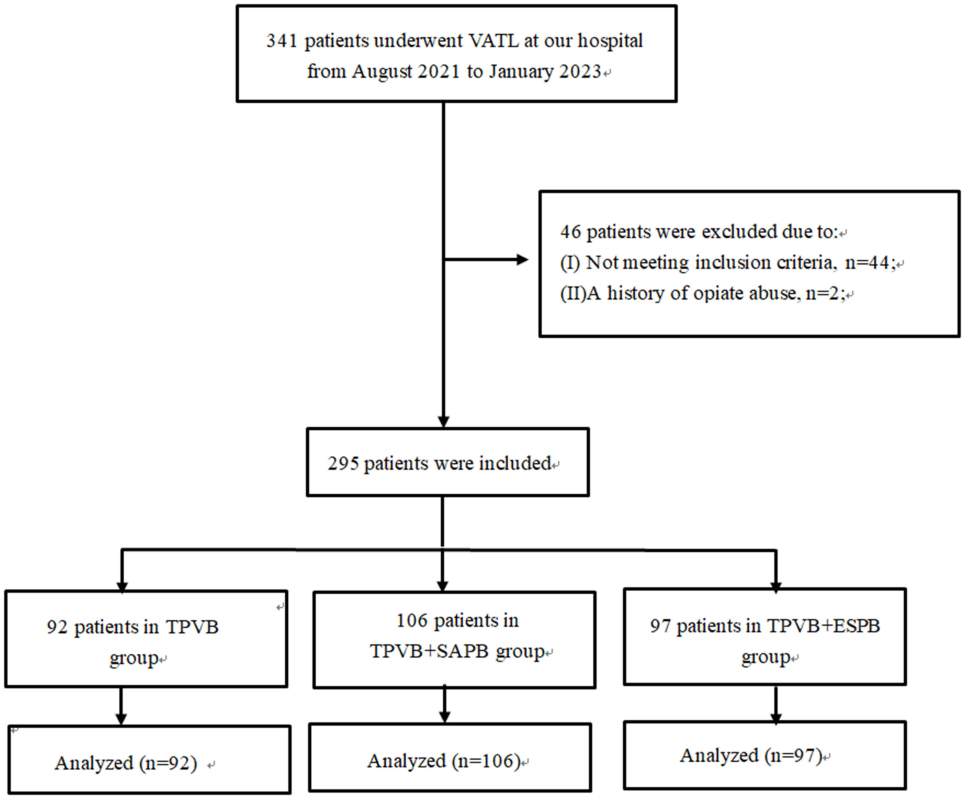

Figure 1 Consort flow diagram of patients. VATL, video-assisted thoracoscopic lobectomy.

during preoperative visits, patients were instructed on using the patient-controlled intravenous analgesia (PCA) device for pain management and guided to assess pain at rest and while coughing using the Visual Analog Scale (VAS).

Anesthesia Application and Surgical Technique

Intraoperative anesthesia management was performed by an leading anesthesiologist, assisted by a colleague. Patient monitoring included continuous electrocardiogram monitoring, pulse oximetry, and temperature assessment. Additionally, a radial artery catheter was placed before the initiation of anesthesia to facilitate invasive arterial pressure measurement and blood gas monitoring. General anesthesia was induced with midazolam (0.03–0.05 mg/kg), sufentanil (0.2–0.3 μg/kg), propofol (1–2 mg/kg), and rocuronium (0.6 mg/kg). Anesthesia was maintained using propofol, remifentanil and sevoflurane, ensuring a sedation level within the range of 40–60 under bispectral index (BIS) monitor. In addition, sufentanil (0.1–0.2 μg/kg) was injected intravenously 3 minutes before skin incision.

Application of Block Interventions

Following the surgical procedure, patients were transferred to the postanesthesia care unit (PACU). Extubation was performed once the patients were fully awake and breathing adequately. The blocks were then administered by a single anesthesiologist with extensive experience in ultrasound-guided regional anesthesia. Depending on the surgical site, the procedure was performed with the patient in either a left or right lateral decubitus position. Standard skin disinfection was carried out, and the ultrasound probe was covered with a sterile membrane.

Procedure of TPVB

The TPVB was performed as follows: A high-frequency linear ultrasound transducer (SonoSite HFL 50x; SonoSite, Inc.) was positioned longitudinally along the patient's midline at the T6 level. The probe was then moved laterally, approximately 2–3 cm from the midline, until a clear view of the adjacent transverse processes, the corresponding paravertebral space, and the pleura was obtained. A 20-gauge block needle was inserted using an in-plane technique, advancing through

the superior costotransverse ligament into the paravertebral space. Once the needle tip was confirmed to be within the paravertebral space, 3 mL of normal saline was injected. When the ultrasound image suggested that the pleural displacement, the needle tip reached the correct position. Following negative aspiration, 20 mL of 0.2% ropivacaine was administered. The TPVB was deemed successful when a pronounced pleural displacement was observed.

Procedure of SAPB

The SAPB procedure was performed as follows: First, the probe is placed in a sagittal position, scanning gradually from the mid-clavicular line downward and laterally until the probe reaches the level of the sixth rib along the mid-axillary line. At this point, the superficial latissimus dorsi and the deep serratus anterior muscles can be clearly visualized. Once the needle tip is positioned between the deep surface of the serratus anterior muscle and the ribs, 3 mL of normal saline is injected. After negative aspiration, blood is excluded to confirm the correct needle position, and then 20 mL of 0.2% ropivacaine is injected in the same plane. When the local anesthetic spreads in a linear pattern beneath the serratus anterior muscle, SAPB is considered successful.

Procedure of ESPB

The ESPB procedure was performed as follows: A high-frequency linear ultrasound transducer was positioned longitudinally along the thoracic T6 horizontal midline and then moved laterally approximately 2–3 cm from the midline to visualize the trapezius muscle, rhomboid muscle, erector spinae muscle, and transverse process.

A 20-gauge block needle was used for in-plane injection. Once the needle tip was positioned beneath the erector spinae muscle and made contact with the transverse process, 3 mL of normal saline was administered. When the ultrasound image indicated that the transverse process was separated from the erector spinae muscle, the needle tip was confirmed to be in the correct position. After negative aspiration, 20 mL of 0.2% ropivacaine was injected in-plane. Successful injection of the study drug was defined by the appearance of a hypoechoic ellipsoid with well-defined margins beneath the erector spinae muscle on ultrasound.

Local Anesthetic Administration in Different Groups

The local anesthetic dosage varied based on the intervention group. In the TPVB group, a total of 20 mL of 0.2% ropivacaine was administered. In the TPVB+SAPB group, 20 mL of 0.2% ropivacaine was injected for TPVB, followed by an additional 20 mL for SAPB, resulting in a total volume of 40 mL. Similarly, in the TPVB+ESPB group, 20 mL of 0.2% ropivacaine was administered for TPVB, with an additional 20 mL for ESPB, also totaling 40 mL.

Routine Analgesia Protocol and Rescue Analgesia

50 mg of flurbiprofen axetil was administered intravenously during the surgery, with an additional 50 mg given daily in the ward postoperatively. After the surgery, each patient was provided with a standardized patient-controlled intravenous analgesia (PCIA) pump containing 0.3 mg/mL oxycodone. The pump was programmed to deliver 3 mL boluses with a 10-minute lock-out interval and a continuous background infusion rate of 0.5 mL/h. If the patient's pain score remained above 3 on the Visual Analogue Scale (VAS) despite pressing the pain pump button five consecutive times, this was classified as insufficient pain relief. In such cases, the acute pain service team would re-adjust the parameters accordingly. Here's how it works: If the patient's pain score remains between 4 and 7 after pressing the PCA pump once, we administer the same bolus dose again. This process is repeated until the pain score decreases to below 3. If the pain score remains between 8 and 10 after pressing the PCA pump, we increase the bolus dose by 1.5 times the original amount and administer it again. This process is repeated as needed until the pain score falls below 4.

Outcome Measures

The primary outcomes in this study were the cumulative oxycodone consumption within 24 and 48 hours postoperatively, as well as the level of postoperative pain, which was assessed using an 11-point visual analogue scale (VAS) during rest and coughing at 2, 6, 12, 24, and 48 hours after surgery. Additionally, the area under the curve (AUC) for pain VAS over time was calculated both at rest and during coughing across the same time points. Secondary outcomes included the

incidence of block-related complications, analgesic satisfaction score at 48 hours, need for rescue analgesia, self-administered dosing times, and postoperative adverse effects such as pruritus, urinary retention, nausea, and vomiting.

Calculation of Area Under Curve (AUC) of Pain

The Area Under Curve (AUC) of pain is a summary measure used to quantify the overall pain experience over time. In this study, AUC was calculated to represent the total pain experienced by participants during the observation period. The AUC provides a single value that captures both the intensity and duration of pain, offering a comprehensive measure of the pain trajectory.

To calculate the AUC of pain, pain intensity ratings were collected at multiple time points during the study period. The AUC was computed using the trapezoidal rule, which involves plotting pain intensity on the y-axis and time on the x-axis, then summing the areas of the trapezoids formed between each pair of consecutive time points. The formula used for AUC calculation is:$\mathrm{AUC} = \sum_{i=1}^{n-1} \left(\frac{(\mathrm{Pain}_i + \mathrm{Pain}_{i+1})}{2} \times (\mathrm{Time}_{i+1} - \mathrm{Time}_i)\right)$. where Pain$i$ and Paini_{+1} are the pain intensity ratings at consecutive time points i and i+1, and Timei_{+1}-Time$_i$ is the time interval between these points. This method provides a robust and reliable measure of total pain experience, allowing for comparisons across different conditions or treatments.[15,16]

Statistical Analysis and Sample Size

The data were analyzed using SPSS statistical software version 20.0 (IBM Corp., NY, USA) and GraphPad Prism version 8 (Salt Lake City, UT, USA). The Kolmogorov–Smirnov test was applied to assess whether continuous data conformed to a normal distribution. Levene's test was conducted to evaluate the homogeneity of variances. Quantitative variables that followed a normal distribution and had homogenous variances are presented as mean (SD), whereas non-normally distributed data are expressed as median and interquartile range (IQR). Categorical data are presented as numbers and percentages. One-way analysis of variance was used to analyze normally distributed continuous data, while the Kruskal–Wallis test was used for continuous data that did not conform to a normal distribution among the three groups. Pairwise comparisons were performed using the Mann–Whitney U-test. Categorical data were assessed using the χ^2-test, and the P-value was adjusted using the Bonferroni method, with a significance threshold set at 0.017 for pairwise comparisons. A significance level of $P < 0.05$ was considered statistically significant. Due to the retrospective nature of this study, propensity score matching was performed to mitigate confounding bias. It is noteworthy that, apart from the study-specific factors, all other matching factors were balanced and comparable across the three groups.

Based on preliminary experimental results from 90 patients, the postoperative cumulative oxycodone consumption within 24 hours for the three groups was reported as mean (SD): 16.56 (7.76), 13.17 (6.16), and 11.72 (6.37), respectively. To achieve a power of 90% (Type II error of 0.1) with a Type I error of 0.05, a minimum of 63 patients per group was required. To account for a potential 20% loss to follow-up and dropout rate, a minimum of 79 patients per group was deemed necessary.

Results

We retrospectively analyzed the medical records of 341 patients who underwent VATL surgery at our hospital between August 2021 and January 2023. Of these, 46 patients were excluded for various reasons: 44 did not meet the inclusion criteria, and 2 had a history of opiate abuse. Ultimately, 295 patients were included in our study and categorized into three groups: the TPVB group (92 patients), the TPVB combined with SAPB group (106 patients), and the TPVB combined with ESPB group (97 patients) (Figure 1).

There were no significant differences in baseline demographics and perioperative variables among the three groups (Table 1). There was no significant difference in intraoperative sufentanil usage among the groups. However, the mean (SD) postoperative cumulative oxycodone consumption within 24 hours differed significantly among the three groups: TPVB group, 18.0 (7.5) mg; TPVB+SAPB group, 12.1 (6.7) mg; and TPVB+ESPB group, 11.4 (6.3) mg (Table 2). This difference was statistically significant in the first 24 and 48 hours postoperatively when comparing the TPVB group with both the TPVB+SAPB group ($P < 0.001$) and the TPVB+ESPB group ($P < 0.001$), but not between the TPVB+SAPB and TPVB+ESPB groups ($P = 0.449$) (Table 2). The TPVB group showed significantly higher postoperative oxycodone consumption compared to the TPVB+SAPB and TPVB+ESPB groups ($P < 0.001$).

Table 1 Comparison of Patient and Surgical Characteristics

Variables	TPVB n=92	TPVB+SAPB n=106	TPVB+ESPB n=97	*P* value
Age(year)	58.7±12.4	59.6±11.7	62.6±12.2	0.064
Female	33(35.9%)	39(36.8%)	48(49.5%)	0.097
BMI(kg/m^2)	24.6±3.2	24.3±3.4	23.9±2.8	0.292
ASA physical status (1/2/3)	4/79/9	3/85/18	7/76/14	0.364
Comorbid diseases				
Hypertension	29(31.5%)	32(30.2%)	38(39.2%)	0.353
Diabetes mellitus	8(8.7%)	11(10.4%)	14(14.4%)	0.433
Cardiac arrhythmias	9(7.6%)	16(15.1%)	13(13.4%)	0.250
Coronary heart disease	3(3.3%)	4(3.8%)	3(3.1%)	0.962
Pulmonary disease	7(7.61%)	16(15.1%)	13(13.4%)	0.125
Cerebral disease	10(10.9%)	11(10.4%)	10(10.3%)	0.991
Duration of anaesthesia (h)	2.8±1.1	2.9±1.0	2.8±1.0	0.535
Duration of surgery (h)	2.2±1.0	2.3±1.0	2.3±1.0	0.531
Blood loss, mL	100(50–100)	50(50–100)	50(20–100)	0.617
Intraoperative sufentanil consumption (ug)	86(65–115)	90(70–125)	90(68–116.5)	0.654
Length of hospital stay(day)	9.9±4.8	11±5.1	11±5.4	0.227
Length of postoperative hospital stay(day)	6.1±3.4	6.9±3.4	6.9±3.8	0.210

Notes: Data are presented as mean ± standard deviation, median and interquartile range (IQR) or number (%).
Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; ESPB, erector spinae plane block; SAPB, serratus anterior plane block; TPVB, thoracic paravertebral block.

Table 2 Primary Outcomes

Primary Outcome	TPVB n=92	TPVB+SAPB n=106	TPVB+ESPB n=97	*P* value
Postoperative oxycodone consumption within 24 h, mg	18.0±7.5	12.1±6.7*	11.4±6.3*	<0.001
Postoperative oxycodone consumption within 48 h, mg	31.5±12.2	22.9±12.4*	21.6±11.6*	<0.001
AUC Pain VAS vs time within 24 h (at rest)	47.3±16.7	33.1±15.3*	41.4±16.8#	<0.001
AUC Pain VAS vs time within 24h (on coughing)	92.9±32.2	87.2±30.1	82.5±26.9*	0.016
AUC Pain VAS vs time within 48h(at rest)	86.5±27.8	78.0±28.6	86.72±32.4	0.087
AUC Pain VAS vs time within 48h(on coughing)	185.0±61.0	187.2±60.9	180.6±61.0	0.614

Notes: Data are expressed as mean ± standard deviation and number (%).* $p < 0.017$ compared to TPVB. # $p < 0.017$ compared to TPVB +SAPB. ($p = 0.017$ is accepted for statistical significance with Bonferroni adjustment).
Abbreviations: AUC, area under the curve; VRS, verbal rating scale.

As shown in Figure 2A and B, and Table 3, VAS scores at rest and during coughing were statistically significantly higher in the TPVB group compared to the TPVB+SAPB and TPVB+ESPB groups at 2 and 6 hours postoperatively. Across all time intervals, there was no significant difference in VAS scores between the TPVB+SAPB and TPVB+ESPB groups, both at rest and during coughing. The area under the curve (AUC) for pain VAS versus time within 24 hours at rest was 33.1 (15.3) mm·h^{-1} for the TPVB+SAPB group compared to 41.4 (16.8) mm·h^{-1} for the TPVB+ESPB group ($P < 0.001$; Table 2 and Figure 3). For VAS scores during coughing, the AUC within 24 hours was 87.2 (30.1) mm·h^{-1} for the TPVB+SAPB group compared to 82.5 (26.9) mm·h^{-1} for the TPVB+ESPB group (P =0.016; Table 2 and Figure 3).

The requirement for remedial analgesia within 48 postoperative hours, as measured by the number of self-controlled doses, did not show statistically significant differences among the three groups (TPVB vs TPVB+SAPB vs TPVB+ESPB; 8 [4–18] vs 10 [7–17] vs 10 [5–17] doses; $P = 0.833$) (Table 4). Intestinal exhaust within 48 hours was observed in 82 (89.1%) patients in the TPVB group, 93 (87.7%) in the TPVB+SAPB group, and 83 (85.6%) in the TPVB+ESPB group ($P = 0.756$) (Table 4). There were no statistically significant differences in pain satisfaction scores among the three groups ($P = 0.999$) (Table 4). However, nausea or vomiting within

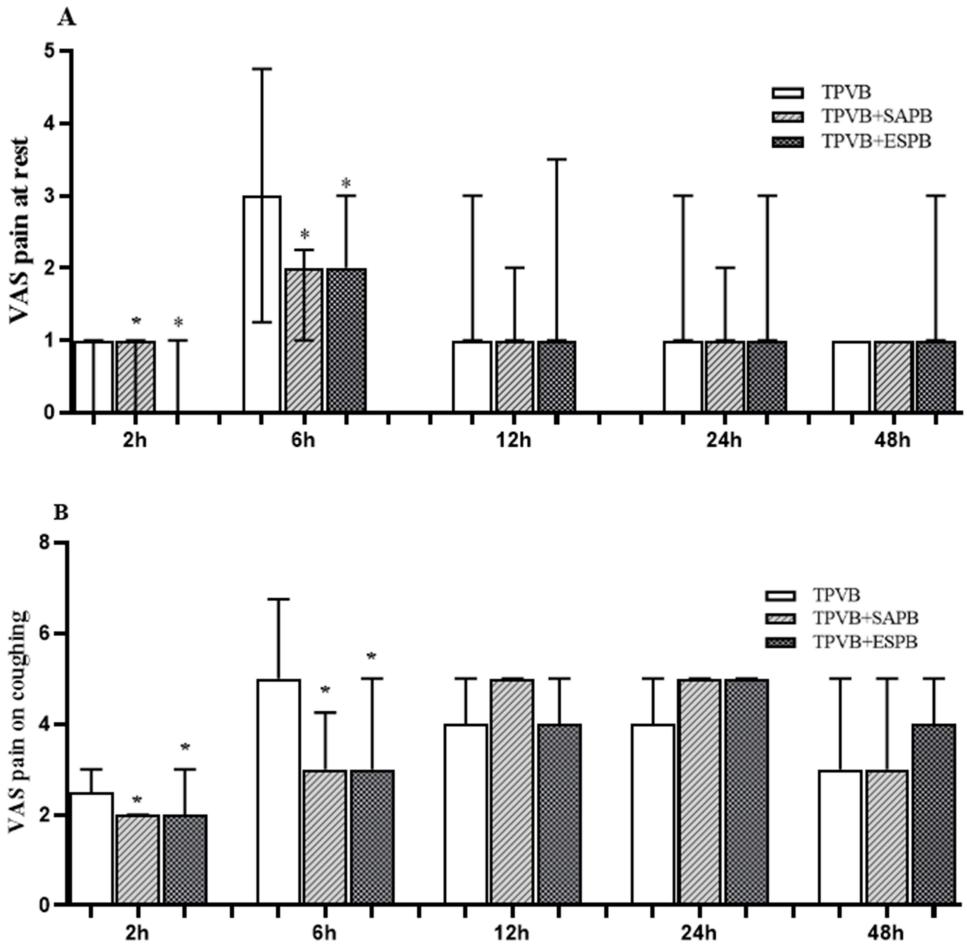

Figure 2 (**A**) VAS scores at rest at 2, 6, 12, 24, and 48 hours postoperatively. (**B**) VAS scores on coughing at 2, 6, 12, 24, and 48 hours postoperatively. Data are expressed as median (horizontal bar) and interquartile range (box). All groups were compared using Kruskal–Wallis test and pairwise comparisons were analyzed using the Mann–Whitney U-test. VAS, visual analogue scale. * P < 0.017 compared to TPVB. (P = 0.017 is accepted for statistical significance with Bonferroni adjustment). All groups were compared using Kruskal–Wallis test and pairwise comparisons were analyzed using the Mann–Whitney *U*-test. * P < 0.017 compared to TPVB. (P = 0.017 is accepted for statistical significance with Bonferroni adjustment).

48 hours was reported by 14 (15.2%) patients in the TPVB group, 12 (11.3%) in the TPVB+SAPB group, and 3 (3.1%) in the TPVB+ESPB group ($P = 0.016$) (Table 4). No patients in any group developed uroschesis, pruritus, or block-related complications (Table 4).

Table 3 Postoperative Pain Scores

	TPVB	**TPVB+SAPB**	**TPVB+ESPB**	***p***	**Pairwise comparions**		
VAS	**n=92**	**n=106**	**n=97**		**TPVB VS.TPVB+SAPB P value**	**TPVB VS.TPVB+ESPB P value**	**TPVB+SAPB VS.TPVB+SAPB P value**
2h(at rest)	1(0–1)	1(0–1)	0(0–1)	0.000	0.005	0.000	0.202
2h(on coughing)	2.5(2–3)	2(0–2)	2(0–3)	0.000	0.000	0.000	0.987
6h(at rest)	3(1.25–4.75)	2(1–2.25)	2(1–3)	0.000	0.000	0.000	0.351
6h(on coughing)	5(3–6.75)	3(2–4.25)	3(2–5)	0.000	0.000	0.000	0.366
12h(at rest)	1(1–3)	1(1–2)	1(1–3.5)	0.326	0.122	0.441	0.546

(*Continued*)

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Table 3 (Continued).

	TPVB	TPVB+SAPB	TPVB+ESPB	*p*	Pairwise comparions		
VAS	**n=92**	**n=106**	**n=97**		**TPVB VS.TPVB+SAPB P value**	**TPVB VS.TPVB+ESPB P value**	**TPVB+SAPB VS.TPVB+SAPB P value**
12h(on coughing)	4(4–5)	5(3–5)	4(3–5)	0. 577	0.483	0.694	0.324
24h(at rest)	1(1–3)	1(1–2)	1(1–3)	0.389	0.271	0.222	0.730
24h(on coughing)	4(3–5)	5(3–5)	5(3–5)	0.367	0.222	0.910	0.229
48h(at rest)	1(1–1)	1(1–1)	1(1–3)	0.051	0.555	0.060	0.074
48h(on coughing)	3(3–5)	3(3–5)	4(3–5)	0.042	0.070	0.073	0.396

Notes: Data are presented as median (IQR). All groups were compared using Kruskal–Wallis test. Pairwise comparisons were analyzed using Mann–Whitney *U*-test.

Discussion

Our study demonstrated that ultrasound-guided TPVB provided less effective analgesia for thoracoscopic surgery compared to TPVB+SAPB and TPVB+ESPB at 2 and 6 hours postoperatively, while TPVB+SAPB and TPVB+ESPB were equally effective in reducing pain in VATL. Notably, to our knowledge, this is the first clinical trial to compare the analgesic effects of TPVB, TPVB+SAPB, and TPVB+ESPB after thoracoscopic surgery.

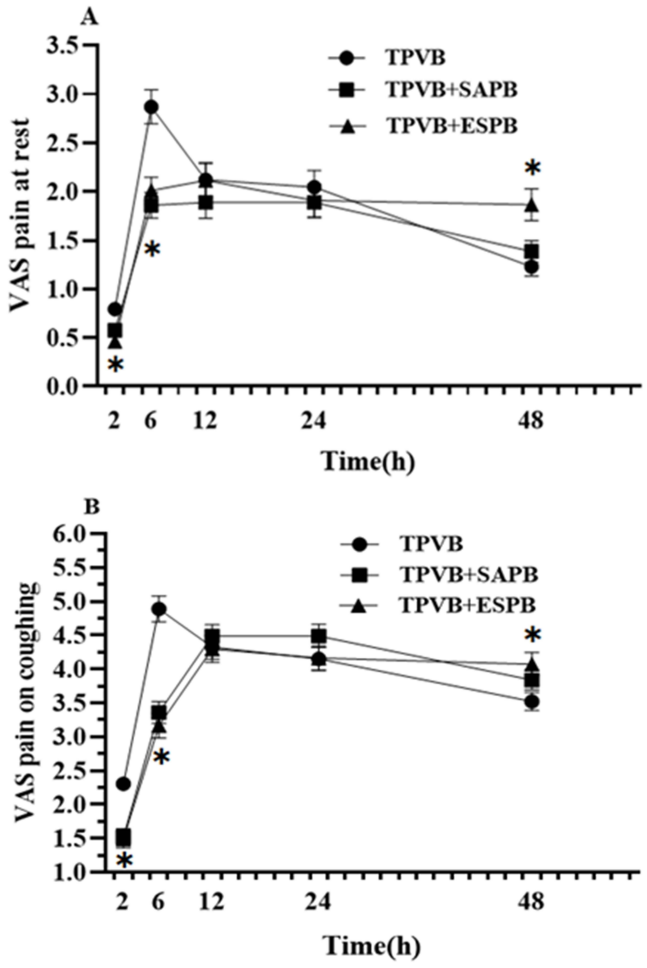

Figure 3 (**A**) Area under the curve (AUC) of VAS pain over time at rest; within 24 hours (P < 0.001) and 48 hours (P = 0.087). (**B**) AUC of VAS pain over time on coughing; within 24 hours (P = 0.016) and 48 hours (P = 0.614). VAS, verbal rating scale. * P < 0.017 compared to TPVB. (P = 0.017 is accepted for statistical significance with Bonferroni adjustment).

Table 4 Secondary Outcomes

Secondary outcome	TPVB n=92	TPVB+SAPB n=106	TPVB+ESPB n=97	*P* value
Analgesic satisfaction score at 48 h	9.2±0.9	9.3±0.9	9.2±0.9	0.999
Nausea and vomiting within 24h	14(15.2%)	11(10.4%)*	3(3.1%)*#	0.016
Nausea and vomiting within 48h	14(15.2%)	12(11.3%)	3(3.1%)*#	0.016
Nausea and vomiting within (24–48h)	0(0%)	4(3.8%)	3(3.1%)	0.187
Intestinal exhaust within 24 h	52(56.5%)	72(67.9%)	67(69.1%)	0.122
Intestinal exhaust within 48 h	82(89.1%)	93(87.7%)	83(85.6%)	0.756
Uroschesis	0(0)	0(0)	0(0)	0.999
Self-controlled dosing times within 24 h	5(3–11)	6(3–8)	5(2–8)	0.649
Self-controlled dosing times within 48 h	8(4–18)	10(7–17)	10(5–17)	0.833
Pruritus	0(0)	0(0)	0(0)	0.999
Block-related complications	0(0)	0(0)	0(0)	0.999

Notes: Data are expressed as mean ± standard deviation and number (%).* $p < 0.017$ compared to TPVB. #$p < 0.017$ compared to TPVB+SAPB. ($p = 0.017$ is accepted for statistical significance with Bonferroni adjustment).
Abbreviations: AUC, area under the curve; VRS, verbal rating scale.

In a resting state, the area under the pain VAS versus time curve (AUC) within 24 hours was slightly lower in the TPVB+SAPB group (33.1 mm h-1) compared to the TPVB+ESPB group (41.4 mm h-1). However, during coughing within the same timeframe, the TPVB+SAPB group exhibited a slightly higher AUC (87.2 mm h-1) compared to the TPVB+ESPB group (82.5 mm h-1). Several factors may explain these findings. Firstly, SAPB has the capability to block the long thoracic nerve, thoracodorsal nerve, and some intercostal nerves. Additionally, while TPVB has a limited duration of action, SAPB offers a relatively prolonged analgesic effect.[4,13] Moreover, ESPB is similar to TPVB,[17,18] SAPB can complement part of the paravertebral block, leading to superior analgesia. This may explain the lower AUC score at rest observed in the TPVB+SAPB group compared to the TPVB+ESPB group. On the other hand, the heart and lungs are highly sensitive to stimuli such as traction and expansion, which can cause significant pain. The nerves responsible for transmitting cardiopulmonary pain are the sympathetic nerves from T_1 to T_5, which enter the spinal cord through the posterior roots. ESPB has the ability to block both the posterior and ventral branches of the thoracic spinal nerves, resulting in a degree of sympathetic block and providing better analgesic effects during coughing.[19] In contrast, SAPB is limited to blocking the anterior and lateral superficial nerves of the chest wall.[4,10]

In terms of postoperative nausea and vomiting, the combination of TPVB and ESPB resulted in the lowest incidence, suggesting its superior effectiveness in minimizing these side effects. The observed lower incidence of nausea and vomiting in the TPVB+ESPB group may be attributed to more effective pain control with ESPB, which could reduce the need for opioids and subsequently minimize side effects like nausea.

A recent study compared ESPB and SAPB in similar surgical patients,[20] Unlike our findings, that study suggests that the AUC in the ESPB group is lower than in the SAPB group, both at rest and during deep breathing. This discrepancy may be attributed to the methodological differences between the studies. Unlike previous studies, our research employed a dual nerve blockade by combining paravertebral nerve blockade, which could be the primary reason for the differing results.

Compared to previous studies, this research features a larger sample size. Notably, our study is the first to compare TPVB alone with combinations such as TPVB+SAPB or TPVB+ESPB for postoperative analgesia following video-assisted thoracoscopic lobectomy. Compared to continuous thoracic paravertebral nerve block, dual nerve block offer the advantage of avoiding the technical difficulties of catheter placement, reducing associated complications, and prolonging the duration of postoperative analgesia.

Although dual block techniques have shown a statistical advantage in reducing postoperative opioid consumption, the extent of this reduction is relatively limited (5.9–6.6 mg within the first 24 hours postoperatively)(Table 2). In clinical practice, it is essential to balance these benefits against the potential risks of systemic complications associated with dual block techniques, such as pneumothorax, intravascular injection, and nerve injury. Therefore, careful selection of analgesic strategies and individualized risk-benefit assessments are necessary for specific patient populations.

The limitations of this study are as follows: (1) The current study utilized a retrospective, single-center trial design. Future studies should aim to validate these conclusions by increasing the sample size and conducting prospective, multicenter trials. (2) This study solely discusses the clinical analgesic effects of three nerve blockade groups. Further research is needed to determine the optimal concentration and dosage of ropivacaine. This is essential for enhancing analgesic efficacy, improving patient safety, and achieving precise anesthesia management for rapid postoperative recovery. (3) There was a difference in the total dose of local anesthetics among the groups. Although all doses remained within the clinically safe range and were consistent with previous studies, higher doses may have influenced the analgesic outcomes. Future studies should standardize dosing across groups to optimize study design and improve result comparability. (4) The study did not observe the duration of the different nerve blocks. This aspect requires further investigation to better understand the long-term effectiveness of each nerve block technique. (5) During the first 6 hours after surgery, a statistically significant difference in pain scores was observed among the three groups. However, the differences in pain scores between 6 and 12 hours postoperatively remain uncertain. Future research should focus on observing changes in pain scores during this period. (6) The incidence of postoperative pneumonia and the postoperative QoR-15 scores were not recorded.

Conclusion

TPVB combined with SAPB or ESPB provides superior analgesic effects compared to TPVB alone after video-assisted thoracoscopic lobectomy, with both techniques showing comparable analgesic efficacy. However, TPVB+SAPB may offer slightly better analgesia at rest, while TPVB+ESPB may have a potential advantage in reducing postoperative nausea and vomiting. These findings suggest that the choice of dual block technique should be tailored to individual patient conditions and clinical needs. Additionally, further multicenter studies are needed to optimize the application strategies of these techniques.

Data Sharing Statement

The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request. However, due to the retrospective nature of the study and the need to protect patient confidentiality, only de-identified participant data will be shared. No additional study documents will be made publicly available. Requests for data access can be directed to the corresponding author via the provided contact details in the manuscript. The data will be available upon request starting from the publication date and will remain accessible for up to 5 years.

Ethics Approval and Informed Consent

This study was conducted in accordance with the ethical guidelines of the 2013 Declaration of Helsinki and its amendments, and the protocol was approved by the Clinical Research Ethics Committee of Zhongda Hospital, School of Medicine, Southeast University (Approval No.: 2022ZDSYLL085-P01). Due to the retrospective nature of the study, the requirement for written informed consent was waived, and patient information was anonymized before analysis. All procedures were carried out in accordance with institutionally approved protocols.

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Disclosure

The authors declare no conflicts of interest in this work.

References

1. Uda Y, Byrne K, Brahmbhatt A, et al. A pilot randomized-controlled trial evaluating the erector spinae plane block in thoracic and breast surgery. *Can J Anaesth*. 2020;67:1371–1380. doi:10.1007/s12630-020-01759-5

2. Bahabin Boroujeni M, Mehrabani K, Raeisi Shahraki H. Clustering trend changes of lung cancer incidence in Europe via the growth mixture model during 1990-2016. *J Environ Public Health*. 2021;2021:8854446. doi:10.1155/2021/8854446
3. Sun X, Xu X, Wang Y, et al. Incidence and mortality rates of lung cancer in Qingdao, China (2013-2017). *Asia Pac J Clin Oncol*. 2022;18:e73–e8. doi:10.1111/ajco.13559
4. Zhang Y, Luo G, Etxeberria J, Hao Y. Global patterns and trends in lung cancer incidence: a population-based study. *J Thorac Oncol*. 2021;16:933–944. doi:10.1016/j.jtho.2021.01.1626
5. Rami-Porta RA-O. The evolving concept of complete resection in lung cancer surgery. *Cancers*. 2023. 13:2583.
6. Richebe P, Capdevila X, Rivat C. Persistent postsurgical pain: pathophysiology and preventative pharmacologic considerations. *Anesthesiology*. 2018;129:590–607. doi:10.1097/ALN.0000000000002238
7. Hernandez MA, Palazzi L, Lapalma J, Forero M, Chin KJ. Erector spinae plane block for surgery of the posterior thoracic wall in a pediatric patient. ***Reg Anesth Pain*** *Med*. 43:217–9.
8. Cesur S, Yayik AM, Ozturk F, Ahiskalioglu A. Ultrasound-guided low thoracic erector spinae plane block for effective postoperative analgesia after lumbar surgery: report of five cases. *Cureus*. 2018;10:e3603. doi:10.7759/cureus.3603
9. Makkad B, Heinke TL, Sheriffdeen R, et al. Practice advisory for preoperative and intraoperative pain management of thoracic surgical patients: part 1. *Anesth Analg*. 2023;137:2–25. doi:10.1213/ANE.0000000000006441
10. Wang Q, Zhang G, Wei S, He Z, Sun L, Zheng H. Comparison of the effects of ultrasound-guided erector spinae plane block and wound infiltration on perioperative opioid consumption and postoperative pain in thoracotomy. *J Coll Physicians Surg Pak*. 2019;29:1138–1143. doi:10.29271/jcpsp.2019.12.1138
11. Moorthy A, Ni Eochagain A, Dempsey E, et al. Postoperative recovery with continuous erector spinae plane block or video-assisted paravertebral block after minimally invasive thoracic surgery: a prospective, randomised controlled trial. *Br J Anaesth*. 2023;130:e137–e47. doi:10.1016/j.bja.2022.07.051
12. Scarfe AJ, Schuhmann-Hingel S, Duncan JK, Ma N, Atukorale YN, Cameron AL. Continuous paravertebral block for post-cardiothoracic surgery analgesia: a systematic review and meta-analysis. *Eur J Cardiothorac Surg*. 2016;50:1010–1018. doi:10.1093/ejcts/ezw168
13. Yang J, Zhao M, Zhang XR, et al. Ropivacaine with dexmedetomidine or dexamethasone in a thoracic paravertebral nerve block combined with an erector spinae plane block for thoracoscopic lobectomy analgesia: a randomized controlled trial. *Drug Des Devel Ther*. 2022;16:1561–1571. doi:10.2147/DDDT.S366428
14. Feray S, Lubach J, Joshi GP, et al. PROSPECT guidelines for video-assisted thoracoscopic surgery: a systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia*. 2022;77(3):311–325. doi:10.1111/anae.15609
15. Pruessner JC, Kirschbaum C, Meinlschmid G, et al. Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*. 2003;28(7):916–931. doi:10.1016/S0306-4530(02)00108-7
16. Matthews JN, Altman DG, Campbell MJ, et al. Analysis of serial measurements in medical research. *BMJ*. 1990;300(6719):230–235. doi:10.1136/bmj.300.6719.230
17. Karmakar MK, Sivakumar RK, Sheah K, Pangthipampai P, Lönnqvist PA. Quest for the elusive mechanism of action for the thoracic paraspinal nerve block techniques. are we ignoring the anatomy of the "retro superior costotransverse ligament space?". *Anesth Analg*. 2023;137:458–65.
18. Schwartzmann A, Peng P, Maciel MA, Alcarraz P, Gonzalez X, Forero M. A magnetic resonance imaging study of local anesthetic spread in patients receiving an erector spinae plane block. *Can J Anaesth*. 2020;67:942–948. doi:10.1007/s12630-020-01613-8
19. 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;41:621–627. doi:10.1097/AAP.0000000000000451
20. Finnerty DT, McMahon A, McNamara JR, Hartigan SD, Griffin M, Buggy DJ. Comparing erector spinae plane block with serratus anterior plane block for minimally invasive thoracic surgery: a randomised clinical trial. *Br J Anaesth*. 2020;125(5):802–810. doi:10.1016/j.bja.2020.06.020