Journal of Inflammation Research

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Effectiveness of Combining Thoracic Paravertebral Nerve Block and Serratus Anterior Plane Block in Non-Intubated Spontaneous-Ventilation Video-Assisted Thoracoscopic Surgery: A Retrospective Case-Control Study

Zhengyuan Shi[1,*], Gang Shao[1,*], Xiajun Zhang[2], Yuchen Shi[3], Guoxiang Rong[4], Dandan Xu[1], Huaili Zhu[1], Danqin Yin[1]

[1]Department of Anesthesiology, The People's Hospital of Danyang, Affiliated Danyang Hospital of Nantong University, Danyang, Jiangsu Province, 212300, People's Republic of China; [2]Medical Laboratory, The People's Hospital of Danyang, Affiliated Danyang Hospital of Nantong University, Danyang, Jiangsu Province, 212300, People's Republic of China; [3]School of Medicine, Nantong University, Nantong, Jiangsu Province, 226007, People's Republic of China; [4]Department of Cardiothoracic Surgery, The People's Hospital of Danyang, Affiliated Danyang Hospital of Nantong University, Danyang, Jiangsu Province, 212300, People's Republic of China

*These authors contributed equally to this work

Correspondence: Danqin Yin, Department of Anesthesiology, The People's Hospital of Danyang, Affiliated Danyang Hospital of Nantong University, No. 2, Xinminxi Road, Danyang, Jiangsu Province, 212300, People's Republic of China, Email 13806103611@163.com

Background: Thoracic paravertebral nerve block (TPNB) and serratus anterior plane block (SAPB) are commonly used regional anesthesia techniques for pain management after thoracic surgery. Non-intubated spontaneous-ventilation video-assisted thoracoscopic surgery (VATS) poses unique challenges in managing postoperative pain and ensuring rapid recovery. We hypothesize that in non-intubated spontaneous VATS, combining TPNB and SAPB may offer enhance pain relief and improve patient prognosis.

Methods: This retrospective study analyzed 315 patients undergoing non-intubated VATS between March 2019 and December 2024, divided into three groups: 98 cases in the TPNB (T Group), 113 cases in the SAPB (S Group), and 104 cases in the combination of TPNB and SAPB (TS Group). The propensity score matching method was used to match the initial data in a 1:1:1 ratio, resulting in the T group (70 cases), S group (70 cases), and TS group (70 cases). Postoperative pain control, analgesic consumption and inflammatory markers were assessed in the matched three groups using standard statistical methods.

Results: Compared with the T and S groups, the pain control of patients in the TS group was significantly better. At 12 hours, the visual analog scale (VAS) of the T group (5.27 ± 0.57) and the S group (5.09 ± 0.49) were significantly higher than those of the TS group (2.51 ± 0.36) ($P<0.05$); At 48 hours, both T group (2.87 ± 0.52) and S group (2.63 ± 0.49) were significantly higher than TS group (1.56 ± 0.24) ($P<0.05$). Compared with the T and S groups, patients in the TS group had a reduced consumption of analgesics. The average consumption of oxycodone in the T group was (49.65 ± 0.71) mg, slightly higher than that in the S group (45.42 ± 0.51) mg and the TS group (30.26 ± 0.53) mg ($P<0.05$). Compared with the T and S groups, the postoperative recovery quality of patients in the TS group was better. The total score of the QoR-15 scale in the TS group was (120.41 ± 7.75), which was significantly better than that in the T group (113.42 ± 7.65) and S group (112.95 ± 7.56) ($P<0.05$). Compared with the T and S groups, the inflammatory markers in the TS group were significantly reduced. For IL-1 β, the TS group showed a significant decrease at T1 [(15.33 ± 0.41) pg/mL] and T2 [(13.45 ± 0.71) pg/mL] ($P<0.05$); For TNF - α, the TS group also showed a significant decrease at T1 [(20.12 ± 1.66) pg/mL] and T2 [(18.42 ± 1.03) pg/mL] ($P<0.05$). In addition, the incidence of adverse reactions such as nausea, vomiting, and dizziness, as well as complications such as atelectasis, hypoxemia, and pulmonary infection, were lower in the TS group ($P<0.05$).

Received: 19 March 2025
Accepted: 30 July 2025
Published: 14 August 2025

Conclusion: The combined use of TPNB and SAPB in non-intubated VATS substantially improves pain management, reduces opioid consumption and minimizes inflammation and postoperative complications compared to the use of individual blocks. These findings advocate for the broader adoption of combined nerve block techniques to enhance patient outcomes in VATS procedures.

Keywords: non-intubated video-assisted thoracoscopic surgery, thoracic paravertebral nerve block, serratus anterior plane block, pain management, postoperative quality of recovery, inflammatory response

Introduction

Video-assisted thoracoscopic surgery (VATS) marks a substantial innovation in the field of minimally invasive surgery, offering notable benefits over the traditional thoracotomy approach. Its advantages, including reduced tissue trauma, shorter hospital stays, and faster patient recovery, have led to its widespread acceptance in clinical practice.[1,2] The use of non-intubated techniques in VATS, where surgeries are performed while patients maintain spontaneous breathing without tracheal intubation, has further optimized recovery times and minimized anesthesia-related complications.[3,4] Despite these advances, efficient postoperative pain management remains a critical factor in enhancing patient satisfaction and overall surgical outcomes. Proper pain control is essential for facilitating early mobilization, reducing the likelihood of postoperative complications, and preventing the transition of acute pain into chronic conditions.[5,6]

Previous studies have shown that percutaneous intercostal nerve block after VATS surgery is a simple and safe technique that can reduce postoperative pain and opioid demand.[7] Among the commonly employed regional anesthesia techniques for managing postoperative pain in thoracic surgeries are the thoracic paravertebral block (TPNB) and the serratus anterior plane block (SAPB). TPNB is well-regarded for its ability to block somatic and sympathetic nerves within the thoracic paravertebral space, providing extensive unilateral analgesia. This technique has been shown to significantly lower opioid consumption and improve postoperative pulmonary function.[8] In contrast, SAPB, a more recent technique, involves the injection of local anesthetics into the fascial plane below the serratus anterior muscle, effectively targeting sensory nerves in the hemithoracic region. Its simplicity and high safety profile make it an attractive option for pain relief.[9,10]

In non-intubated, spontaneous-ventilation VATS, combining TPNB and SAPB may offer enhanced pain relief compared to using either TPNB or SAPB alone. However, there is a lack of comprehensive studies evaluating the impact of these combined techniques on postoperative pain management. This research aims to investigate the potential benefits of using both TPNB and SAPB together, as compared to TPNB or SAPB alone, in patients undergoing non-intubated VATS, with a focus on improving analgesic outcomes.

Methods

Study Design

A retrospective case-control study was conducted to select 315 patients who underwent VATS without intubation between March 2019 and December 2024. The patients were divided into three groups: the TPNB group (T Group), the SAPB group (S Group), and the combined TPNB and SAPB group (TS Group). In order to significantly reduce selection bias and confounding variables among T group, S group, and TS group, this study used propensity score matching method to complete data screening and retrospectively analyzed the matched data. Patients' perioperative data, analgesic consumption, and recovery outcomes were collected and analyzed. The research methodology, objectives, and protocols underwent rigorous review and were subsequently sanctioned by the Ethics Committee of our hospital. The CONSORT flow diagram is shown in Figure 1.

Inclusion and Exclusion Criteria

Inclusion Criteria: Patients aged 18 years or older, able to provide informed consent. All patients scheduled for elective non-intubated spontaneous-ventilation VATS. Patients willing to undergo TPNB and/or SAPB as part of their anesthetic management.

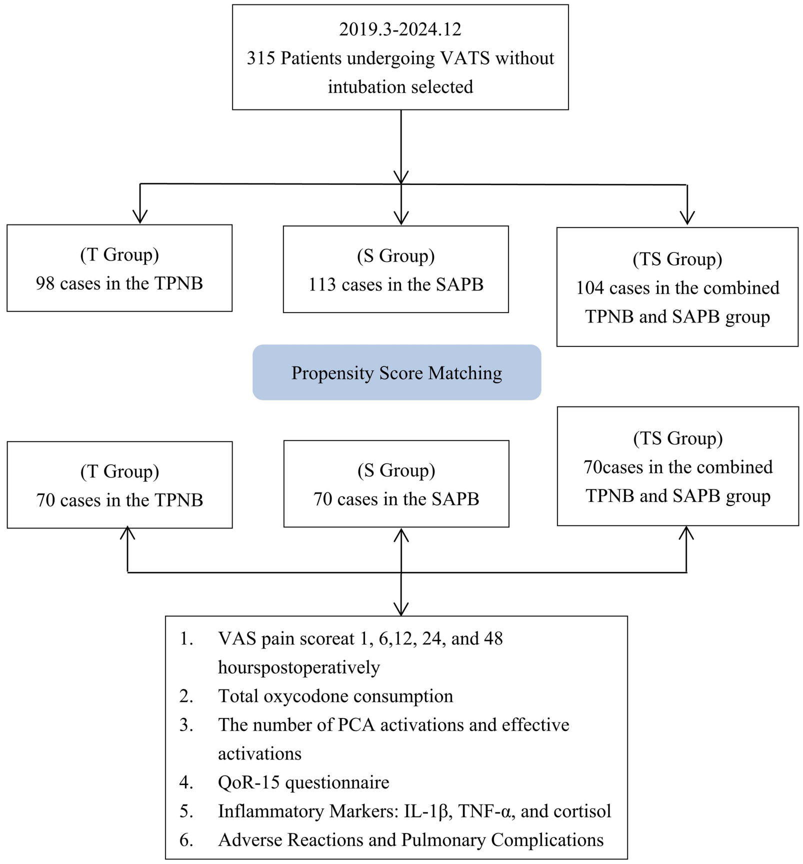

Figure 1 CONSORT flow diagram.

Exclusion Criteria:Patients with a known allergy to local anesthetics or components used in the nerve block procedures. Patients with bleeding disorders or on anticoagulant therapy that contraindicates regional anesthesia due to increased risk of hematoma. Presence of infection at the proposed site of injection, posing a risk of spreading infection via needle placement. Patients with severe underlying pulmonary conditions (eg, severe COPD or asthma) that could exacerbate with non-intubated techniques. Patients with a history of previous thoracic surgery that might have altered anatomical landmarks critical for effective nerve blockade.

Pre-Anesthesia Preparation Protocol

Prior to surgery, patients were required to adhere to routine fasting guidelines. Upon entering the operating room, peripheral venous access was established, and radial artery cannulation was performed for continuous blood pressure monitoring. Other parameters monitored included heart rate (HR), electrocardiography (ECG), peripheral oxygen saturation (SpO2), and bispectral index (BIS). An intravenous infusion of dexmedetomidine was initiated at a loading dose of 0.5 μg/kg over 10 minutes, followed by a maintenance dose of 0.5 μg/kg/hour to ensure adequate sedation before anesthesia induction.[11]

Anesthesia Implementation Protocol

Nerve Block Administration: After achieving adequate sedation, patients were positioned laterally. Under ultrasound guidance (GE LOGIQ P6, GE Healthcare, USA), nerve blocks were administered on the operative side. In the TPNB group, a high-frequency ultrasound probe was placed perpendicular to the spine, identifying the thoracic vertebrae and pleural line. A local anesthetic (0.3% ropivacaine) was injected at the T4 and T7 paravertebral spaces, 15 mL at each level. For the SAPB group, the probe was positioned along the mid-axillary line at the fifth rib, identifying relevant muscular layers, and 20 mL of 0.3% ropivacaine was administered superficial to the serratus anterior muscle. In the TS group, 10 mL of 0.3% ropivacaine was injected at both T4 and T7 paravertebral spaces, and 20 mL at the serratus anterior plane. All nerve block procedures were performed by the same anesthesiologist. The effectiveness of the blocks was assessed by pinprick 20 minutes post-administration, ensuring anesthetic coverage from T3 to T7.

Non-intubated General Anesthesia: Induction of anesthesia was performed using propofol (2.0 mg/kg) and oxycodone (0.2 mg/kg), ensuring muscle relaxation was avoided to maintain spontaneous breathing. A bispectral index (BIS) value of 40–60 was targeted. A laryngeal mask airway (LMA) dual-tube was inserted, followed by a gastric tube. Patients breathed spontaneously with supplemental oxygen delivered at a flow rate of 2 L/min and a concentration of 100% FiO_2. Manual intermittent positive pressure ventilation was adjusted to maintain end-tidal CO2 ($PETCO_2$) between 30–60 mmHg. After the start of surgery, 5 mL of 2% lidocaine was sprayed onto the lung surface, and a vagal nerve block was performed using 2 mL of 1% lidocaine. Anesthesia was maintained with continuous infusions of propofol, and incremental doses of oxycodone were adjusted based on blood pressure, heart rate, and BIS.

Postoperative Management Protocol

Postoperative analgesia for all patients was delivered using a patient-controlled analgesia (PCA) pump, set to operate without background infusion, meaning no continuous infusion of analgesic was administered. Instead, the PCA pump delivered bolus doses only when the patient initiated them. The analgesic solution contained 50 mg of oxycodone and 10 mg of tropisetron, diluted in 100 mL of saline. The pump was configured to administer a 5 mL bolus upon patient demand, with a 15-minute lockout interval between doses, ensuring patient-controlled dosing without a continuous baseline infusion. If the PCA reservoir became depleted within the 48-hour postoperative period, anesthesia staff refilled the pump with the same solution. For cases where the VAS (Visual Analog Scale) pain score reached ≥4, patients received a rescue dose of 500 mg of acetaminophen in mannitol solution via intravenous infusion, with a maximum daily dose not exceeding 1500 mg, administered at intervals of no less than 8 hours. The study recorded several key outcomes for each group, including total oxycodone consumption (in mg), the number of PCA activations, effective activations, and the frequency of rescue analgesic interventions within the 48-hour postoperative period.

Outcome Measures

Pain Assessment: Pain intensity was assessed using the VAS at rest and during coughing. VAS scores were collected at 1, 6, 12, 24, and 48 hours postoperatively to evaluate postoperative pain levels across all groups.

Opioid Consumption and Analgesia Metrics: Total oxycodone consumption within the first 48 hours postoperatively was recorded for each patient. Additionally, the number of PCA activations, effective PCA activations, the first Press Time of Analgesic Pump and instances of rescue analgesic interventions were documented.

Quality of Recovery: Patient recovery quality was evaluated using the QoR-15 questionnaire, which assesses five key dimensions: physiological comfort, psychological support, emotional state, behavior, and pain. Scores were recorded at two time points—1 day before surgery, and 2 days postoperatively. Higher scores indicated better recovery. The QoR-15 is recognized for its internal consistency, strong correlation with total scores, and superior responsiveness compared to the QoR-40, making it a reliable and feasible tool for assessing recovery.[12]

Inflammatory Markers: Inflammatory response was analyzed by measuring the levels of IL-1β, TNF-α, and cortisol (Cor) at T0 (before anesthesia induction), T1 (before leaving the recovery room), T2 (24 hours after surgery), T3 (48 hours after surgery). This comparison aimed to assess the impact of the combined nerve block on controlling postoperative inflammation.

Adverse Reactions and Pulmonary Complications: Postoperative complications were monitored, including typical opioid-related side effects such as nausea, vomiting, and dizziness, as well as pulmonary complications like atelectasis, hypoxemia, and pulmonary infections. These complications were compared across groups to evaluate the safety and effectiveness of the analgesic regimens.

Statistical Analysis

Statistical analysis was conducted using SPSS software (Version 27.0). Initially, data were categorized as either quantitative or categorical. Normality tests were performed to determine the distribution of the quantitative data. For data adhering to a normal distribution, differences between groups were evaluated using independent sample t-tests, with results expressed as mean ± standard deviation. In cases where quantitative data did not follow a normal distribution, values were described using medians and interquartile ranges (M[P25, P75]), and comparisons between groups were made using the Mann–Whitney *U*-test. Categorical variables were presented as frequencies and percentages. Associations between these categorical data were assessed using Chi-square (χ^2) tests. All tests were two-tailed, and statistical significance was established at a p-value of less than 0.05.

Results

Comparison of Baseline Data Between Three Groups Before and After Propensity Score Matching

This study included a total of 315 VATS patients, including 98 in the T group, 113 in the S group, and 104 in the TS group. There was no statistically significant difference in age and gender among the three groups (P>0.05), but there was a statistically significant difference in body mass index (BMI) and ASA grading (P<0.05). The baseline data between the three groups are inconsistent, with selection bias and confounding variables, making direct comparison inappropriate. This study used propensity score matching method to match three groups of patients in a 1:1:1 ratio, resulting in 70 patients in the T group, 70 patients in the S group, and 70 patients in the TS group. There was no statistically significant difference (P>0.05) in gender composition, body mass index, and ASA grading among the three groups after propensity score matching (Table 1).

Preoperative Status of Patients Undergoing Non-Intubated VATS

Operation times were also consistent across groups, with the T Group having a slightly longer duration [(74.67±5.12) minutes] compared to the S Group [(72.34±5.66) minutes] and TS Group [(72.08±4.45) minutes], although these differences were not substantial. QoR-15 scores, which assess patient recovery quality across five dimensions—physiological comfort, psychological support, emotional state, behavior, and pain—were evaluated for all groups. The average scores were generally high, indicating good recovery potential. Specifically, the TS Group had an average QoR-15 score of (133.22±7.41), which was slightly higher compared to the T Group (131.50±6.27) and the S Group (131.55 ±6.59), but the difference was statistically significant (P>0.05). These features indicate that the patients in all groups were well-matched in clinical preoperative status, providing a solid foundation for evaluating the effects of the different nerve block strategies used in their surgical procedures (Figure 2).

Table 1 Baseline Characteristics Before and After Propensity Score Matching in VATS Patients

Propensity Score	Group	Number of Cases	Age/Year	Gender [n (%)]		BMI/(kg/m²)	ASA Grade		
				Male	Female		I	II	III
Before matching	T group	98	45.36±5.81	52 (53.1%)	46 (46.9%)	24.47±2.66	35 (35.7%)	43 (43.9%)	20 (20.4%)
	S group	113	47.11±6.33	58 (51.3%)	55(48.7%)	27.05±3.41	40 (35.4%)	38 (33.6%)	35 (31.0%)
	TS group	104	46.39±5.85	49 (47.1%)	55 (52.9%)	26.77±1.06	31 (29.8%)	46(44.2%)	27 (26.0%)
	P value		0.474	0.682		0.028	0.299		
After matching	T group	70	45.22±4.36	34 (48.6%)	36(51.4%)	25.33±2.09	23 (32.9%)	35 (50.0%)	12 (17.1%)
	S group	70	44.16±4.20	32 (45.7%)	38 (54.3%)	25.16±2.30	33 (47.1%)	22 (31.4%)	15 (21.4%)
	TS group	370	44.18±4.27	36(51.4%)	34 (48.6%)	25.21±2.18	27 (38.6%)	29 (41.4%)	14 (20.0%)
	P value		0.479	0.796		0.343	0.275		

https://doi.org/10.2147/JIR.S526948

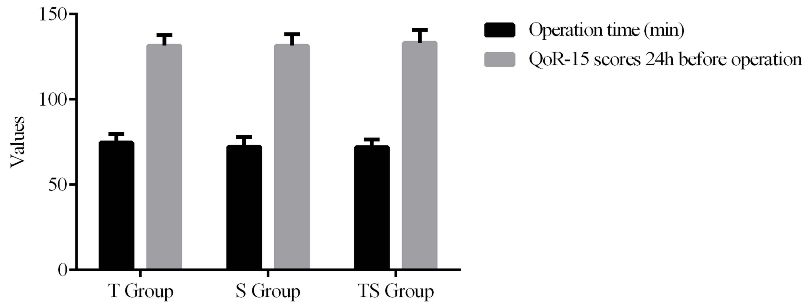

Figure 2 Preoperative Status of Patients Undergoing Non-Intubated Spontaneous-Ventilation VATS. Comparison of preoperative status across the T Group, S Group, and TS Group, including operation time (minutes) and QoR-15 score 24 hours before operation. The QoR-15 scores were slightly higher in the TS Group compared to the T and S Groups.

Analysis of Postoperative Pain Management Efficacy in VATS Patients Using VAS Scores

Postoperative resting pain, assessed by VAS, was initially similar in the T Group (3.53 ± 0.49) and S Group (3.55 ± 0.41), while the TS Group reported significantly lower scores (2.21 ± 0.34). Pain peaked at 12 hours in both T (5.27 ± 0.57) and S Groups (5.09 ± 0.49), then gradually declined to 2.87 ± 0.52 and 2.63 ± 0.49 by 48 hours, respectively. In contrast, the TS Group maintained consistently lower VAS scores throughout, peaking only at 2.51 ± 0.36 at 12 hours and dropping to 1.56 ± 0.24 at 48 hours. These findings indicate that the combined TPNB and SAPB approach provided superior and sustained pain relief across all time points (Figure 3).

Comparative Analysis of Analgesic Use and Efficacy in Postoperative Pain Management

The T Group had an average oxycodone consumption of (49.65±0.71) mg, which was slightly higher than the S Group's (45.42±0.51) mg and significantly higher than the TS Group's (30.26±0.53) mg ($P < 0.05$). The total number of PCA activations was also reduced in the TS Group, with an average of (11.05±1.14) activations, compared to (22.37±2.44) in the T Group and (20.08±1.47) in the S Group. The number of effective activations followed a similar trend, with the TS Group reporting (11.09±1.33) effective activations, while the T and S Groups had (21.58±1.26) and (18.74±1.17), respectively. Additionally, the time to the first press of the analgesic pump was significantly delayed in the TS Group [(7.42±1.10) hours] compared to the T Group [(3.61±0.41) hours] and the S Group [(3.84±0.61) hours], indicating a longer duration of pain relief provided by the combined nerve block approach. The incidence of additional analgesic remedies was also lowest in the TS Group (4 cases), compared to 16 in the T Group and 13 in the S Group ($P < 0.05$).

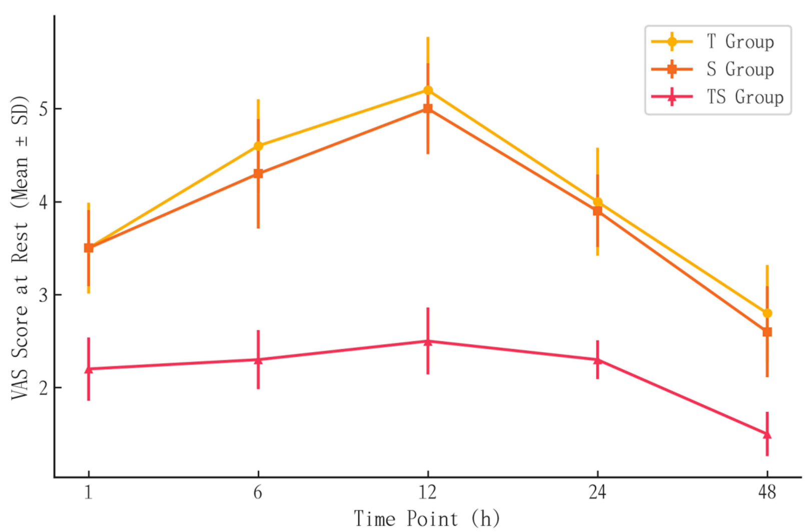

Figure 3 VAS Scores at Rest Over Time. Postoperative Visual Analog Scale (VAS) scores at rest were compared across the T Group, S Group, and TS Group at 1h, 6h, 12h, 24h, and 48h. The TS Group showed significantly lower VAS scores at all time points compared to the T and S Groups.

Table 2 Comparison of Analgesic Usage and PCA Date

Item	T Group (n=70)	S Group (n=70)	TS Group (n=70)	*P* Value
Dose of oxycodone (mg)	49.65±0.71	45.42±0.51*	30.26±0.53*#	<0.001
Total PCA activations	22.37±2.44	20.08±1.47*	11.05±1.14*#	<0.001
Effective PCA activations	21.58±1.26	18.74±1.17*	11.09±1.33*#	<0.001
First press time (hours)	3.61±0.41	3.84±0.61	7.42±1.10*#	<0.001
Number of analgesic remedies	16 (22.9%)	13 (18.6%)	4 (5.7%)	0.015

Note: * indicate comparison with T group, $P<0.05$; # indicate comparison with S Group, $P<0.05$.

These findings demonstrate the clear analgesic advantage of the combined use of TPNB and SAPB, which not only reduced opioid consumption but also extended the time before the need for patient-controlled analgesia and minimized the requirement for additional pain relief interventions. This prolonged and superior pain control in the TS Group likely contributed to enhanced patient comfort and a smoother postoperative recovery process (Table 2 and Figure 4).

Comparative Assessment of Postoperative Quality of Recovery Using the QoR-15 Scale

The QoR-15 scale measures recovery quality across five domains: Physical Comfort, Emotional State, Self-Care Ability, Psychological Support, and Pain Management. Analysis of the QoR-15 results reveals that the TS Group exhibited superior recovery scores in nearly all domains. This group achieved the highest total QoR-15 score of (120.41±7.75), significantly outperforming the T Group (113.42±7.65) and the S Group (112.95±7.56). This suggests that patients receiving the combined nerve block approach experienced not only better overall physical comfort but also reported less pain, contributing to a higher total recovery quality score. In the domain of Emotional State and Psychological Support, scores were consistently not very low across all groups, with the TS Group showing a slight advantage over the others. (Table 3 and Figure 5).

Comparative Analysis of Inflammatory Marker Levels Post-Surgery Across Anesthetic Techniques

This section examines the postoperative inflammatory response, focusing on key cytokines and other markers, including IL-1β, TNF-α, and Cor, in patients undergoing non-intubated spontaneous-ventilation VATS. Table 4 shows that the TS

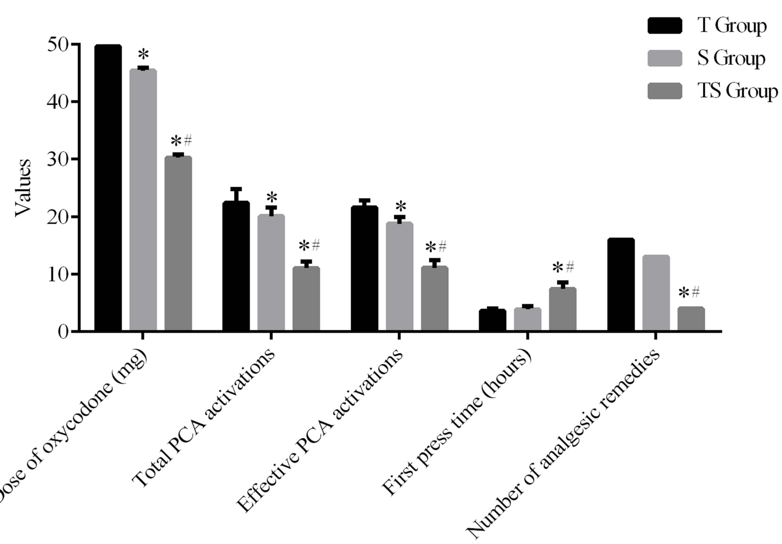

Figure 4 Comparison of Analgesic Usage and PCA Data. Key metrics related to analgesic use and PCA performance were compared across the T Group, S Group, and TS Group, including the dose of oxycodone (mg), total PCA activations, effective PCA activations, first press time (hours), and the number of analgesic remedies used. The TS Group demonstrated a significant reduction in the dose of oxycodone and PCA activations compared to the T and S Groups. *indicate comparison with T group, $P<0.05$; #indicate comparison with S Group, $P<0.05$.

https://doi.org/10.2147/JIR.S526948

Table 3 Comparison of QoR-15 Score

Item	T Group (n=70)	S Group (n=70)	TS Group (n=70)	*P* Value
Physical comfort	23.59±3.15	24.21±3.40	27.77±3.13*#	<0.001
Emotional State	21.59±2.34	21.22±1.97	23.06±2.24#	<0.001
Self-care ability	24.18±3.16	24.56±3.33	25.62±2.11*	0.008
Psychological support	21.05±2.42	20.18±2.56	23.74±3.22*#	<0.001
Pain	21.45±3.12	21.65±3.26	23.88±2.57*#	<0.001
Total	113.42±7.65	112.95±7.56	120.41±7.75*#	<0.001

Note: * indicate comparison with T group, $P<0.05$; # indicate comparison with S Group, $P<0.05$.

group demonstrated significant reductions in multiple inflammatory markers compared to the T and S groups at both T1 and T2 (Table 4 and Figure 6).

Specifically, IL-1β levels in the TS group were significantly lower at T1 [(15.33±0.41) pg/mL] and T2 [(13.45±0.71) pg/mL] compared to the T group at T1 [(20.57±1.23) pg/mL] and T2 [(17.24±0.96) pg/mL] and the S group at T1 [(17.44 ±1.02) pg/mL] and T2 [(16.12±0.88) pg/mL], with reductions over 20% at each time point. For TNF-α, the TS group showed marked decreases at T1 [(20.12±1.66) pg/mL] and T2 [(18.42±1.03) pg/mL], highlighting a reduction of over 15%.

Cortisol levels, an indicator of stress response, were notably lower in the TS Group at T1 [(289.53±79.01) ng/mL] and T2 [(250.11±50.03) ng/mL] compared to the T Group at T1 [(360.03±42.15) ng/mL] and T2 [(312.75±50.66) ng/mL] and S Group at T1 [(306.44±76.23) ng/mL] and T2 [(259.41±47.33) ng/mL], underscoring improved stress control with the combined block technique. These reductions across inflammatory markers indicate the efficacy of the combined nerve block technique in reducing postoperative inflammation and stress response, potentially contributing to enhanced recovery and lower complication rates for patients.

Postoperative Adverse Reaction and Complication Rates Across Anesthetic Techniques

The incidence of adverse reactions, including nausea, vomiting, and dizziness, was significantly lower in the TS Group. Nausea and vomiting occurred in 7.14% of patients in the TS Group, compared to 22.86% in the T Group and 18.57% in

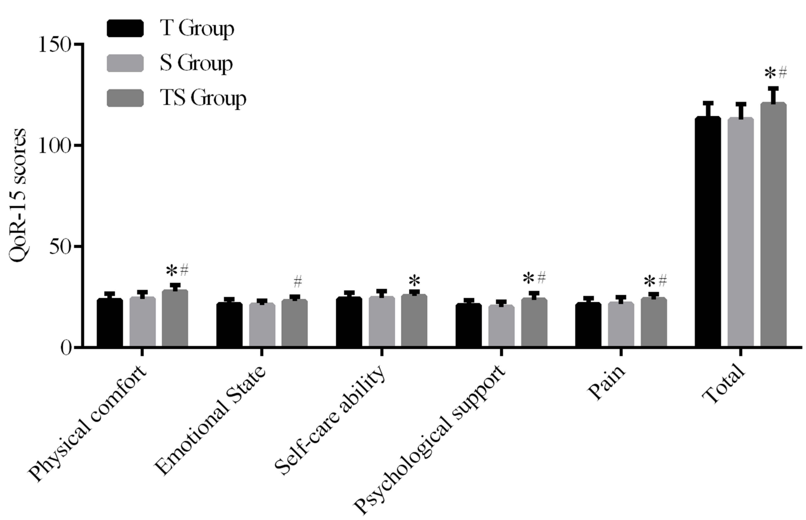

Figure 5 QoR-15 Scores Comparison. Comparison of Quality of Recovery (QoR-15) scores across five domains: Physical Comfort, Emotional State, Self-Care Ability, Psychological Support, and Pain, as well as total scores. The TS Group demonstrated significantly higher scores in Physical Comfort and Pain domains, as well as total scores, compared to the T and S Groups.

Table 4 Inflammatory Marker Levels Over Time Across Groups

Item		T Group (n=70)	S Group (n=70)	TS Group (n=70)	*P* Value
IL-1β (pg/mL)	T0	10.28±0.75	10.52±0.82	10.36±0.76	0.702
	T1	20.57±1.23	17.44±1.02*	15.33±0.41*#	<0.001
	T2	17.24±0.96	16.12± 0.88*	13.45±0.71*#	<0.001
	T3	13.41±1.05	13.25±1.01	12.14±0.92#	<0.001
TNF-α (pg/mL)	T0	16.37±1.21	16.45±0.83	16.22±0.90	0.191
	T1	25.51±1.08	23.14±1.35*	20.12± 1.66*#	<0.001
	T2	22.59±1.16	21.25±1.33*	18.42 ±1.03*#	<0.001
	T3	17.52±0.91	15.65±1.41*	16.03 ± 1.25*#	<0.001
Cortisol (ng/mL)	T0	270.77±34.32	272.58±43.65	277.44±50.21	0.535
	T1	360.03±42.15	306.44±76.23*	289.53±79.01*#	<0.001
	T2	312.75±50.66	259.41±47.33*	250.11±50.03*#	<0.001
	T3	287.19±36.26	245.44±61.58*	228.32±45.75*#	<0.001

Note: * indicate comparison with T group, *P*<0.05; # indicate comparison with S Group, *P*<0.05.

the S Group (P < 0.05). Dizziness was reported in 11.43% of patients in the TS Group, notably lower than the 28.57% in the T Group and 25.71% in the S Group (P < 0.05).

Pulmonary complications, including atelectasis, hypoxemia, and pulmonary infection, were also less frequent in the TS Group. Only 1.43% of patients in the TS Group experienced pulmonary complications, compared to 12.86% in the T Group and 10.00% in the S Group. Specifically, the incidence of atelectasis was significantly reduced to 1.43% in the TS Group, compared to 8.57% in the T Group and 5.71% in the S Group. Additionally, no cases of hypoxemia or pulmonary infection were observed in the TS Group, while both conditions were present in the T and S Groups at varying rates (P < 0.05).

These findings suggest that the combined use of thoracic paravertebral and serratus anterior plane blocks not only reduces adverse reactions but also effectively lowers the occurrence of postoperative pulmonary complications, including atelectasis, hypoxemia, and infection (Table 5 and Figure 7).

Overall, the results demonstrate that the TS Group exhibited the lowest rates of both adverse reactions and post-operative complications, indicating that an integrated approach to nerve blocking enhances recovery, minimizes common side effects, and improves patient outcomes following VATS procedures.

Discussion

Pain is one of the key factors affecting postoperative recovery in thoracic surgery. Good postoperative analgesia can alleviate surgical stress response, and early and timely control of acute postoperative pain can ensure that patients can breathe or cough forcefully after surgery, which is beneficial for accelerating respiratory function recovery. The combined application of TPNB and SAPB has shown notably superior outcomes in postoperative pain management

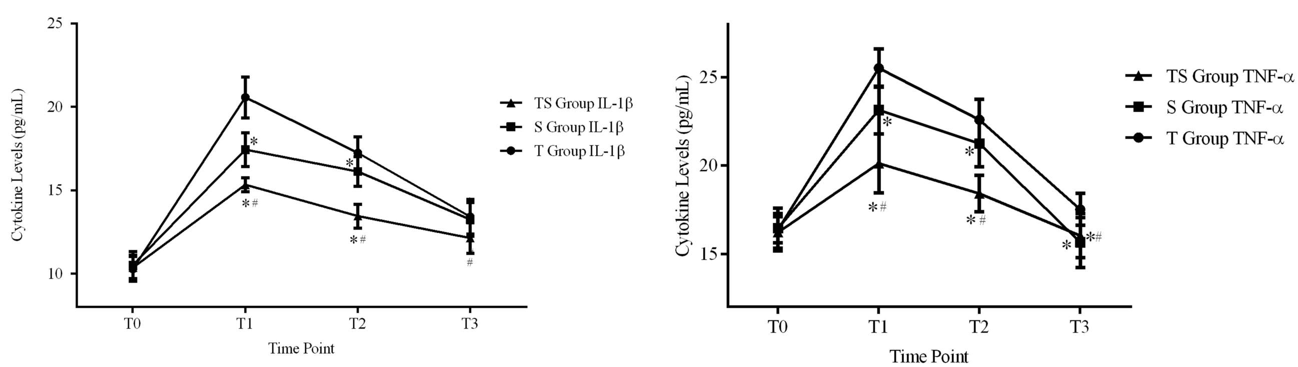

Figure 6 IL-1β and TNF-α Levels Over Time Across Groups. The levels of inflammatory markers IL-1β and TNF-α were measured at different time points (T0, T1, T2, T3) across the T Group, S Group, and TS Group. The TS Group showed significantly lower levels of both markers at T1 and T2 compared to the T and S Groups. *indicate comparison with T group, *P*<0.05; #indicate comparison with S Group, *P*<0.05.

https://doi.org/10.2147/JIR.S526948

Table 5 Incidence of Adverse Reactions and Complications

Item	T Group (n=70)	S Group (n=70)	TS Group (n=70)	*P* Value
Nausea and Vomiting	16 (22.86%)*	13(18.57%)#	5 (7.14%)	0.033
Dizziness	20 (28.57%)*	18 (25.71%)#	8 (11.43%)	0.040
Atelectasis	6 (8.57%)	4 (5.71%)	1 (1.43%)	0.008
Hypoxemia	3 (4.29%)	3 (4.29%)	0	0.214
Pulmonary Infection	3 (4.29%)	3 (4.29%)	0	0.214
Total Pulmonary Complications	9 (12.86%)*	7 (10.00%)#	1 (1.43%)	0.036

Note: * indicate comparison with T group, $P<0.05$; # indicate comparison with S Group, $P<0.05$.

and recovery indicators. At 12 hours, the VAS of the TS group was significantly lower than that of the T group (5.27 ± 0.57) and the S group (5.09 ± 0.49) (P<0.05); At 48 hours, the TS group (1.56 ± 0.24) was significantly lower than the T group (2.87 ± 0.52) and S group (2.63 ± 0.49) (P<0.05). In particular, the markedly lower consumption of oxycodone in the TS Group (30.26±0.53) mg compared to the T Group (49.65±0.71) mg and S Group (45.42±0.51) mg emphasizes the enhanced analgesic effect of the dual-block approach. Additionally, the reduced need for supplementary analgesics and fewer PCA activations in the TS Group further suggest prolonged pain relief, contributing to better patient comfort and accelerated recovery.

The choice of oxycodone as the primary analgesic is justified by its pharmacological properties, specifically its low selectivity for the μ-opioid receptor, which minimizes respiratory depression.[13,14] This characteristic is especially beneficial in non-intubated thoracic surgery, where preserving spontaneous breathing is crucial. Oxycodone allows for effective pain management without compromising respiratory function, making it an ideal option for patients undergoing VATS under non-intubated anesthesia.[15,16]

Comparing this study to other research, Zheng et al demonstrated that combining TPNB with SAPB in non-intubated VATS significantly improved postoperative pain management, reducing opioid consumption and minimizing inflammation compared to using TPNB alone.[17] Our study builds on these findings by specifically demonstrating the added benefits of combining TPNB with SAPB in non-intubated patients, who are at risk for more pronounced postoperative pain. Chen et al also highlighted the effectiveness of SAPB in providing analgesia during thoracoscopic pulmonary

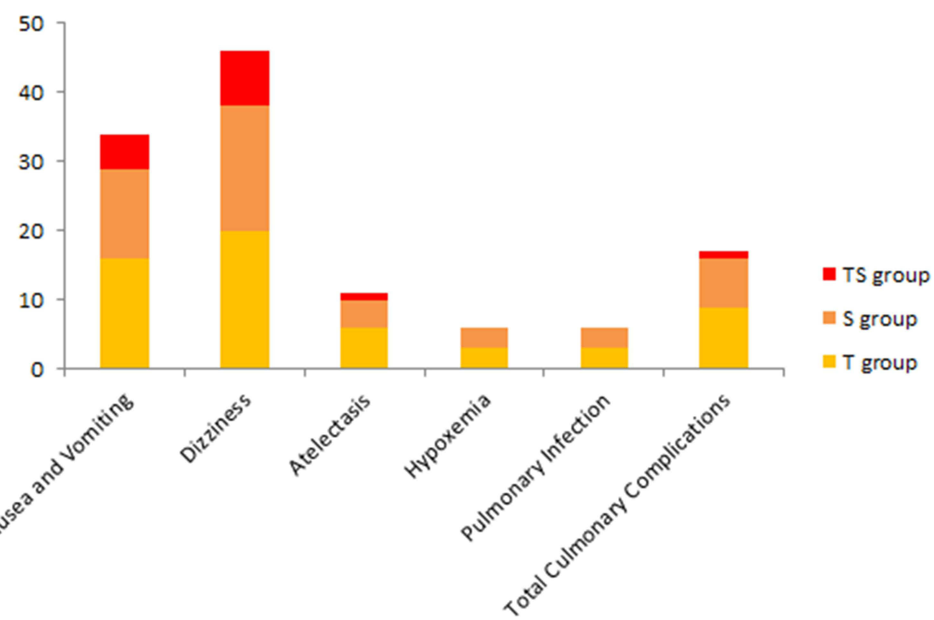

Figure 7 Incidence of Adverse Reactions and Complications. The incidence of postoperative adverse reactions and complications, including nausea and vomiting, dizziness, atelectasis, hypoxemia, pulmonary infection, and total pulmonary complications, was compared across the T Group, S Group, and TS Group. The TS Group demonstrated a significantly lower incidence of complications compared to the T and S Groups.

lobectomy; however, their study noted that while SAPB offers effective pain control for somatic pain, it is less effective in managing visceral pain.[18] In our study, by integrating TPNB, we have successfully enhanced pain control, addressing both somatic and visceral pain components, and providing more comprehensive analgesia compared to SAPB alone.

The distinct mechanisms of action of SAPB and TPNB complement each other well. SAPB is a fascial plane block method that precisely injects local anesthetics into the fascial or fascial plane of the serratus anterior muscle to block the lateral cutaneous branches of the intercostal nerves, generally in the range of T2 to T9 in the chest. The nerve coverage includes the anterior chest wall, lateral chest wall, and posterior chest wall, providing extensive analgesic effects on one side of the chest wall nerves, but with limited sympathetic blockade.[14,15,19] In contrast, TPNB precisely injects local anesthetics into the paraspinal space, which can simultaneously block the dorsal, ventral, sympathetic, and communicating branches of the intercostal nerves in this area, achieving selective blockade of the unilateral spinal and sympathetic nerves, extending analgesia to deeper chest structures, and providing a more comprehensive and predictable blockade. This combination effectively compensates for the individual limitations of each block, offering more extensive pain relief and reducing the need for systemic opioids.[16,19]

The synergistic effects of these blocks not only enhance pain control but also accelerate postoperative recovery, as evidenced by the faster mobilization times observed in the TS Group. Early mobilization is essential for preventing complications like deep vein thrombosis and pulmonary issues while promoting lung function recovery after thoracic surgery. Compared with the T and S groups, patients in the TS group had better postoperative recovery quality. The total score of the QoR-15 scale in the TS group was (120.41 ± 7.75), which was significantly better than that in the T group (113.42 ± 7.65) and S group (112.95 ± 7.56) ($P<0.05$). The prompt for comprehensive analgesia makes patients feel comfortable and emotionally stable, thereby accelerating postoperative recovery. The occurrence of inflammatory reactions caused by surgical trauma and other stimuli, and the significantly reduced levels of inflammatory cytokines, such as IL-1β and TNF-α in the TS Group can be attributed to the decreased surgical stress and tissue trauma resulting from more effective pain management. As pain and stress are known to trigger inflammatory cascades, their control likely mitigates systemic inflammation, which can otherwise negatively impact respiratory recovery.[20,21]

In line with this, the incidence of adverse effects, particularly nausea, vomiting, and dizziness, was notably lower in the TS Group. This reduction can be explained by the lower opioid consumption, as opioid-related side effects are dose-dependent.[22] Effective pain management likely contributed to improved hemodynamic stability, which in turn reduced dizziness and promoted faster overall recovery.[23,24] The broader sensory blockade achieved by the combination of TPNB and SAPB also played a critical role in reducing the overall pain experience, leading to fewer opioid requirements and a lower risk of associated side effects.[25–27]

Despite these promising outcomes, this study has certain limitations. The retrospective design may introduce selection biases, and the relatively small sample size may not fully capture subtler differences between the groups. Future prospective, randomized controlled trials with larger patient populations are necessary to validate these findings. Moreover, the follow-up period in this study was limited to 48 hours, which restricts the ability to assess the long-term benefits of this dual-block approach. Additional studies should explore longer postoperative follow-up periods to better understand the sustained effects of combined TPNB and SAPB on pain management and recovery.

In conclusion, the combined use of thoracic paravertebral and serratus anterior plane blocks offers significant advantages in postoperative pain relief for non-intubated VATS patients. It reduces opioid consumption, minimizes systemic inflammatory responses, and enhances overall recovery. Given these benefits, this dual-block technique should be considered for broader adoption in thoracic surgery, particularly for non-intubated procedures. However, further studies are needed to confirm these findings and explore the long-term outcomes of this analgesic strategy.

Conclusions

The combined application of TPNB and SAPB offers substantial advantages over the use of either block alone in non-intubated VATS. Patients who received the dual-block technique exhibited superior pain relief, demonstrated by significantly lower opioid consumption and a reduced need for additional analgesia. Moreover, the incidence of adverse effects, including nausea, vomiting, and dizziness, as well as pulmonary complications, was notably lower in the TS Group. The enhanced pain management provided by the combined blocks contributed to faster recovery, allowing for earlier mobilization and potentially shorter hospital stays. These results advocate for the more widespread adoption of this combined nerve block strategy in thoracic surgery to optimize postoperative outcomes and patient recovery.

Data Sharing Statement

The datasets used during the present study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The study was approved by the Institutional Review Board and Research Ethics Committee of the People's Hospital of Danyang, Affiliated Danyang Hospital of Nantong University, and was conducted in accordance to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Funding

This work was supported by grants from the Key Research and Development Program of Danyang City (Social Development) (SSF202209); Guiding Science and Technology Program for Social Development of Zhenjiang City (FZ2020012).

Disclosure

The authors have no conflicts of interest to declare.

References

1. Jayadeep I, Srinivasan G, Sethuramachandran A, Elakkumanan LB, Swaminathan S, Bidkar P. Comparison of the analgesic efficacy of ultrasound-guided superficial serratus anterior plane block with deep serratus anterior plane block in patients undergoing modified radical mastectomy: a randomized clinical trial. *Cureus*. 2022;14(10):e30828. doi:10.7759/cureus.30828
2. Shen L, Ye Z, Wang F, Sun GF, Ji C. Comparative analysis of the analgesic effects of intercostal nerve block, ultrasound-guided paravertebral nerve block, and epidural block following single-port thoracoscopic lung surgery. *J Cardiothorac Surg*. 2024;19(1):406. doi:10.1186/s13019-024-02877-7
3. Das S, Saha D, Sen C. Comparison among ultrasound-guided thoracic paravertebral block, erector spinae plane block and serratus anterior plane block for analgesia in thoracotomy for lung surgery. *J Cardiothorac Vasc Anesth*. 2022;36(12):4386–4392. doi:10.1053/j.jvca.2022.08.022
4. Helms O, Mariano J, Hentz JG, et al. Intra-operative paravertebral block for postoperative analgesia in thoracotomy patients: a randomized, double-blind, placebo-controlled study. *Eur J Cardiothorac Surg*. 2011;40(4):902–906. doi:10.1016/j.ejcts.2011.01.067
5. Khalil AE, Abdallah NM, Bashandy GM, Kaddah TA. Ultrasound-guided serratus anterior plane block versus thoracic epidural analgesia for thoracotomy pain. *J Cardiothorac Vasc Anesth*. 2017;31(1):152–158. doi:10.1053/j.jvca.2016.08.023
6. Li J, Wang X, Wang Y, Zhang W. Analgesic effectiveness of serratus anterior plane block in patients undergoing video-assisted thoracoscopic surgery: a systematic review and updated meta-analysis of randomized controlled trials. *BMC Anesthesiol*. 2023;23(1):235. doi:10.1186/s12871-023-02197-8
7. Ahmed Z, Samad K, Ullah H. Role of intercostal nerve block in reducing postoperative pain following video-assisted thoracoscopy: a randomized controlled trial. *Saudi J Anaesth*. 2017;11(1):54–57. doi:10.4103/1658-354X.197342
8. Patel A, Kumar V, Garg R, et al. Comparison of analgesic efficacy of ultrasound-guided thoracic paravertebral block versus surgeon-guided serratus anterior plane block for acute postoperative pain in patients undergoing thoracotomy for lung surgery-A prospective randomized study. *Saudi J Anaesth*. 2020;14(4):423–430. doi:10.4103/sja.SJA_143_20
9. Li B, Chen Y, Ma R. Optimizing patient outcomes: the impact of multimodal preemptive analgesia in video-assisted thoracoscopic lobectomy. *Interdiscip Cardiovasc Thorac Surg*. 2024;38(5). doi:10.1093/icvts/ivae096
10. Clairoux A, Moore A, Caron-Goudreault M, et al. Erector spinae plane block did not improve postoperative pain-related outcomes and recovery after video-assisted thoracoscopic surgery: a randomised controlled double-blinded multi-center trial. *BMC Anesthesiol*. 2024;24(1):156. doi:10.1186/s12871-024-02544-3
11. Xu CY, An MZ, Hou YR, Zhou QH. Effect of dexmedetomidine on postoperative high-sensitivity cardiac troponin T in patients undergoing video-assisted thoracoscopic surgery: a prospective, randomised controlled trial. *BMC Pulm Med*. 2024;24(1):500. doi:10.1186/s12890-024-03325-x
12. Kleif J, Waage J, Christensen KB, Gögenur I. Systematic review of the QoR-15 score, a patient-reported outcome measure measuring quality of recovery after surgery and anaesthesia. *Br J Anaesth*. 2018;120(1):28–36. doi:10.1016/j.bja.2017.11.013
13. Leviel F, Fourdrain A, Delatre F, et al. S erratus anterior plane block alone, paravertebral block alone and their combination in video-assisted thoracoscopic surgery: the THORACOSOPIC double-blind, randomized trial. *Eur J Cardiothorac Surg*. 2024;65(4). doi:10.1093/ejcts/ezae082
14. Wu W, Wang D, Liu Y, Zhu T, He W, Shi H. Comparison of ultrasound-guided subtransverse process interligamentary plane block with paravertebral block for postoperative analgesia in thoracic surgery: protocol for a randomised non-inferiority trial. *BMJ Open*. 2024;14(3):e082135. doi:10.1136/bmjopen-2023-082135
15. Zhu J, Wei B, Wu L, et al. Thoracic paravertebral block for perioperative lung preservation during VATS pulmonary surgery: study protocol of a randomized clinical trial. *Trials*. 2024;25(1):74. doi:10.1186/s13063-023-07826-8
16. Muhammad QUA, Sohail MA, Azam NM, et al. Analgesic efficacy and safety of erector spinae versus serratus anterior plane block in thoracic surgery: a systematic review and meta-analysis of randomized controlled trials. *J Anesth Analg Crit Care*. 2024;4(1):3. doi:10.1186/s44158-023-00138-y

17. Zheng MM, Xie J, Tan W, et al. 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. *Ther Clin Risk Manag*. 2025;21:343–353. doi:10.2147/TCRM.S507154
18. Chen X, Zhang W, Wang L, et al. The impact of hydromorphone combined with ropivacaine in serratus anterior plane block on postoperative pain in patients undergoing video-assisted thoracoscopic pulmonary lobectomy: a randomized, double-blind clinical trial. *BMC Anesthesiol*. 2025;25 (1):237. doi:10.1186/s12871-025-03101-2
19. Xue FS, Li CW, Luo X. Comparing analgesic efficacy of paravertebral and epidural blocks after thoracoscopic surgery. *Ann Thorac Surg*. 2024;118 (1):286–287. doi:10.1016/j.athoracsur.2023.12.005
20. Wu X, Chen H, Wang M, Wang P, Zhang Y, Wu Y. Rescue analgesia with serratus anterior plane block improved pain relief after thoracic surgery. *Minerva Anestesiol*. 2023;89(12):1082–1091. doi:10.23736/S0375-9393.23.17688-7
21. Wu Z, Wang Q, Wu C, et al. Paravertebral vs epidural anesthesia for video-assisted thoracoscopic surgery: a randomized trial. *Ann Thorac Surg*. 2023;116(5):1006–1012. doi:10.1016/j.athoracsur.2023.07.038
22. Gao X, Chen M, Liu P, et al. Comparison of edge of lamina block with thoracic paravertebral block and retrolaminar block for analgesic efficacy in adult patients undergoing video-assisted thoracic surgery: a prospective randomized study. *J Pain Res*. 2023;16:2375–2382. doi:10.2147/JPR.S409721
23. Zheng YF, Jiang YS, Liu HT, et al. Thoracic paravertebral nerve block combined laryngeal mask airway with preservation of spontaneous breathing can accelerate postoperative recovery. *Eur Rev Med Pharmacol Sci*. 2023;27(22):10875–10883. doi:10.26355/eurrev_202311_34455
24. Sethuraman RM. Combination of paravertebral block and serratus anterior plane block in video-assisted thoracic surgeries-comment. *Eur J Cardiothorac Surg*. 2023;64(1).
25. Zhang L, Hu Y, Liu H, et al. Analgesic efficacy of combined thoracic paravertebral block and erector spinae plane block for video-assisted thoracic surgery: a prospective randomized clinical trial. *Med Sci Monit*. 2023;29:e940247. doi:10.12659/MSM.940247
26. Mo X, Jiang T, Wang H, Zhang Y. Erector spinae plane block combined with serratus anterior plane block versus thoracic paravertebral block for postoperative analgesia and recovery after thoracoscopic surgery: a randomized controlled non-inferiority clinical trial. *Curr Med Sci*. 2023;43 (3):615–622. doi:10.1007/s11596-023-2745-2
27. Dusseaux MM, Grego V, Baste JM, et al. Paravertebral block combined with serratus anterior plane block after video-assisted thoracic surgery: a prospective randomized controlled trial. *Eur J Cardiothorac Surg*. 2023;64(1). doi:10.1093/ejcts/ezad170