BMC Surgery

RESEARCH Open Access

Comparative efficacy of erector spinae plane block versus surgeon-performed intraoperative intercostal nerve block in video-assisted thoracoscopic surgery: a retrospective analysis

Soner Kına[1], Güntuğ Batıhan[2,3*], Hüseyin Türkan[1] and Yekta Bektaş[1]

Abstract

Background Video-assisted thoracoscopic surgery (VATS) offers reduced postoperative pain and faster recovery, yet optimal analgesia remains essential. Regional anesthesia techniques, such as the erector spinae plane (ESP) block and intercostal nerve block (ICNB), are commonly employed. This study compares preoperative ESP block with surgeon-performed intraoperative ICNB in VATS patients.

Methods In this retrospective study, 82 patients (≥ 18 years; ASA I–III) underwent elective VATS between January 2020 and December 2022 were analyzed. Forty patients received a postoperative ESP block and 42 an intraoperative ICNB. Primary outcomes included postoperative pain scores using the Visual Analog Scale, postoperative peak expiratory flow (PEF), postoperative IV opioid analgesic use, drainage time, and hospital length of stay.

Results Baseline demographics were similar. VAS scores were comparable at postoperative 1, 3, 6, 12 and 24 h. At postoperative 48 h, the ICNB group had significantly lower VAS scores (4.17 ± 1.03 vs. 4.78 ± 1.03; $p = 0.00987$). No significant differences were observed in postoperative iv opioid analgesic use, drainage time or hospital stay.

Conclusions Both techniques provide effective early analgesia in VATS, with ICNB showing prolonged pain relief. Further prospective studies are warranted.

Keywords Erector spinae plane block, Intercostal nerve block, Postoperative pain, VATS.

*Correspondence:
Güntuğ Batıhan
guntugbatihan@gmail.com
[1]Faculty of Medicine, Department of Anesthesiology and Reanimation, Kafkas University, Kars, Türkiye
[2]Faculty of Medicine, Department of Thoracic Surgery, Kafkas University, Sehitler district, Ahmet Arslan Street, Kars 36000, Türkiye
[3]Faculty of Medicine, Department of Thoracic Surgery, Çanakkale Onsekiz Mart University, 17100 Çanakkale, Türkiye

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Introduction

Video-assisted thoracoscopic surgery (VATS) has revolutionized thoracic procedures by providing a minimally invasive alternative that is associated with reduced postoperative pain, shorter hospital stays, and faster recovery compared to open thoracotomy [1–3]. Despite these benefits, effective perioperative pain management remains critical for optimizing patient comfort, facilitating early mobilization, and minimizing opioid consumption. In this context, regional anesthesia techniques have become integral components of multimodal analgesia in thoracic surgery [4, 5]. Two commonly utilized single-shot techniques are the intercostal nerve block (ICNB) and the erector spinae plane (ESP) block. The ICNB is performed intraoperatively by the surgeon under direct visualization, with a local anesthetic injected at four to five intercostal levels corresponding to the surgical site. In contrast, the ESP block is administered preoperatively or postoperatively under ultrasound guidance at the T4–T6 level, depositing of local anesthetic deep to the erector spinae muscle to allow spread across multiple dermatomes [6]. Although both techniques are widely used, there is limited direct comparative evidence regarding their effectiveness in VATS. This study was designed to compare the efficacy of ICNB and ESP block in terms of early postoperative pain control, postoperative peak expiratory flow (PEF), postoperative IV opioid analgesic use, drainage time, and hospital length of stay in patients undergoing VATS.

Methods

Patient selection

This retrospective cohort study was conducted at a single tertiary institution after obtaining approval from the Institutional Review Board (80576354-050-99/439, 03-2024). Data were collected from electronic medical records for patients who underwent elective VATS between January 2020 and December 2022. Eligible patients were 18 years or older, had an American Society of Anesthesiologists (ASA) physical status of I–III, and underwent VATS lung resection for diagnostic or therapeutic purposes while receiving either an ICNB or an ESP block as part of their perioperative analgesia regimen. Patients undergoing bilateral thoracic procedures, pleurectomy, those with known allergies to local anesthetics, individuals with pre-existing chronic pain conditions or chronic opioid use, and patients with incomplete perioperative data were excluded.

The primary outcomes included:

1. Postoperative pain scores measured by the Visual Analog Scale (VAS) at 1, 3, 6, 12, 24, and 48 h postoperatively.
2. The amount of IV opioid analgesics administered on postoperative days 1, 2, and 3.
3. Postoperative peak expiratory flow (PEF) measured at 1, 6, 12, 24, and 48 h.
4. Drainage time.
5. Hospital length of stay (number of days from surgery to discharge).

Perioperative pain management

The choice of regional anesthesia technique (ESP or ICNB) was determined by the attending anesthesiologist based on personal preference and the availability of ultrasound equipment in the operating room at the time of surgery. During the VATS procedure, after completion of the resection, the intercostal nerve block (ICNB) was performed by the surgeon under direct visualization (Fig. 1c-d). For this purpose, a 25-gauge needle was used to deliver the local anesthetic under direct thoracoscopic vision. Approximately 20 mL of a local anesthetic solution, consisting of 8 mg/2 cc dexamethasone, 9 cc of 0.5% bupivacaine, and 9 cc of 2% prilocaine, was injected into 5–6 intercostal levels corresponding to the surgical site. The erector spinae plane (ESP) block, on the other hand, was performed after the VATS procedure was completed but before the patient left the operating room, with the patient in lateral decubitus position. Using ultrasound guidance, a high-frequency linear transducer was placed over the thoracic level (typically T4–T6), identifying the transverse process and the erector spinae muscle. Approximately 20 ml of a local anesthetic solution, consisting of 8 mg/2 cc dexamethasone, 9 cc of 0.5% bupivacaine, and 9 cc of 2% prilocaine, was injected into the fascial plane deep to the erector spinae muscle (Fig. 1a-b).

Standardized general anesthesia protocols were followed for all patients, including induction with intravenous agents such as propofol and fentanyl, combined with a neuromuscular blocking agent. Anesthesia maintenance was achieved using either volatile anesthetics or total intravenous anesthesia (TIVA), based on the anesthesiologist's preference. The VATS procedures were performed by the same surgical team using a standardized two-port technique. The camera port was placed at the 7th–8th intercostal space along the anterior axillary line, with an approximate length of 1 cm. The utility port was positioned at the 4th–5th intercostal space along the mid-axillary line, measuring approximately 3–4 cm in length. A sterile nylon wound protector retractor was routinely used at the utility port site to minimize tissue trauma and maintain incision integrity. Intraoperative parameters, including surgical time and complications, were carefully recorded.

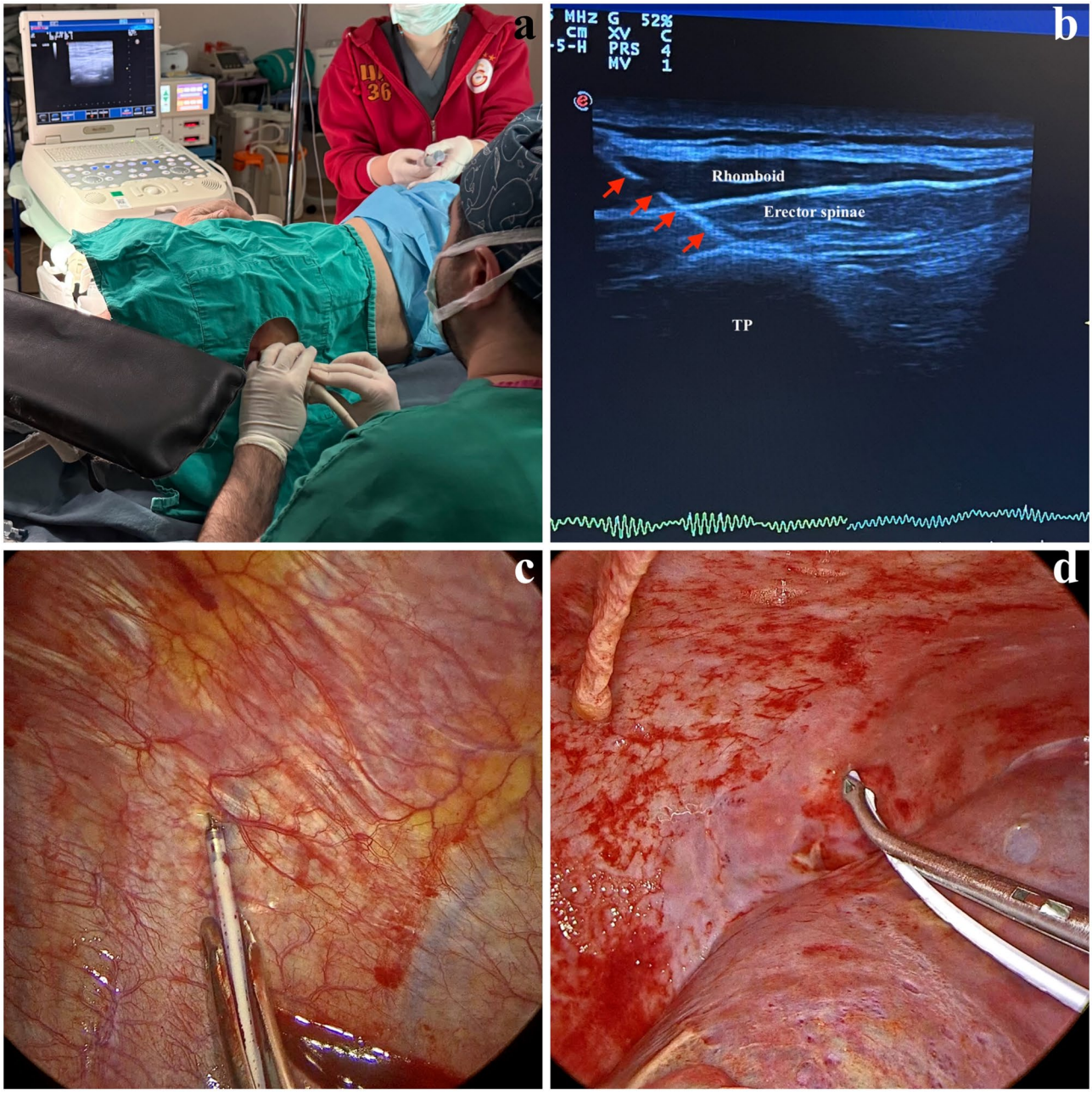

Fig. 1 (**a**) Preoperative ultrasound-guided single-shot erector spinae plane (ESP) block application in a patient undergoing video-assisted thoracoscopic surgery (VATS). (**b**) Ultrasound image demonstrating the local anesthetic spread (red arrows) between the erector spinae muscle and transverse process (TP). (**c**) Intraoperative view of the intercostal nerve block application during left-sided VATS procedure. (**d**) Intraoperative view of the intercostal nerve block application during right-sided VATS procedure

Postoperative pain management and follow-up

In all patients, a stepwise pain management approach was implemented in accordance with the World Health Organization (WHO) guidelines. Postoperative analgesia was standardized across both groups and included a routine combination of intravenous paracetamol (1 g every 8 h) and NSAIDs (dexketoprofen 50 mg IV twice daily). Opioids administered only when necessary for adequate pain control. This multimodal regimen was administered to all patients unless contraindicated. When required, intravenous tramadol hydrochloride was used as the opioid agent. For consistency and comparative analysis, all opioid dosages were converted to morphine milligram equivalents (MME) and incorporated into the study.

Postoperatively, all patients were mobilized early as part of an Enhanced Recovery After Surgery (ERAS) protocol, and effective respiratory physiotherapy was encouraged. Peak expiratory flow (PEF) measurements

were recorded preoperatively and at 1, 6, 24, and 48 h postoperatively. The 1-hour PEF value was obtained shortly after extubation in the recovery room to reflect immediate postoperative respiratory function. The chest tube was removed once air leakage had ceased, and fluid drainage had decreased to less than 200 mL per day.

Statistical analyzes

Continuous variables were expressed as means ± standard deviations and compared using either the Mann–Whitney U test or Student's t-test, depending on the data distribution. The normality of continuous variables was assessed using the Shapiro–Wilk test. Categorical variables were analyzed using the chi-square test or Fisher's exact test. A p-value < 0.05 was considered statistically significant. All analyses were performed using SPSS software (version 25.0).

Results

A total of 82 patients met the inclusion criteria, with 40 in the ESP group and 42 in the ICNB group. The mean age was 57.6 ± 11.4 years (range 40–79). 40 (48.8%) had comorbidities while 42 (51.2%) did not. The surgical procedures performed were lobectomy (45.1%), segmentectomy (13.4%), and wedge resection (41.5%). Postoperative analgesia was provided as either ESP block (48.8%) or ICNB (51.2%). The mean VAS scores recorded at 1, 3, 6, 12, 24, and 48 h postoperatively were 3.46, 3.54, 5.65, 5.48, 4.66, and 4.46 respectively, with a peak at 6 h (5.65 ± 0.948) (Fig. 2). Postoperative complications occurred in 26 patients (31.7%), whereas 56 (68.3%) experienced none. The opioid requirement averaged 9.39 ± 7.26 mg on the first day (range 0–20) and 38.7 ± 12.0 mg on the second day (range 20–60), and the mean BMI was 27.0 ± 5.01 (range 18.5–38.4). Demographic characteristics—including age, sex, ASA status, and surgical indications—were similar between the groups (Table 1). While VAS scores at 1, 3, 6, 12, and 24 h were comparable, the ICNB group exhibited significantly lower scores at 48 h (4.17 ± 1.03 versus 4.78 ± 1.03; $p = 0.009$), indicating a longer duration of analgesia with ICNB (Table 2). No significant differences were observed between the groups in terms of postoperative opioid use, PEF, drainage time, or overall hospital length of stay (Tables 1 and 2).

Discussion

Effective postoperative pain control is a critical component of enhanced recovery after surgery (ERAS) protocols in thoracic surgery [7]. Video-assisted thoracoscopic surgery (VATS) is associated with reduced surgical trauma compared to open thoracotomy; however,

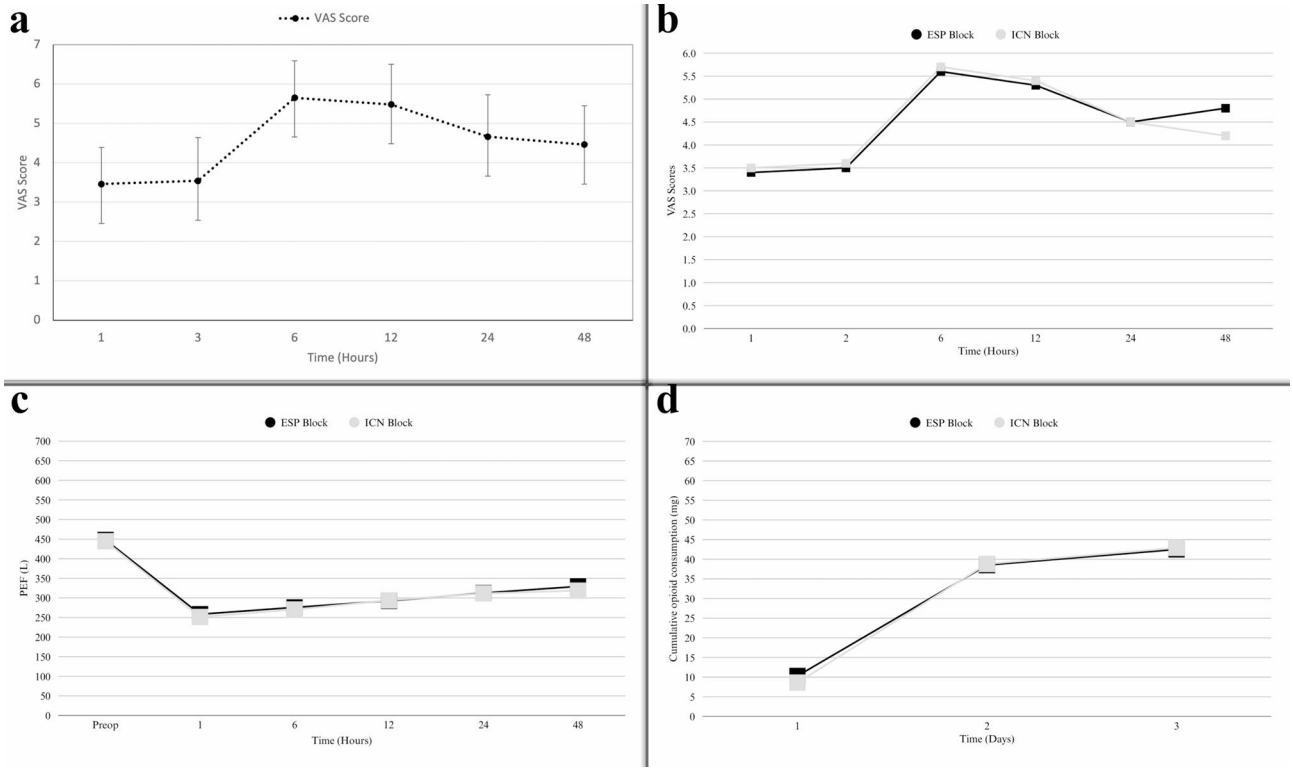

Fig. 2 (**a**) Mean visual analog scale (VAS) pain scores over time after surgery. (**b**) Comparison of VAS scores between the erector spinae plane block (ESP) and intercostal nerve block (ICNB) groups at different time points. (**c**) Peak expiratory flow (PEF) measurements before and after surgery in the ESP and ICNB groups. Data are presented as mean ± standard deviation. (**d**) Cumulative opioid consumption (mg) in both groups over three postoperative days

Table 1 Patient characteristics

Characteristics	ESP Block	ICNB	*p*-value
Age (years, mean ± SD)	57.2 ± 11.7	58.1 ± 11.2	0.72
Sex (male, %)	32 (80.0)	30 (71.4)	0.52
BMI	27.4 ± 4.6	26.8 ± 5.5	0.69
Diagnosis			0.29
Benign	17 (42.5)	13 (31.0)	
Malign	23 (57.5)	29 (69.0)	
Comorbidity (yes, %)	17 (42.5)	23 (54.8)	0.28
Preoperative PEF (L/min)	447.9 ± 84.7	444.5 ± 93.6	0.86
Surgery			0.91
Lobectomy-bilobectomy	18 (45.0)	19 (45.2)	
Segmentectomy	6 (15.0)	5 (11.9)	
Wedge	16 (40.0)	18 (42.9)	
Postoperative complication (yes, %)	11 (27.5)	15 (35.7)	0.42
Drainage time (days, mean ± SD)	4.72 ± 2.17	5.14 ± 2.49	0.42
Hospital stays (days, mean ± SD)	5.85 ± 1.99	5.76 ± 2.28	0.85

BMI: Body mass index, ESP: Erector spina plane, ICN: Intercostal nerve, SD: Standard deviation

Table 2 Comparison of pain control parameters based on block techniques

	ESP Block	ICN Block	*p*-value
Postoperative VAS scores (PO hours)			
1	3.40 ± 0.87	3.52 ± 0.99	0.55
3	3.50 ± 0.98	3.57 ± 1.00	0.75
6	5.60 ± 0.96	5.69 ± 0.95	0.67
12	5.53 ± 0.99	5.43 ± 1.10	0.67
24	4.53 ± 0.99	4.79 ± 1.00	0.24
48	4.78 ± 1.02	4.17 ± 1.03	0.009
Opioid analgesic need (MME/day) (PO days)			
1	10.3 ± 7.3	8.6 ± 7.2	0.30
2	38.5 ± 12.5	38.8 ± 11.7	0.91
3	42.5 ± 11.5	42.9 ± 11.7	0.89
Postoperative PEF (L/min) (PO hours)			
1	258.3 ± 32.2	251.2 ± 29.0	0.51
6	275.7 ± 32.8	270.3 ± 28.8	0.70
12	292.4 ± 32.1	293.8 ± 31.1	0.92
24	312.4 ± 28.2	311.3 ± 29.3	0.93
48	329.4 ± 28.2	318.6 ± 22.9	0.36

ESP: Erector spina plane, ICNB: Intercostal nerve block, MME: Morphine milligram equivalent, VAS: Visual analogue scale, PEF: Peak expiratory flow, PO: Postoperative

significant postoperative pain remains a challenge, particularly during the early recovery period [8, 9]. The use of regional anesthesia techniques, such as intercostal nerve block (ICNB) and erector spinae plane block (ESP), has been widely advocated to minimize opioid consumption and improve patient outcomes [10–13]. Our study aimed to compare the efficacy of these two commonly used regional anesthesia techniques in VATS patients in terms of postoperative pain relief, opioid requirements, and length of hospital stay.

Our findings demonstrated that both ICNB and ESP block provide effective early postoperative analgesia, as evidenced by comparable Visual Analog Scale (VAS) scores during the first 24 h following surgery. However, at 48 h postoperatively, the ICNB group exhibited significantly lower pain scores compared to the ESP group (4.17 ± 1.03 vs. 4.78 ± 1.03; $p = 0.009$). This suggests that ICNB may offer a longer-lasting analgesic effect in the early postoperative period. A potential explanation for this observation is the direct deposition of local anesthetic around the intercostal nerves, which allows for a more predictable and concentrated segmental blockade. In contrast, the ESP relies on the diffusion of local anesthetic through the fascial plane, which may lead to variable spread and efficacy depending on tissue permeability and individual anatomical differences [14].

Although injecting local anesthetic from within the thoracic cavity may theoretically allow for minimal leakage through the needle puncture site, we performed the intercostal nerve blocks under direct thoracoscopic vision at the end of the procedure, immediately before chest closure. This approach enabled the surgeon to ensure precise infiltration of the anesthetic agent into the target intercostal spaces while visually confirming adequate spread and minimizing loss.

Several studies have investigated the comparative effectiveness of ICNB and ESP block in thoracic surgery. In a pilot randomized controlled trial, Horth et al. [10] found that continuous ESP block resulted in lower opioid consumption over 48 h compared to single-shot ICNB; however, pain scores were similar between groups. Similarly, Gams et al. [11] reported that continuous ESP block significantly reduced opioid requirements and resulted in lower pain scores than ICNB in the first 48 h following lung cancer surgery. These findings highlight an important distinction: while a single-shot ESP block, as utilized in our study, may not provide prolonged analgesia, a continuous ESP block infusion could enhance pain control, potentially surpassing ICNB in effectiveness over an extended period.

The role of ESP block as an alternative to thoracic epidural analgesia (TEA) has also been explored. Sun et al. [12] compared ESP block combined with ICNB against thoracic paravertebral block (TPVB) and found that ESP block provided comparable pain relief to TPVB, reinforcing its potential as a safer and technically simpler alternative. Moreover, Mogahed et al. [13] reported that ESP block and TPVB offered superior intraoperative anesthetic sparing effects compared to multiple intercostal nerve blocks (MICNB), while all three techniques provided comparable postoperative analgesia.

In our study, both techniques were comparable in terms of hospital length of stay and opioid consumption. These findings suggest that, while ICNB may provide superior pain relief at 48 h, both techniques are well-integrated into the perioperative workflow and can

be effectively used within ERAS protocols. The ease of administration is another important consideration when selecting a regional anesthesia technique. ICNB is performed intraoperatively under direct visualization by the surgeon, requiring no additional imaging or time before surgery. In contrast, ESP block requires ultrasound guidance and preoperative preparation, which may impact operating room efficiency. However, ESP block may be a preferable option in selected patients, particularly when direct access to the intercostal spaces is limited due to surgical constraints or when thoracic cavity puncture is undesirable—for example, in the presence of pleural infection. The indication should be tailored based on individual clinical context, rather than generalized contraindications such as coagulopathy.

Limitations and future directions

Our study has several limitations. First, its retrospective design introduces potential selection bias and limits its causal inference. Second, the sample size is relatively small, which may reduce the statistical power to detect subtle differences in analgesic efficacy. Third, while we assessed pain scores up to 48 h postoperatively, we did not evaluate long-term pain outcomes or chronic post-thoracotomy pain syndrome (CPTPS), which is an important consideration in thoracic surgery. Finally, we did not include a continuous ESP group, which could have provided additional insights into the potential benefits of prolonged analgesia. Additionally, the choice between ESP and ICNB was not randomized but instead based on anesthesiologist preference and the availability of ultrasound equipment, which may have introduced allocation bias.

Future prospective, randomized controlled trials with larger patient cohorts are warranted to validate these findings and refine analgesic protocols. In particular, studies evaluating the pharmacokinetics of local anesthetic spread in ESP block, the optimal dosing regimen, and the potential role of adjuvants (e.g., dexmedetomidine or dexamethasone) would be valuable. Additionally, further research should explore patient-reported outcomes, cost-effectiveness, and functional recovery metrics to better guide clinical decision-making in thoracic anesthesia.

Conclusions

Both ICNB and ESP block provide effective perioperative analgesia in VATS, with comparable early postoperative pain control. However, ICNB appears to offer a more prolonged analgesic effect, as evidenced by lower VAS scores at 48 h postoperatively. Given the ease of administration and direct visualization, ICNB may be the preferred technique for many thoracic surgeons. Nonetheless, ESP block remains a valuable alternative, particularly in patients with contraindications to ICNB. The choice between these regional anesthesia techniques should be individualized based on patient characteristics, institutional protocols, and available expertise. Further prospective studies are needed to confirm these findings and optimize regional anesthesia strategies within enhanced recovery pathways in minimally invasive thoracic surgery.

Acknowledgements
Not applicable.

Author contributions
SK: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Supervision; Writing—review & editing. GB: Conceptualization; Data curation; Investigation; Methodology; Project administration; Writing—original draft; Writing—review & editing. HT: Conceptualization; Investigation; Methodology; Project administration; Writing—original draft; Writing—review & editing. YB: Conceptualization; Data curation; Review; Methodology.

Funding
The authors declare that no financial support or fund was received for this study.

Data availability
The datasets generated and/or analysed during the current study are not publicly available due but are available from the corresponding author on reasonable request.

Declarations

Ethical approval
Ethical approval for this study was obtained from Kafkas University Faculty of Medicine Scientific Research Ethics Committee, and all procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki. Informed consent to participate was obtained from all participants prior to their inclusion in the study. The study protocol was reviewed and approved by the relevant ethics committee, ensuring compliance with international ethical standards for research involving human subjects.

Human ethics and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of [Kafkas University Faculty of Medicine] (Approval No: [80576354-050-99/439, 03-2024]). Given the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

Received: 27 March 2025 / Accepted: 20 August 2025
Published online: 09 October 2025

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