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Erector Spinae Plane Block VS. Thoracic Paravertebral Block for Video Assisted Thoracoscopic Surgery (Vats): A Comparative Analysis of Regional Anesthesia Techniques on Current Literature

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Erector spinae plane block; enhanced recovery after surgery; thoracic paravertebral block; thoracotomy; video-assisted thoracoscopic surgery

ABSTRACT

Video-assisted thoracoscopic surgery (VATS) has become a widely adopted minimally invasive thoracic procedure because it reduces surgical trauma, postoperative complications, and hospital length of stay compared with conventional thoracotomy. However, postoperative pain after VATS remains a significant clinical challenge that may impair respiratory function, delay mobilization, and prolong recovery. Regional anesthesia techniques such as erector spinae plane block (ESPB) and thoracic paravertebral block (TPVB) are increasingly incorporated into enhanced recovery after surgery (ERAS) protocols, although their comparative effectiveness remains under debate. This study aimed to compare the analgesic efficacy, perioperative outcomes, and safety profiles of ESPB and TPVB in patients undergoing VATS. This research employed a narrative review design by synthesizing evidence from randomized controlled trials, comparative studies, and meta-analyses published between 2021 and 2026. Data were collected from PubMed, Scopus, and Web of Science databases using a structured literature search strategy. The findings demonstrated that both ESPB and TPVB provide comparable postoperative analgesia, opioid consumption, respiratory recovery, and length of hospital stay within the first 24–48 hours after surgery. TPVB showed slightly superior early pain control, whereas ESPB offered greater procedural simplicity and a lower risk of pleura-related complications. In conclusion, both techniques are effective regional anesthesia options for VATS, and their selection should be individualized based on clinical priorities, surgical complexity, and patient safety considerations.

INTRODUCTION

Video-assisted thoracoscopic surgery (VATS) has become an important surgical approach in modern thoracic surgery because it offers a minimally invasive alternative to conventional open thoracotomy. Compared with thoracotomy, VATS is associated with smaller incisions, reduced tissue disruption, a lower inflammatory response, shorter hospital stay, faster functional recovery, and improved postoperative outcomes (Ocheli et al., 2025). This technique is widely applied in various thoracic procedures, including wedge resection, lobectomy, pleural procedures, and diagnostic interventions. Despite these advantages, VATS is not entirely free from postoperative pain. Many patients still experience moderate to severe pain during the early postoperative period, particularly within the first 24–72 hours after surgery. This pain may arise from intercostal nerve

irritation caused by trocar insertion, pleural manipulation, rib spreading or compression, surgical incision sites, and discomfort related to chest tube placement (Zhao et al., 2024).

Postoperative pain after VATS is clinically important because inadequate pain control can impair respiratory mechanics and delay recovery. Thoracic surgical pain may limit deep breathing, coughing, and effective airway clearance, thereby increasing the risk of atelectasis, pneumonia, hypoxemia, and other pulmonary complications. Pain may also reduce patient mobility, prolong hospitalization, increase opioid requirements, and negatively affect overall quality of recovery. Therefore, effective postoperative analgesia is a central component of perioperative care in patients undergoing VATS. Adequate analgesia is not only intended to reduce pain intensity but also to preserve pulmonary function, facilitate early mobilization, improve patient comfort, reduce opioid-related adverse effects, and support enhanced recovery after surgery (ERAS) principles (Batchelor, 2024).

Thoracic epidural analgesia (TEA) has traditionally been regarded as the gold standard for pain management after thoracic surgery because of its strong analgesic effect. However, its routine use in minimally invasive thoracic procedures has become increasingly limited due to several concerns. TEA may be associated with hypotension, urinary retention, motor blockade, nausea, technical failure, risk of epidural hematoma, and contraindications in patients receiving anticoagulant therapy. These limitations have encouraged the use of alternative regional analgesic techniques that provide effective pain control while offering greater technical simplicity and safety. In this context, thoracic paravertebral block (TPVB) and erector spinae plane block (ESPB) have gained increasing attention as regional anesthesia techniques for postoperative analgesia in VATS patients.

TPVB provides unilateral thoracic analgesia by delivering local anesthetic near the spinal nerves in the paravertebral space. This technique can block somatic and sympathetic nerve transmission, making it effective for reducing postoperative pain and opioid consumption after thoracic surgery. However, TPVB requires precise needle placement close to the pleura and neuraxis, which may increase the risk of complications such as pneumothorax, vascular puncture, hypotension, or local anesthetic systemic toxicity. In contrast, ESPB is a relatively newer interfascial plane block performed by injecting local anesthetic deep to the erector spinae muscle and superficial to the transverse process. Because the injection site is farther from the pleura and major neurovascular structures, ESPB is considered technically simpler and potentially safer. It can be performed using ultrasound guidance and may provide extensive craniocaudal spread of local anesthetic, resulting in analgesia across multiple thoracic dermatomes (Mehta et al., 2023).

Several previous studies from Scopus- and PubMed-indexed journals have attempted to compare ESPB and TPVB in thoracic surgery. Sun et al. (2022) reported that ESPB and TPVB demonstrated comparable postoperative pain scores and opioid consumption after VATS lobectomy. Kim et al. (2022) similarly found no significant difference in postoperative analgesic efficacy when ESPB and TPVB were combined with intercostal nerve block. In contrast, Zhang et al. (2023) showed that TPVB produced stronger early postoperative analgesia during the first postoperative hours due to more reliable anterior diffusion into the paravertebral space. More

recent meta-analyses also suggest that TPVB may provide slightly superior early pain control, whereas analgesic outcomes between ESPB and TPVB become comparable after 24–48 hours.

Although previous studies have provided important findings regarding ESPB and TPVB, the available evidence remains inconsistent and heterogeneous. Variations in surgical procedures, block techniques, local anesthetic concentrations, adjuvant regimens, catheter use, outcome measurement timing, and patient populations continue to complicate interpretation of comparative effectiveness. Some studies emphasize superior early analgesia with TPVB, while others report equivalent analgesic and functional outcomes between both techniques. Moreover, many previous investigations have focused primarily on pain scores and opioid consumption without comprehensively evaluating respiratory recovery, ERAS outcomes, patient satisfaction, procedural feasibility, and complication profiles.

The research gap of the present study therefore lies in the limited comprehensive synthesis of current evidence evaluating both clinical efficacy and perioperative recovery outcomes between ESPB and TPVB in VATS patients. Existing literature still lacks consensus regarding the optimal regional anesthesia technique capable of balancing effective analgesia, procedural simplicity, safety, respiratory recovery, opioid minimization, and enhanced postoperative rehabilitation. Furthermore, the rapid expansion of minimally invasive thoracic surgery and ERAS implementation requires updated evidence-based evaluation of regional analgesia strategies suitable for contemporary thoracic surgical practice.

This research is considered urgent because postoperative pain management remains one of the major determinants of recovery quality after thoracic surgery. Inadequate analgesia may delay ambulation, prolong hospital stay, increase pulmonary complications, and elevate healthcare costs. At the same time, the global effort to minimize opioid exposure has increased the need for effective multimodal analgesia protocols. Identifying the most appropriate regional anesthesia technique for VATS is therefore clinically important not only for improving postoperative comfort but also for supporting ERAS implementation, reducing opioid-related adverse effects, and optimizing perioperative patient outcomes in thoracic surgery.

The novelty of this research lies in its comprehensive comparative evaluation of ESPB and TPVB within the context of modern VATS and ERAS protocols by integrating evidence related to postoperative pain trajectories, opioid consumption, respiratory function, perioperative recovery, procedural feasibility, quality of recovery, and complication patterns. Unlike many previous studies that focused only on short-term analgesic outcomes, this study emphasizes multidimensional perioperative recovery parameters and contemporary multimodal analgesia frameworks. This approach provides a broader clinical perspective regarding the role of interfascial and paravertebral regional anesthesia techniques in minimally invasive thoracic surgery.

Based on these considerations, this research aims to compare the effectiveness and safety of erector spinae plane block and thoracic paravertebral block for postoperative analgesia in patients undergoing video-assisted thoracoscopic surgery. The study specifically seeks to evaluate differences in postoperative pain scores, opioid consumption, respiratory recovery, quality of

recovery, perioperative outcomes, and complication incidence between both techniques. The findings of this research are expected to contribute theoretically by enriching current evidence regarding regional anesthesia in thoracic surgery and practically by assisting anesthesiologists, thoracic surgeons, and perioperative teams in selecting the most appropriate analgesic strategy for VATS patients. In addition, this study may support the future development of standardized ERAS-based pain management protocols to improve postoperative outcomes and patient quality of care in thoracic surgery.

METHOD

This narrative review synthesized recent evidence comparing ESPB and TPVB for postoperative analgesia in patients undergoing VATS. A structured search of PubMed, Scopus, and Web of Science was conducted. Medical Subject Headings (MeSH) were applied to optimize search sensitivity. Study selection followed the PICOS framework presented in Table and Figure **1**. Eligible studies include peer-reviewed literature published within the last five years (2021–2026) and available in full-text English. Exclusion criteria comprised of non-minimally invasive procedures such as open thoracotomy, pediatric or animal subjects, research with insufficient methodological or anesthetic detail, case reports or abstracts, and studies involving patients with clinical contraindications to regional anesthesia.

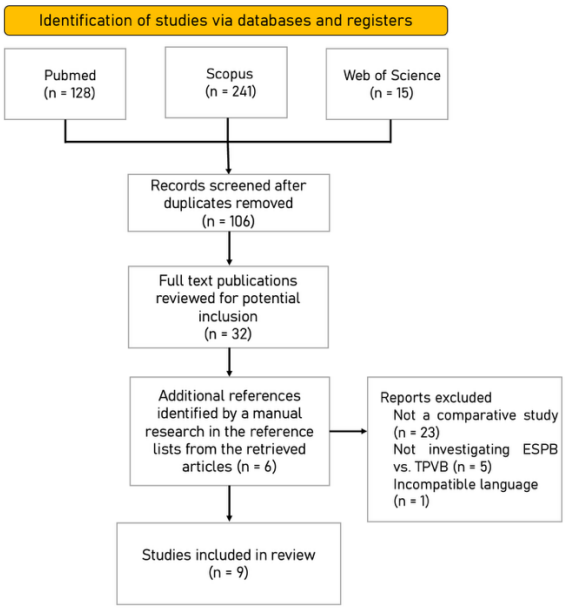

Figure 1. Literature selection flowchart

RESULTS AND DISCUSSION

Eight clinical trials and one meta-analysis were included. Main characteristics and findings are summarized in Table 2. Adverse events between ESPV vs. TPVB are summarized in Table 3. Ultrasound-guided ESPB offers a superficial, technically simpler target with consistent bony landmarks, though its anterior spread toward the paravertebral space remains indirect. In contrast,

TPVB involves deeper needle placement near the pleura, increasing technical difficulty and risks like pneumothorax or hypotension. 3D imaging by Chen et al. (2023) demonstrated that while ESPB provides superior cephalocaudal spread averaging 10 segments, it reaches the paravertebral space in only 20% of cases. Conversely, deeper paraspinal techniques achieve 100% anterior and lateral diffusion, ensuring a more consistent and stable block for the chest walls (Chen et al., 2023).

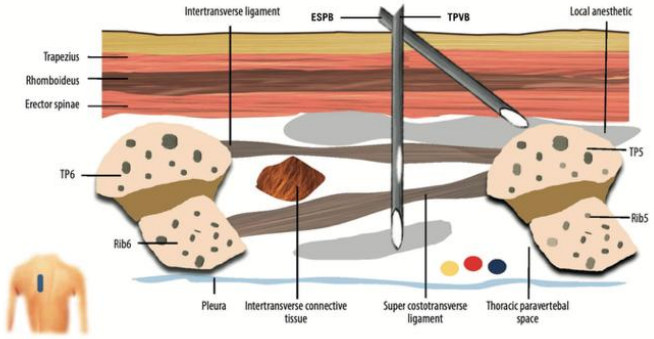

Figure 2. Ultrasound-guided ESPB vs. TPVB schematic illustration. (Modified from Zhang et al. (2023) [9])

Postoperative Efficacy

Contemporary randomized trials indicate that ESPB and TPVB provide generally comparable analgesia after VATS within the first 24–48 hours (Sun et al., 2022; Zhang et al., 2023; Sun et al., 2024; Li et al., 2025; Wang et al., 2025; Kim et al., 2022). While TPVB may offer slightly favorable early pain control, particularly for dynamic pain during the first 12 hours, this is likely due to the direct deposition of local anesthetic in the thoracic paravertebral space providing a more reliable blockade compared to the indirect fascial plane diffusion of ESPB (Li et al., 2025; Costache & Ramnanan, 2021). However, cumulative opioid consumption remains similar across studies, which is attributed to standardized multimodal analgesic protocols and variations in block techniques (Sun et al., 2022; Kim et al., 2022; Moorthy et al., 2023; Zhang et al., 2023; Sun et al., 2024; Li et al., 2025; Wang et al., 2025). The clinical outcomes appear further influenced by administration modality and surgical complexity. Single-shot injections in less invasive procedures like uniportal VATS show negligible differences in opioid use, whereas continuous catheter infusions in elderly cohorts or extensive resections like lobectomies often bridge the gap in analgesic duration to stabilize recovery profiles (Sun et al., 2024; Wang et al., 2025).

Table 2. Summary of Included Studies for Efficacy Analysis

Study	Author (Year)	Country	Population (ESPB vs. TPVB)	Procedure	Administration Technique	Findings	
Clinical Trial							
[5]	Sun (2022)	China	115 (59 vs. 56)	Lobectomy	Single-shot	▪ No significant difference of resting pain at 2-48h and moderate-to-severe pain incidence (VAS $\geq$ 4) when coughing at 24h and 48h	▪ Sulfentanyl consumption withing 24h and 48h is not significantly different ▪ Length of stay in PACU, hospital, & ambulation is not significanly different
[6]	Kim (2022)	Korea	52 (26 vs. 26)	Lobectomy, segment, wedge resection, mediastinal mass	Single-shot (both combined with ICNB)	▪ No significant difference in VAS PACU, 24-48h and in intraoperative dose of remifentanil or the frequency of hypotension, bradycardia.	▪ Satisfaction of patients and rescue analgesics (MME) is similar ▪ Hospital stay is not statistically different among groups
[7]	Chen (2023)	China	20 (10 vs. 10)	Wedge resection or segmentectomy	Single-shot (3D reconstruction imaging study)	▪ Drug difussion to the cephalocaudal area was improved in ESPB ▪ In TPVB, drug difussion improved anteriorly and laterally (10/10) in the paravertebral & intercostal spaces	▪ In ESPB, very few segments of the drug reached the paravertebral (2/10, 20%) and intercostal (3/10, 30%) spaces ▪ The blocking effect of both group paraspinal zone was excellent (100%)
[8]	Moorthy (2023)	Inggris	74 (37 vs. 37)	Lobectomy, wedge resection, biopsy, decortication, pleurectomy, bullectomy, other	Continuous catheter	▪ No significant difference in VRS pain at rest, 1-48h ▪ Higher total QoR-15 score in ESPB group at 24h and 48h. ESPB group showed favorable outcomes in resting, anxiety, and depressed (p<0.05)	▪ Similar antiemetics at PACU and 24h, but higher demand in TPVB at 48h ▪ Similar result in time to first IV opioid, total morphine, and peak inspiratory flow in PACU, 24-48h. Similar length of stay between group
[9]	Zhang (2023)	China	66 (33 vs. 33)	Bullectomy, segmentectomy, lobectomy	Single-shot	▪ Higher resting & coughing NRS score and intraoperative remifentanil consumption in ESPB compared with TPVB at 0.5-2h post-op (p<0.05) ▪ More patients in TPVB group presented with pre-operative sensory loss (p<0.05)	▪ First opioid administration is longer in TPVB in first 30 minutes (p<0.05) ▪ No differences in 8-24h post-op NRS. Similar intraoperative propofol, post-op sufentanil consumption, analgesia satisfaction score, & length of stay
[10]	Sun (2024)	China	50 (25 vs. 25)	Lobectomy	Continuous catheter	▪ Similar posto-op resting & coughing VAS at 2, 6, 8, 12, 24, and 48h. Similar intra-op sufentanil & tramadol dosage for additional analgesic	▪ Similar length of stay in PACU and ambulation time ▪ Longer postoperative hospital stay in TPVB (p<0.05)
[11]	Li (2025)	China	50 (25 vs. 25)	Lobectomy, segmentectomy, wedge resection	Single-shot	▪ Higher NRS score in ESPB at PACU, 1-6h (p<0.05) ▪ Similar OME, patients requiring analgesia, total dose of analgesia	▪ Higher satisfaction score in TPVB. More blocked dermatomes in TPVB (p<0.05) ▪ Similar length of hospital stay in both group
[12]	Wang (2025)	China	72 (36 vs. 36)	Lobectomy, segmentectomy, wedge resection	Single-shot	▪ Similar post-op pain within 1 week, persisted pain for 1-3 months, and postoperative use of non-opioid for > 3 days.	▪ More consumption in total opioid in TPVB (p<0.05) ▪ Similar intra-op sufentanil & norepinephrine, ambulation, & stay length
Reference	**Author (Year)**	**No. of Studies**	**Population**			**Findings**	
Meta-Analysis							
[13]	Sandeep (2022)	4	124 vs. 125	NS	Both	▪ Lower resting & coughing pain score at 24h in TPVB (p<0.05)	▪ Similar resting and coughing pain score at 48h

Abbreviation: ESPB, erector spinae plane block; ICNB, intercostal nerve block; IV, intravenous; MME, morphine milligram equivalents; NRS, numeric rating scale; OME, oral morphine equivalents; PACU, post anesthesia care unit; QoR-15, Quality of Recovery-15 questionnaire; TPVB, thoracic paravertebral block; VAS, visual analogue scale; VRS, verbal rating scale.

Beyond pain scores, postoperative recovery is closely linked to functional outcomes where both techniques show similar respiratory performance, including comparable peak inspiratory flow at 24–48 hours (Moorthy et al., 2023). While TPVB may provide higher early patient satisfaction due to stronger immediate analgesia, ESPB has been reported with slightly favorable results in specific Quality of Recovery (QoR-15) domains such as sleep and restfulness. These outcomes are also highly dependent on whether the regional technique is supplemented by adjuvant intercostal blocks, which often standardizes clinical results and diminishes comparative differences between the two blocks (Kim et al., 2022; Moorthy et al., 2023; Zhang et al., 2023; Sun et al., 2024; Li et al., 2025).

Perioperative Measures

Early ambulation remains a cornerstone of thoracic ERAS pathways as it significantly supports pulmonary recovery and discharge readiness (Park et al., 2025). Evidence from

comparative VATS trials shows similar mobilization outcomes between ESPB and TPVB, with no significant differences in ambulation time, PACU stay, or hospital length of stay (Sun et al., 2022; Moorthy et al., 2023; Zhang et al., 2023; Li et al., 2025; Wang et al., 2025; Ho et al., 2024). However, these perioperative measures are often influenced by the administration modality and surgical complexity. For instance, the use of continuous catheters in elderly patients or more invasive lobectomies may prioritize hemodynamic stability to ensure consistent mobilization. Overall, length of stay appears to depend more on broader perioperative factors, such as chest drain management and pulmonary complications, than on the regional anesthesia technique itself, although isolated studies report longer hospitalization with TPVB possibly due to procedural or workflow factors (Sun et al., 2024).

Cost considerations are increasingly relevant when selecting ESPB versus TPVB for VATS within ERAS-based value-driven perioperative care. Available evidence indicates that overall anesthesia costs are similar between techniques; for example, Wang et al. (2025) reported no significant difference in total anesthesia expenses between ESPB and TPVB groups (Zhang et al., 2023). This likely reflects the multifactorial nature of perioperative costs, which include procedural resources, equipment, clinician workload, and downstream factors such as complications, opioid-related effects, mobilization, and hospital stay (Feray et al., 2022).

Complication/Adverse Events

Most randomized trials show similar overall adverse event rates between ESPB and TPVB in VATS patients, although complication patterns differ. Pleura-related events such as pleural puncture and pneumothorax occur more often with TPVB due to its deeper needle placement near the pleura, whereas ESPB targets a more superficial plane and may reduce this risk (Sun et al., 2022; Kim et al., 2022; Moorthy et al., 2023). TPVB has also been associated with more intraoperative hypotension from sympathetic blockade, while nausea and vomiting are generally similar (Zhang et al., 2023). The incidence of these complications is further influenced by administration techniques, as continuous catheters require more intensive monitoring than single-shots, and surgical procedures, where extensive resections like lobectomies may exacerbate the clinical impact of adverse events (Sun et al., 2022; Kim et al., 2022; Moorthy et al., 2023; Zhang et al., 2023; Sun et al., 2024; Wang et al., 2025).

Table 3. Adverse Events/Complication in Both Technique

Author	Adverse Events/Complication	
Clinical Trial		
Sun (2022)	▪ PONV within 48h is not statistically different	▪ Incidence of hematoma in TPBV group (2/56), although not significantly different
Kim (2022)	▪ Pleural puncture is observed in 2 patients undergoing TPVB, but not statistically significant	
Moorthy (2023)	▪ Similar comprehensive complication index	▪ Similar block complication (1 blood aspirated from catheter in ESPB and 4 pleural puncture in TPVB)
Zhang (2023)	▪ Similar postoperative pulmonary complications	
Sun (2024)	▪ Similar PONV in both group	▪ 1 case of pneumothorax and postoperative fever in TPVB

Author	Adverse Events/Complication	
Clinical Trial		
Li (2025)	▪ Similar PONV in both group ▪ Similar ClassIntra, Claviean-Dindo, and EQ-5D$_{index}$ complication	▪ Similar PONV incidence between group ▪ No intraoperative awereness observed
Wang (2025)	▪ More adverse events related to neural blockade in ESPB	▪ Similar adverse events related to opioids
Meta-Analysis		
Sandeep (2022)	-	

Abbreviation: Clavien-Dindo, Clavien–Dindo classification; EQ-5D index, EuroQol five-dimension index; ESPB, erector spinae plane block; PONV, postoperative nausea and vomiting; TPVB, thoracic paravertebral block.

The Role of ESPB in ERAS and Long-term Recovery

The clinical utility of ESPB extends beyond acute analgesia, serving as a vital component of ERAS pathways by facilitating early ambulation and enhancing the overall quality of recovery. Its superficial target minimizes motor blockade and hemodynamic instability, supporting pulmonary hygiene and potentially shortening hospital stays, especially in elderly cohorts. Furthermore, establishing effective multimodal analgesia within the 24–72 hour window is crucial for preventing the transition to chronic post-surgical pain (CPSP) resulting from intercostal and pleural irritation (Viderman & Sarria-Santamera, 2021; Saadawi et al., 2021). With its favorable safety profile and consistent paraspinal spread, ESPB provides a reliable alternative for long-term pain modulation while minimizing pleura-related risks associated with deeper blocks.

Technique Selection Consideration: ESPB vs. TPVB

Technique selection should be tailored to clinical priorities and surgical complexity. TPVB is preferred for robust, early blockade of spinal and sympathetic nerves to manage intense dynamic pain within the first 12 hours. Conversely, ESPB is recommended for ERAS pathways due to its technical simplicity and superior safety profile, as its superficial target minimizes pleura-related risks. While single-shot injections suffice for less invasive procedures like uniportal VATS, continuous catheter infusions are essential in extensive resections or elderly cohorts to ensure the sustained analgesia and hemodynamic stability required for early mobilization (Sun et al., 2024; Wang et al., 2025). Ultimately, both techniques provide comparable cumulative opioid consumption and functional recovery by 24–48 hours, however ESPB offers a more versatile and safer alternative for modern multimodal frameworks.

CONCLUSION

The findings of this review demonstrate that both erector spinae plane block (ESPB) and thoracic paravertebral block (TPVB) are effective regional anesthesia techniques for postoperative pain management in patients undergoing video-assisted thoracoscopic surgery (VATS). TPVB tends to provide stronger early postoperative analgesia, particularly during the first 12 hours after surgery, due to its direct spread into the paravertebral space and more consistent blockade of thoracic spinal nerves. However, this early advantage does not appear to translate into substantial differences in cumulative opioid consumption, respiratory function, mobilization, or hospital length of stay when compared with ESPB.

In contrast, ESPB offers several practical advantages, including easier ultrasound-guided administration, broader cephalocaudal anesthetic spread, and a lower risk of pleura-related complications such as pneumothorax and pleural puncture. Both techniques support enhanced recovery after surgery (ERAS) principles by improving postoperative comfort, facilitating pulmonary recovery, and reducing opioid-related adverse effects. Therefore, the selection of ESPB or TPVB should be individualized based on surgical complexity, patient condition, institutional expertise, and perioperative recovery priorities.

Future research should focus on conducting larger multicenter randomized controlled trials with standardized anesthetic protocols, homogeneous surgical populations, and longer follow-up periods to strengthen the current evidence regarding ESPB and TPVB in VATS. Additional studies are also needed to evaluate long-term outcomes such as chronic post-surgical pain prevention, quality of life, cost-effectiveness, and patient satisfaction across different thoracic surgical procedures. Furthermore, future investigations should compare the efficacy of single-shot versus continuous catheter techniques and explore optimal local anesthetic concentrations, adjuvant agents, and timing of block administration. Research integrating objective pulmonary recovery indicators, ERAS compliance parameters, and functional rehabilitation outcomes would also provide a more comprehensive understanding of the role of regional anesthesia in modern thoracic surgical practice.

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