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REVIEW

Paravertebral Block versus Erector Spinae Plane Block for Postoperative Analgesia and Recovery: A Systematic Review and Meta-Analysis

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Background: This systematic review and meta-analysis was performed to assess the relative efficacy of paravertebral block (PVB) and erector spinae plane block (ESPB) for postoperative analgesia and recovery.

Methods: Randomized controlled trials (RCTs) evaluating PVB and ESPB for postoperative analgesia and recovery were retrieved from databases, including PubMed, Embase, MEDLINE, Cochrane Library, Science-Direct, and Google Scholar, from inception to January 2025. The primary outcome included resting Visual Analogue Scale (VAS) at 6 h and quality of recovery (QoR) score in first 24 h. The meta-analysis was conducted using Stata 15.1 software. The certainty of the evidence was assessed utilizing the risk of bias and GRADE frameworks.

Results: We included 33 RCTs with 2256 patients. For resting VAS at 6 h, there was no significant difference between PVB and ESPB (mean difference [MD] = −0.08, 95% confidence interval [CI]: −0.44 to 0.27). For QoR, there was no significant difference between PVB and ESPB (MD = −0.44, 95% CI: −2.64 to 1.76). For resting VAS at 12 h, ESPB had a lower VAS than PVB. For resting VAS at 24 h, movement VAS at 6 h, 12 h, 24 h, time of first rescue analgesia, LOS, and postoperative nausea and vomiting (PONV), there were no significant differences between PVB and ESPB. However, PVB had a lower morphine consumption than ESPB.

Conclusion: There were no significant clinical differences between PVB and ESPB in terms of the VAS, QoR, time of first rescue analgesia, LOS, and PONV. Based on existing evidences, we recommended the application of ESPB in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery.

Limitation: The included studies showed considerable variability in postoperative analgesia protocols, which increased heterogeneity in the results. There was a lack of data on long-term analgesia and functional outcomes.

Keywords: analgesia, erector spinae plane block, meta-analysis, paravertebral block, recovery

Introduction

Effective postoperative analgesia is essential for facilitating recovery, minimizing complications, and enhancing patient satisfaction after surgical procedures.[1] Among various regional anesthesia techniques, paravertebral block (PVB) and erector spinae plane block (ESPB) have garnered significant attention for their potential in managing postoperative pain.[2,3] Other nerve blocks such as intercostal nerve block, quadratus lumborum block, and transversus abdominis plane block are all derivatives of the ESPB and PVB. Both techniques offer distinct mechanisms and approaches to provide analgesia, yet comparative analyses of their effectiveness, safety profiles, and impact on recovery remain limited.

The PVB is a procedure that involves the injection of local anesthetics (LAs) into the paravertebral space.[4] It has demonstrated significant efficacy in controlling postoperative pain, particularly in surgeries involving the chest and abdomen.[4–6] Numerous studies have indicated that PVB can reduce opioid consumption, lower pain scores, and enhance pulmonary function.[7–9] However, despite its benefits, PVB is not without limitations, potential complications

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such as pneumothorax, hematoma formation, and nerve injury, along with its technically demanding nature, create barriers to its widespread adoption.[2] The ESPB is a relatively novel technique that involves depositing LAs in the fascial plane deep to the erector spinae muscle.[10] Initial studies suggest that ESPB is associated with a favorable safety profile, simpler technique, and effective pain relief.[11,12] The growing body of literature has highlighted its potential to spare the use of systemic opioids while providing adequate analgesia, thereby minimizing opioid-related side effects such as nausea, vomiting, and sedation.[10] However, its requirement for large volumes of LAs to achieve an extensive and effective blockade, which raises concerns about potential toxicity and limits its safety in certain patient populations.[11,12]

Given the distinct characteristics of both PVB and ESPB, the precise comparative efficacy in terms of pain control, opioid-sparing effects, and overall recovery outcomes remains inadequately addressed in the literature. Our meta-analysis will compare the effectiveness of PVB with ESPB in providing postoperative analgesia and enhancing recovery outcomes. The findings will provide evidence-based recommendations for clinicians in selecting the optimal analgesic strategy tailored to individual patient and surgical needs.

Methods

Our study adhered to the guidelines of the PRISMA[13] and the protocol was registered in the International Prospective Register of Systematic Reviews (CRD42025633254). This work started in 6 January 2025.

Inclusion and Exclusion Criteria

Eligibility criteria were designed according to PICOS criteria: patients undergoing surgeries for adults or children (P); interventions included single-injection PVB and ESPB (I); PVB or ESPB (C); resting and movement pain score, quality of recovery (QoR) scores, time of first rescue analgesia, total morphine consumption in first 24h, length of hospital stay, postoperative nausea and vomiting (PONV) (O); randomized controlled trials (RCTs) (S). Studies were excluded if they met the following criteria: (1) studies that did not report outcomes or the data can not be used for statistical analysis; (2) unpublished studies, parallel and crossover randomized design studies; (3) studies that appear to report the same data more than once.

Search Strategy

We searched PubMed, MEDLINE, Embase, Cochrane Library, Science-Direct, and Web of Science without language restriction from inception to January 2025. The search strategy was based on the PICOS framework and principles, the key words and Medical Subject headings (MESH) descriptor terms were as follows: “paravertebral block”, ‘‘erector spinae plane block”, “PVB”, and “ESPB”. There was no limitation on sample size, surgical types and language.

Data Extraction

Two researchers individually reviewed all titles, abstracts, and then full texts sequentially. The disagreements on eligibility were resolved by the third reviewer. The data extracted from each RCT included author, year of publication, country, blinding, surgical types, interventions description, sample size, postoperative analgesic regimens, and outcomes. The primary outcome included resting pain score at 6 h and QoR score in first 24 h. The secondary outcomes included resting pain score at 12 h, 24 h, movement pain score at 6 h, 12 h, 24 h, time of first rescue analgesia, total morphine consumption in first 24h, length of hospital stay (LOS), and PONV.

Certainty of Evidence

Two independent investigators assessed the certainty of evidence by using the Cochrane Collaboration’s tool, which included of sequence generation, allocation sequence concealment, blinding of participants and personal, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and other potential sources bias.[14] The result was shown by the risk of bias and GRADE framework.

Statistical Analysis

Statistical analysis was carried out in STATA 15.1 software, and the data were synthesized by random-effects model. Pain scores were converted to the 0–10 VAS, and opiates consumption was converted to intravenous morphine equivalent doses. Meanwhile, we used Luo's and Wan's formula to convert the data expressed as median and inter-quartile range to mean and standard deviations.[15,16] The effect estimate was reported as the relative risk (RR) and 95% confidential intervals (CIs) for PONV. The effect estimate was reported as the mean difference (MD) and 95% CIs for pain score, QoR score, time of first rescue analgesia, total morphine consumption in first 24h, and LOS. Overall effect sizes were illustrated by forest plots, and the subgroup analysis was based on the surgical types. Heterogeneity was considered significant if $I^2 \geq 50\%$,[17] and then we performed sensitivity analysis and subgroup analysis to find the sources of heterogeneity. P value < 0.05 was considered as statistical significance in all analyses. The publication bias was usually assessed by funnel plot, but it was assessed by using Begg's and Egger's tests if the number of included studies was less than 10.[18,19]

Results

We obtained 260 potentially relevant records, 193 were excluded after reviewing titles and abstracts alone. We reviewed the full text of the remaining 67 potentially eligible studies, 33 RCTs with 2256 patients were included in this meta-analysis,[20–52] between PVB (n = 1131 patients) and ESPB (n = 1125 patients) groups. Figure 1 showed the process of

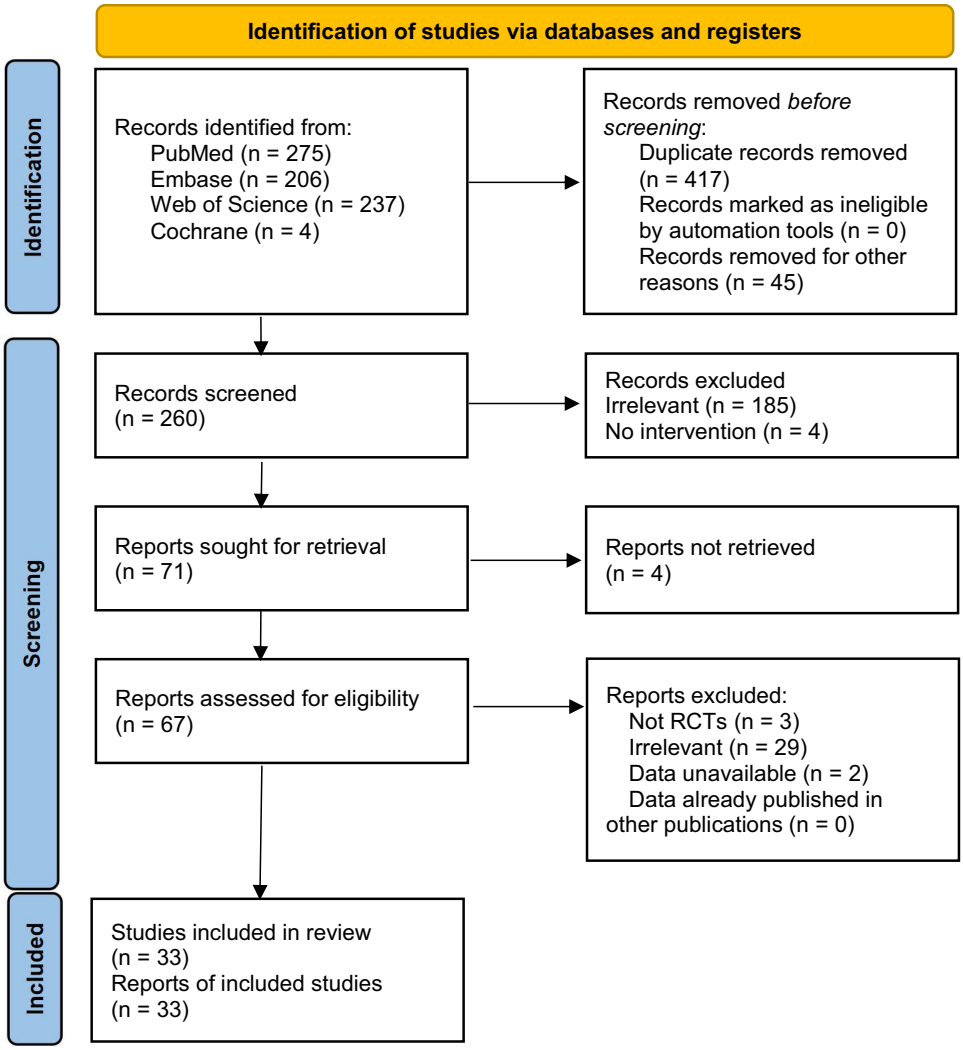

Figure 1 PRISMA flow diagram of study selection.

Notes: PRISMA figure adapted from Page MJ, Moher D, Bossuyt PM et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. BMJ. 2021;372:n160. doi: 10.1136/bmj.n160.[13.]

literature selection. Table 1 showed the basic characteristics of the included studies. The vast majority of trials used ropivacaine or bupivacaine alone, and a total volume between 20 and 30 mL. The most common types of surgeries included video-assisted thoracic surgery (8 RCTs) and modified radical mastectomy (8 RCTs). The resting VAS at 6 h was reported in 17 RCTs, and the QoR was reported in 5 RCTs.

Assessment of Bias

Risk of bias of the primary outcomes were presented in Figures 2 and 3. The funnel plot of resting VAS at 6 h did not suggest any publication bias (Figure 4). For QoR, the results of Begg's test and Egger's test indicated that there were no publication bias (p=0.462 and p=0.378, respectively).

Resting VAS at 6 h

The pooled data of seventeen studies did not suggest that PVB was superior to ESPB (MD = −0.08, 95% CI: −0.44 to 0.27; I^2 = 92.2%; Figure 5). Due to the significant heterogeneity, we had to perform a sensitivity analysis and subgroup analysis. The sensitivity analysis demonstrated that the result was robust (Figure 6). The subgroup analysis showed that ESPB had a lower VAS than PVB in abdominal surgery (MD = −0.8, 95% CI: −1.1 to −0.5), but there were no significant differences in thoracic surgery, breast surgery, and kidney surgery (Figure 7).

QoR

The pooled data of five studies did not suggest that PVB was superior to ESPB (MD = −0.44, 95% CI: −2.64 to 1.76; I^2 = 82.7%; Figure 8). The sensitivity analysis demonstrated that the result was not robust (Figure 9). The subgroup analysis showed the similar effects in thoracic surgery, kidney surgery, and abdominal surgery (Figure 10).

Resting VAS at 12 h

The pooled data of seventeen studies suggested that ESPB had a lower VAS than PVB (MD = −0.15, 95% CI: −0.27 to 0.02; I^2 = 87.1%; Table 2). The subgroup analysis showed that ESPB had a lower VAS than PVB in breast surgery, but there were no significant differences in thoracic surgery, abdominal surgery, and kidney surgery (Supplementary material: Figure 1).

Resting VAS at 24 h

The pooled data of seventeen studies did not suggest that PVB was superior to ESPB (MD = −0.03, 95% CI: −0.15 to 0.09; I^2 = 79.6%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 2).

Movement VAS at 6 h

The pooled data of nine studies did not suggest that PVB was superior to ESPB (MD = −0.11, 95% CI: −0.25 to 0.03; I^2 = 94.1%; Table 2). The subgroup analysis showed that ESPB had a lower VAS than PVB in thoracic surgery, abdominal surgery, and kidney surgery. However, PVB had a lower VAS than ESPB in breast surgery (Supplementary material: Figure 3).

Movement VAS at 12 h

The pooled data of nine studies did not suggest that PVB was superior to ESPB (MD = −0.09, 95% CI: −0.23 to 0.06; I^2 = 96.2%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 4).

Movement VAS at 24 h

The pooled data of ten studies did not suggest that PVB was superior to ESPB (MD = −0.00, 95% CI: −0.14 to 0.13; I^2 = 89.1%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 5).

Table 1 Study Characteristics of Included Studies

Author	Country	Blinding	Types of Surgery	Comparison (n)	Postoperative Analgesic Regimen	Outcomes
Zhao[20]	China	2	VATS	ESPB(33):T4 and T6 levels,30 mL 0.4% ropivacaine TPVB(33):T4 and T6 levels,30 mL 0.4% ropivacaine	Flurbiprofen 8 mg/h was given and then a oxycodone PCIA	(2)(4)(7)(8) (9)(10)
Turhan[21]	Turkey	1	VATS	ESPB(35):20 mL of 0.5% bupivacaine TPVB(35):20 mL of 0.5% bupivacaine	Paracetamol 1g every 8 h and tenoxicam 20 mg were given and then a morphine PCIA	(1)(3)(4)(5) (6)(7)(8) (10)(11)
Chen[22]	China	2	VATS	ESPB(24): T5 level, 20 mL of 0.375% ropivacaine TPVB(24):T5-T7 levels, 20 mL of 0.375% ropivacaine	A morphine PCIA and then diclofenacsodium suppositories 50 mg was given if VAS > 3	(8)(11)
Zhang[23]	China	2	VATS	ESPB(37): T5 level, 25 mL of 0.5% ropivacaine TPVB(37):T5 level, 25 mL of 0.5% ropivacaine	A sufentanil PCIA	(9)(10)(11)
Zengin[24]	Turkey	1	VATS	ESPB(25): 20 mL of 0.25% bupivacaine PVB(25): 20 mL of 0.25% bupivacaine	IV paracetamol 1 g every 8 h and dexketoprofen 50 mg every 12 h. A morphine PCIA and IV tramadol 0.5 mg/kg if resting VAS ≥ 4	(1)(3)(4)(5) (6)(7)(8)
Fu[25]	China	2	VATS	ESPB(20): 20 mL of 0.5% ropivacaine at T5 level PVB(22): 20 mL of 0.5% ropivacaine at T5 level	A hydromorphone PCIA and then IV oxycodone 3 mg if resting VAS ≥4	(8)(11)
Zhang[26]	China	2	VATS	ESPB(22): 30 mL of 0.5% ropivacaine at T4-5 level PVB(22): 30 mL of 0.5% ropivacaine at T4–5 paravertebral spaces	A sufentanil PCIA and then IV furbiprofen 50 mg if coughing VAS ≥4	(1)(3)(4)(5) (6)(7)(8) (11)
Zhu[27]	China	2	VATS	ESPB(24): 20 mL of 0.5% ropivacaine PVB(25): 20 mL of 0.5% ropivacaine	A PCIA and then diclofenac sodium or acetaminophen was given	(2)(8)(9) (10)(11)
Duran[28]	Turkey	2	Thoracotomy	ESPB(23): 20 mL of 0.5% bupivacaine at T4 level PVB(22): 20 mL of 0.5% bupivacaine at T4 level	A morphine PCIA and paracetamol 1 g was given if NRS ≥ 4	(1)(3)(4)(8)
Fang[29]	China	2	Thoracotomy	ESPB(45): 20 mL of 0.25% bupivacaine PVB(46): 20 mL of 0.25% bupivacaine	A sufentanil PCIA	(11)
Das[30]	India	2	Thoracotomy	ESPB(30):30 mL of local anesthetic mixture (bupivacaine 0.5% and 2% lignocaine with adrenaline 1:1,00,000) were injected at T5 TPVB(28):30 mL of local anesthetic mixture (bupivacaine 0.5% and 2% lignocaine with adrenaline 1:1,00,000) were injected at T5	IV fentanyl	(1)(3)(4)(8) (9)
Xu[31]	China	2	Nuss	ESPB(34):0.25% ropivacaine (0.5 mL/kg) TPVB(34):0.25% ropivacaine (0.5 mL/kg)	Oral acetaminophen 15 mg/kg every 6 h and then a sufentanil PCIA	(8)(9)(10) (11)
Jayakrishnan[32]	India	1	MRM	ESPB(30): 20 mL of 0.25% bupivacaine at T5 level PVB(30): 20 mL of 0.25% bupivacaine at T5 level	A morphine PCIA	(1)(3)(4)(8) (10)
Agarwal[33]	India	2	MRM	ESPB(40): 20 mL of 0.5% ropivacaine at T5 level PVB(40): 20 mL of 0.5% ropivacaine at T4 level	Paracetamol 20 mg/kg was given every 6 h and then diclofenac 1.5 mg/kg was given if NRS >4	(9)

(*Continued*)

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Table 1 (Continued).

Author	Country	Blinding	Types of Surgery	Comparison (n)	Postoperative Analgesic Regimen	Outcomes
El[34]	Egypt	2	MRM	ESPB(35): 20 mL of 0.25% bupivacaine at T5 level PVB(35): 20 mL of 0.25% bupivacaine at T5 level	IV morphine 0.1 mg/kg if VAS ≧ 4	(8)(9)(11)
Sivrikoz[35]	Turkey	2	MRM	ESPB(42):20 mL 0.375% bupivacaine at T4 TPVB(41):20 mL 0.375% bupivacaine at T4	A morphine PCIA and IV tramadol 0.5 mg/kg if NRS≥4	(1)(3)(4)(5) (6)(7)(8)
Elewa[36]	Egypt	2	MRM	ESPB(30):30 mL of 0.25% bupivacaine TPVB(30):30 mL of 0.25% bupivacaine	A morphine PCIA	(3)(8)(9) (11)
Moustafa[37]	Egypt	NR	MRM	ESPB(45): 20 mL of 0.25% bupivacaine at T4 level PVB(45): 20 mL of 0.25% bupivacaine at T4 level	IV morphine if VAS ≧ 4	(8)(9)
Sayed[38]	Egypt	2	MRM	ESPB(20):T4–T5 level, 20 mL of 0.5% bupivacaine TPVB(20):T4, 20 mL of 0.5% bupivacaine	IV nalbuphine 0.1 mg/kg if NRS ≥ 4	(1)(3)(4)(8) (9)
Amr[39]	Egypt	2	MRM	ESPB(35):20 mL of 0.25% bupivacaine at the level of T4 TPVB(35):20 mL of 0.25% bupivacaine at the level of T2, T4, T6	A morphine PCIA	(1)(3)(4)(5) (6)(7)(8)(9) (11)
Gürkan[40]	Turkey	2	MRM, breast conserving surgery, simple mastectomy	ESPB(25):20 mL 0.25% bupivacaine TPVB(25):20 mL 0.25% bupivacaine at T4 level	Paracetamol 1 mg was given for every 6 h and then a morphine PCIA	(1)(3)(4)(8) (11)
Santonastaso[41]	Italy	NR	RADICAL mastectomy	ESPB(41):T2 and T5 levels, each level 12 mL of 0.5% ropivacaine TPVB(41):T2 and T4 levels, each level 8 mL of 0.75% ropivacaine	IV Ketorolac 30 mg if NRS ≧ 4 and then IV morphine 2 mg if NRS persists exceeded 3	(1)(10)(11)
Wittayapairoj[42]	Thailand	2	Breast surgery	ESPB(22): 20 mL of 0.5% levobupivacaine at T4 level PVB(22): 20 mL of 0.5% levobupivacaine at T4 level	Oral acetaminophen 1g every 6 h and then IV morphine 2 mg on-demand or NRS > 3	(8)(9)
But[43]	Poland	1	Breast surgery	ESPB(24): 10 mL of 2% lidocaine with 10 mL of 0.5% bupivacaine at T5 level PVB(30): 10 mL of 2% lidocaine with 10 mL of 0.5% bupivacaine at T4 level	A morphine PCIA	(1)(3)(4)(5) (6)(7)(8)
Hu[44]	China	NR	Radical mastectomy	ESPB(52): 30 mL of 0.25% ropivacaine at T5 level PVB(52): 0.4 mL/kg 0.5% ropivacaine at T5 level	A dezocine plus sufentanil PCIA	(1)(3)(4)(5) (6)(7)(10) (11)
Swisher[45]	USA	2	Non-mastectomy breast surgery	ESPB(50): 0.5% ropivacaine with 1:400000 of epinephrine, 20mL for unilateral surgery or 16mL on each side for bilateral surgery TPVB(50): 0.5% ropivacaine with 1:400000 of epinephrine, 20mL for unilateral surgery or 16mL on each side for bilateral surgery	IV oxycodone	(8)
Yılmaz[46]	Turkey	NR	Laparoscopic cholecystectomy	ESPB(30):20 mL of 0.25% bupivacaine TPVB(30):20 mL of 0.25% bupivacaine	A tramadol PCIA and then IV morphine 1 mg if VAS ≧ 4 within 30 min	(8)

Yang[47]	China	2	Laparoscopic sleeve gastrectomy	ESPB(54):T8, 40 mL of 0.33% ropivacaine TPVB(53):T8, 40 mL of 0.33% ropivacaine	A flurbiprofen plus oxycodone PCIA	(1)(2)(3)(4)(5)(6)(7)
Xu[48]	China	2	Laparoscopic nephroureterectomy	ESPB(83):0.4 mL/kg ropivacaine 0.375% TPVB(83):0.4 mL/kg ropivacaine 0.375%	A sufentanil PCIA and then oxycodone or non-steroidal anti-inflammatory drugs were given if VAS > 3	(2)(8)(9)(10)
Fan[49]	China	2	Laparoscopic nephrectomy	ESPB(30):25 mL 0.5% ropivacaine TPVB(31):25 mL 0.5% ropivacaine	A hydromorphone PCIA and then flurbiprofen axetil 50 mg was given if VAS > 3	(1)(2)(3)(4)(5)(6)(7)(9)(10)(11)
Gs[50]	India	2	Percutaneous Nephrolithotomy	ESPB(25): 25 mL of 0.25% levobupivacaine at T8 level PVB(25): 25 mL of 0.25% levobupivacaine at T8 level	IV paracetamol 1 g if NRS ≥ 4	(1)(3)(4)(9)
Khot[51]	India	2	Percutaneous Nephrolithotomy	ESPB(30): 20 mL of 0.25% bupivacaine at T10 level PVB(30): 20 mL of 0.25% bupivacaine at T10 level	IV tramadol 50mg every 12 h and then IV paracetamol 1 g or diclofenac 75 mg if NRS≥4	(9)
Elsayed[52]	Egypt	2	Pelvi-ureteric surgeries	ESPB(30): 20 mL of 0.25% bupivacaine at T8 level PVB(30): 20 mL of 0.25% bupivacaine at T8 level	IV morphine 3 mg if NRS ≥ 4	(1)(3)(4)(8)(9)(11)

Abbreviations: NR, not reported; MRM, Modified radical mastectomy; VATS, video-assisted thoracoscopic surgery; PCIA, patient-controlled intravenous analgesia; ESPB, erector spinae plane block; PVB, paravertebral block. (1) resting VAS at 6 h. (2) QoR, quality of recovery. (3) resting VAS at 12 h. (4) resting VAS at 24 h. (5) movement VAS at 6 h. (6) movement VAS at 12 h. (7) movement VAS at 24 h. (8) total morphine consumption in first 24h postoperative (intravenous morphine equivalent, mg). (9) time of first rescue analgesia (h). (10) LOS, length of hospital stay (days). (11) PONV, postoperative nausea and vomiting.

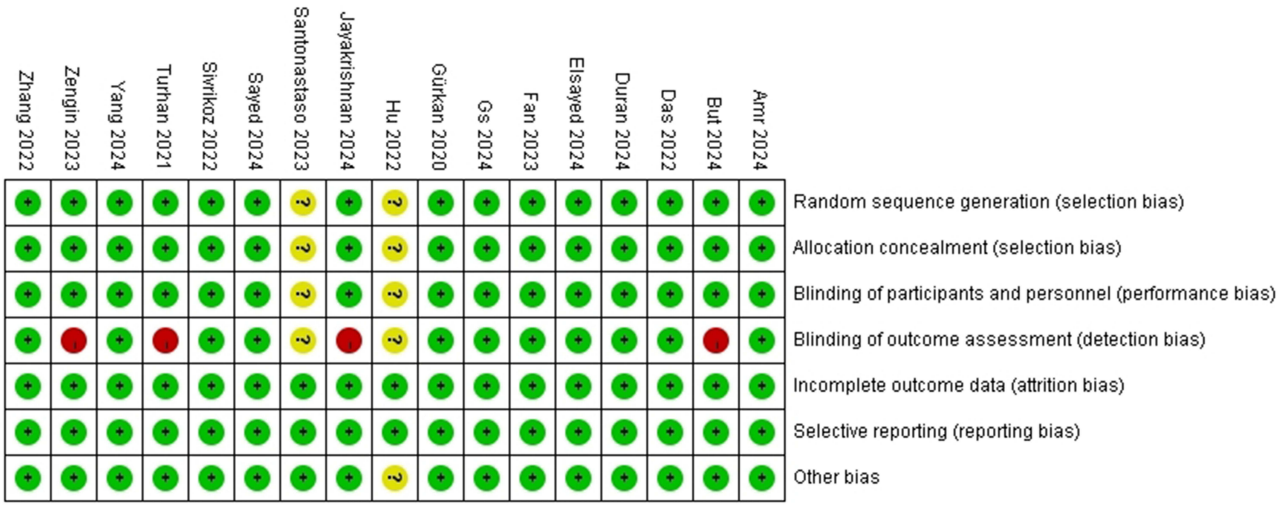

Figure 2 Risk of bias of resting VAS at 6 h. Data from these studies - Amr 2024.[39] But 2024,[43] Das 2022,[30] Duran 2024,[28] Elsayed 2024,[52] Fan 2023,[49] Gs 2024,[50] Gürkan 2020,[40] Hu 2022,[44] Jayakrishnan 2024,[32] Santonastaso 2023,[41] Sayed 2024,[38] Sivrikoz 2022,[35] Turhan 2021,[21] Yang 2024,[47] Zengin 2023,[24] Zhang 2022.[26]

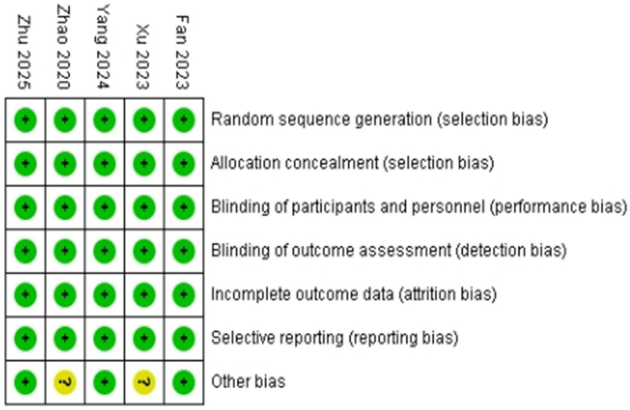

Figure 3 Risk of bias of QoR.
Notes: Data from these studies - Fan 2023,[49] Xu 2023,[48] Yang 2024,[47] Zhao 2020,[20] Zhu 2025.[27]

Total Morphine Consumption in First 24 h (Mg)

The pooled data of twenty-four studies suggested that PVB had a lower morphine consumption than ESPB (MD = 0.23, 95% CI: 0.13 to 0.33; I^2 = 85.2%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, and abdominal surgery. However, there was no significant difference in kidney surgery (Supplementary material: Figure 6).

Time of First Rescue Analgesia (h)

The pooled data of seventeen studies did not suggest that PVB was superior to ESPB (MD = 0.04, 95% CI: −0.11 to 0.19; I^2 = 86.1%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 7).

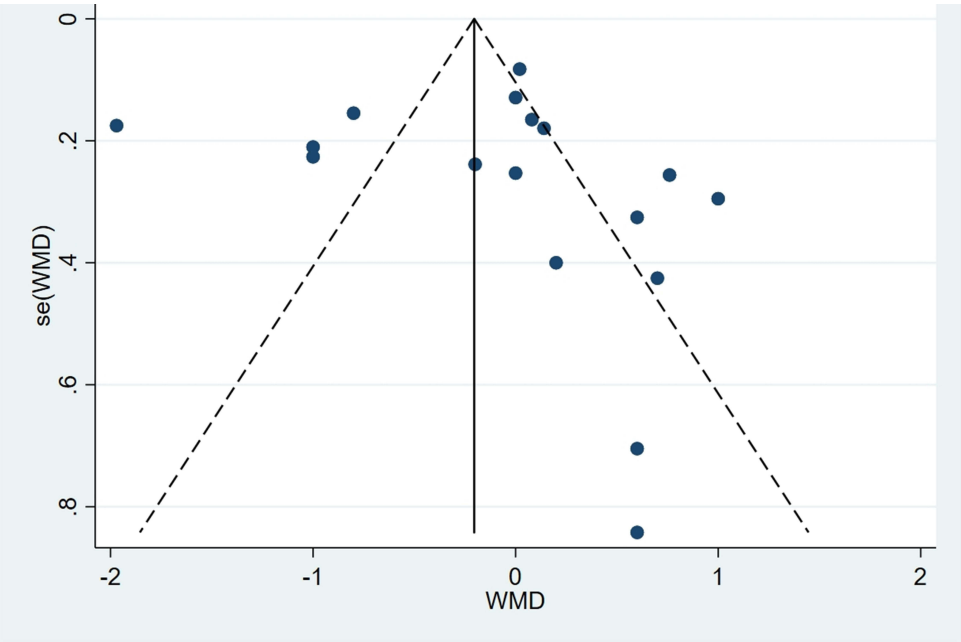

Figure 4 Funnel plot of resting VAS at 6 h.
Abbreviation: WMD, weighted mean difference.

Length of Stay Hospital (d)

The pooled data of ten studies did not suggest that PVB was superior to ESPB (MD = −0.05, 95% CI: −0.16 to 0.06; I^2 = 46.6%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 8).

PONV

The pooled data of sixteen studies did not suggest that PVB was superior to ESPB (RR = 0.92, 95% CI: 0.69 to 1.23; I^2 = 0%; Table 2). The subgroup analysis showed the similar effects in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery (Supplementary material: Figure 9).

Discussion

Our meta-analysis demonstrated that PVB was not significantly better than ESPB in the primary outcomes, including resting VAS at 6 h and QoR. The similar results were shown in the secondary outcome, including other VAS, time of first rescue analgesia, LOS, and the incidence of PONV. The subgroup analysis showed similar results in thoracic surgery, breast surgery, kidney surgery, and abdominal surgery. Although there were slight differences in some outcomes, these effect sizes could not be considered as having clinical differences. Meanwhile, the degree of elevation in movement VAS markedly exceeded that of resting VAS within 12–24 hours postoperatively. This indicated a rising trend in inflammatory pain and visceral pain during this period, while nerve blockade appeared to have no inhibitory effect on these nociceptive modalities. For breast surgery, many meta-analysis also showed that there was no significant clinical difference between ESPB and PVB, and suggesting that the operation of ESPB was easier and safer.[53–55] For thoracic surgery, however, the existing meta-analyses did not show consistent results. Xiong et al found the analgesic effect of PVB was better than ESPB for thoracic surgery.[56] Capuano et al found ESPB was a safer technique than PVB and they had similar analgesic effects after thoracic surgery.[57] Pang et al found two techniques had similar pain scores within 6 h and incidence of PONV after thoracic surgery, but PVB reduced pain scores at 12 h (SMD = 1.12; 95% CI 0.42 to 1.81) and postoperative

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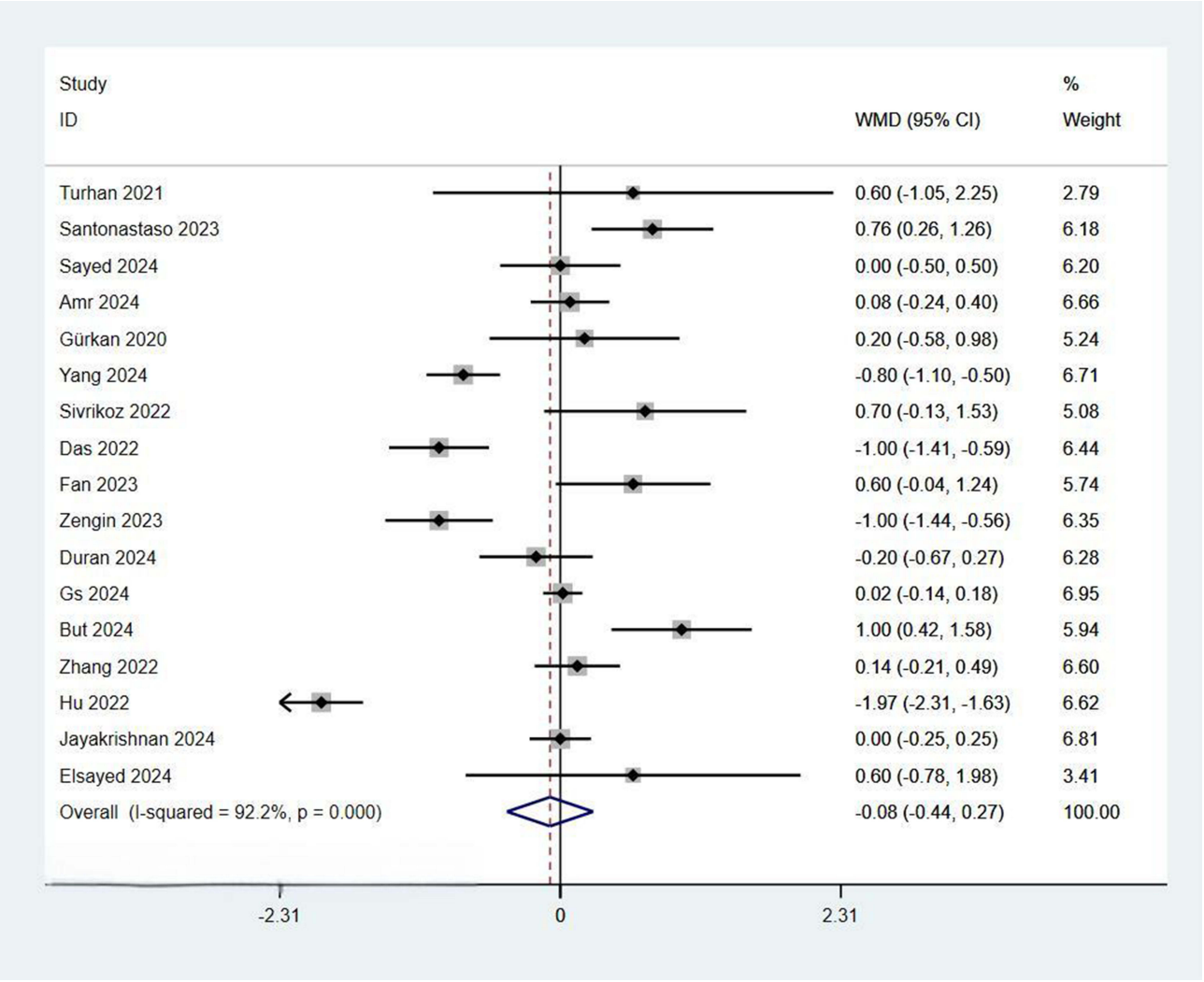

Figure 5 Forest plot of resting VAS at 6 h.
Notes: Weights are from random effects analysis. Turhan 2021,[21] Santonastaso 2023,[41] Sayed 2024,[38] Amr 2024,[39] Gürkan 2020,[40] Yang 2024,[47] Sivrikoz 2022,[35] Das 2022,[30] Fan 2023,[49] Zengin 2023,[24] Duran 2024,[28] Gs 2024,[50] But 2024,[43] Zhang 2022,[26] Hu 2022,[44] Jayakrishnan 2024,[32] Elsayed 2024.[52]
Abbreviation: WMD, weighted mean difference.

anesthesia consumption (SMD = 1.27; 95% CI 0.30 to 2.23).[58] A recent network meta-analysis suggested that ESPB was more effective and safer technique for analgesia after thoracic surgery, shortening the LOS and reducing the complications.[59] These inconsistent conclusions required us to interpret the results with caution. Currently, there was limited meta-analysis on kidney surgery and abdominal surgery.

For thoracic surgery, these inconsistent conclusions could be explained by next reasons. Firstly, there were baseline differences among the populations undergoing thoracic surgery, which include variations in patients' pain tolerance, the presence of chronic pain, and the extent of surgical resection. Secondly, there were inherent discrepancies in regional anesthesia techniques, including the types and dosages of LAs, the locations of needle insertion, the timing of drug administration (whether preoperative or postoperative), and the potential use of adjuncts. These two factors represented intrinsic limitations of our meta-analysis, as it is unlikely that the subjects and experimental designs would be identical across the two RCTs. Furthermore, there was considerable variability in postoperative analgesic protocols, including the

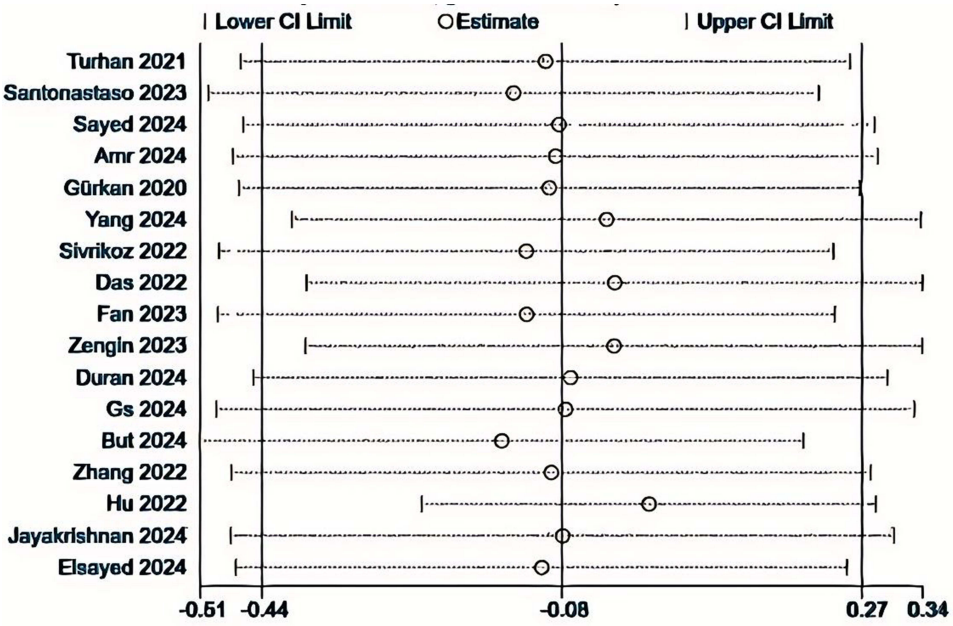

Figure 6 Sensitivity analysis of resting VAS at 6 h. Turhan 2021,[21] Santonastaso 2023,[41] Sayed 2024,[38] Amr 2024,[39] Gürkan 2020,[40] Yang 2024,[47] Sivrikoz 2022,[35] Das 2022,[30] Fan 2023,[49] Zengin 2023,[24] Duran 2024,[28] Gs 2024,[50] But 2024,[43] Zhang 2022,[26] Hu 2022,[44] Jayakrishnan 2024,[32] Elsayed 2024.[52]

types and dosages of baseline and rescue analgesics. This variability might be a primary contributor to the inconsistent conclusions observed and could also be a major source of heterogeneity in the results.

Patients undergoing thoracoscopic surgery may experience pain originating from thoracic incisional trauma, pleural irritation, inflammation of intercostal muscles, and manipulation of surrounding tissues.[60] In the case of breast surgery, pain sources typically include surgical trauma to the breast tissue and surrounding structures.[61] In laparoscopic surgery, sources of pain predominantly include incisional pain and visceral pain related to organ resection.[62] Additionally, the potential neuropathic pain stemming from nerve damage during dissection and complications such as seroma or infection may contribute to prolonged pain experiences.[63] The reason that ESPB and PVB can alleviate pain from the aforementioned surgeries lies in their unique mechanisms of action. The analgesic effect of ESPB is primarily attributed to the blockade of the dorsal rami of spinal nerves.[64] By injecting LAs into the plane between the erector spinae muscle and the transverse processes of the vertebrae, the block eases pain by inhibiting nociceptive signals from the thoracic and abdominal structures.[64] Other researches suggest that the spread of anesthetics can reach the anterior paravertebral space and the intercostal nerves.[65–67] The analgesic effect of PVB is primarily attributed to the blockade of spinal nerve roots and sympathetic nerves.[4] By injecting LAs into the paravertebral space, the afferent sensory pathways leading to the central nervous system are interrupted, effectively reducing nociceptive transmission.[4] This mechanism not only diminishes pain perception but also provides a sympathetic block, contributing to decreased intraoperative stress responses.[4]

ESPB is increasingly recognized for its role in perioperative analgesia, providing effective pain relief while minimizing opioid consumption and associated side effects, which makes it an important consideration in the multimodal management of postoperative pain. LAs such as bupivacaine, ropivacaine, and levobupivacaine are commonly employed in ESPB. Typical dosages range from 0.25% to 0.5% bupivacaine, with volumes between 15 and 30 mL per side, depending on the surgical procedure and patient factors. The addition of adjuvants such as dexmedetomidine or dexamethasone can enhance the duration and quality of analgesia by prolonging the action of LAs.[68] ESPB provides unilateral sensory coverage primarily across the dermatomes corresponding to the thoracic and upper abdominal areas.[3]

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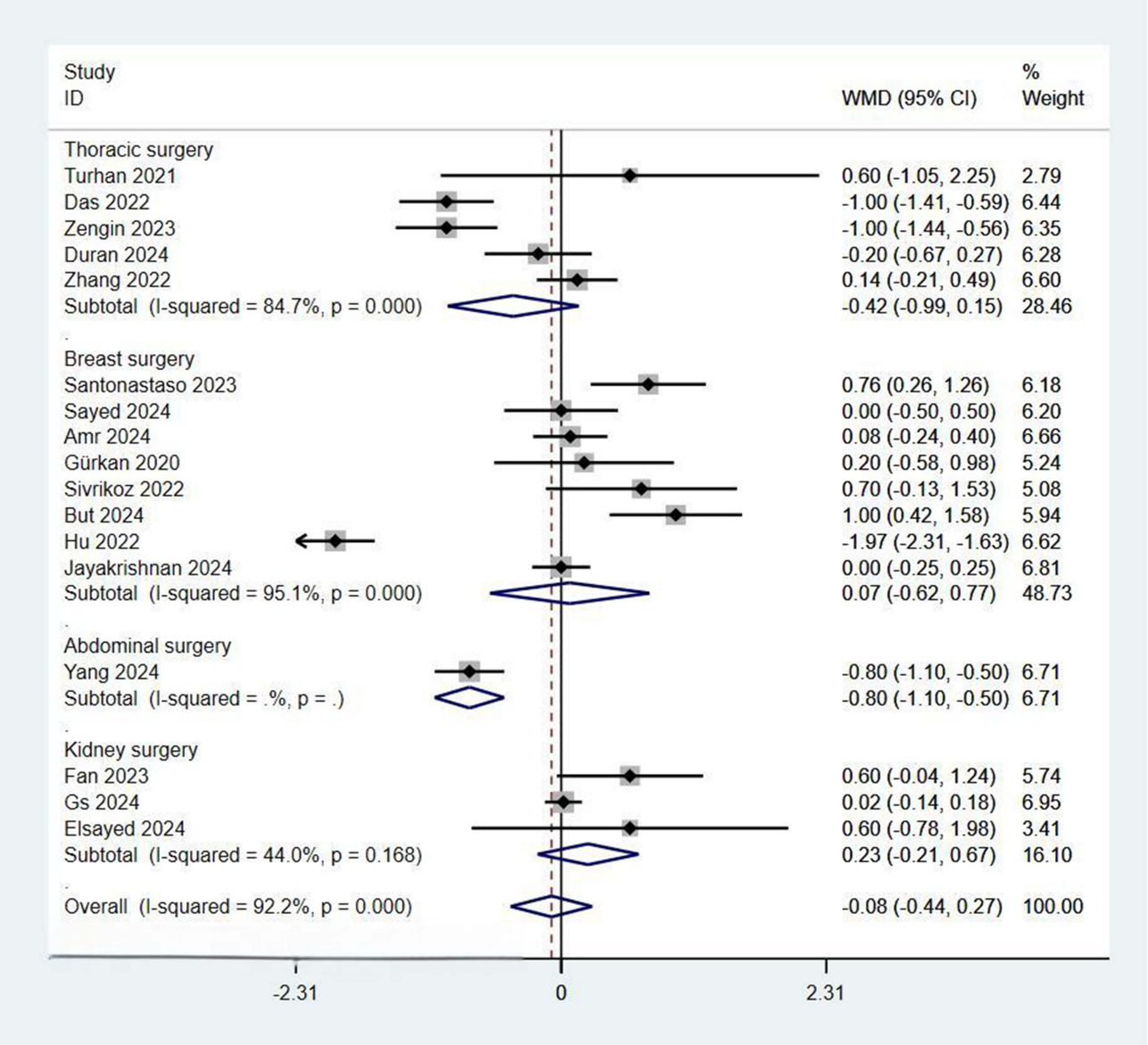

Figure 7 Subgroup analysis of resting VAS at 6 h.
Notes: Weights are from random effects analysis. Turhan 2021,[21] Das 2022,[30] Zengin 2023,[24] Duran 2024,[28] Zhang 2022,[26] Santonastaso 2023,[41] Sayed 2024,[38] Amr 2024,[39] Gürkan 2020,[40] Sivrikoz 2022,[35] But 2024,[43] Hu 2022,[44] Jayakrishnan 2024,[32] Yang 2024,[47] Fan 2023,[49] Gs 2024,[50] Elsayed 2024.[52]
Abbreviation: WMD, weighted mean difference.

This targeted coverage helps alleviate pain from surgical sites while preserving motor function, crucial for early mobilization after surgery.[3] The ESPB is generally regarded as easier to perform, often taking about 5 to 10 minutes per side.[51] It has a relatively lower risk of complications, such as pneumothorax or inadvertent vascular puncture, due to the injection being executed in a more superficial plane.[3] The fewer anatomical structures involved in the ESPB technique simplify the learning curve for clinicians, making it an attractive option for practitioners of varying skill levels.

The PVB typically provides unilateral sensory coverage, impacting dermatomes corresponding to the levels of blockade.[2] A well-placed injection can cover multiple dermatomes, with the ability to extend from T2 to L3.[69,70] A single injection of 10 mL LAs can provide sensory coverage of at least two segments.[71] The PVB can be more time-consuming, often taking 10

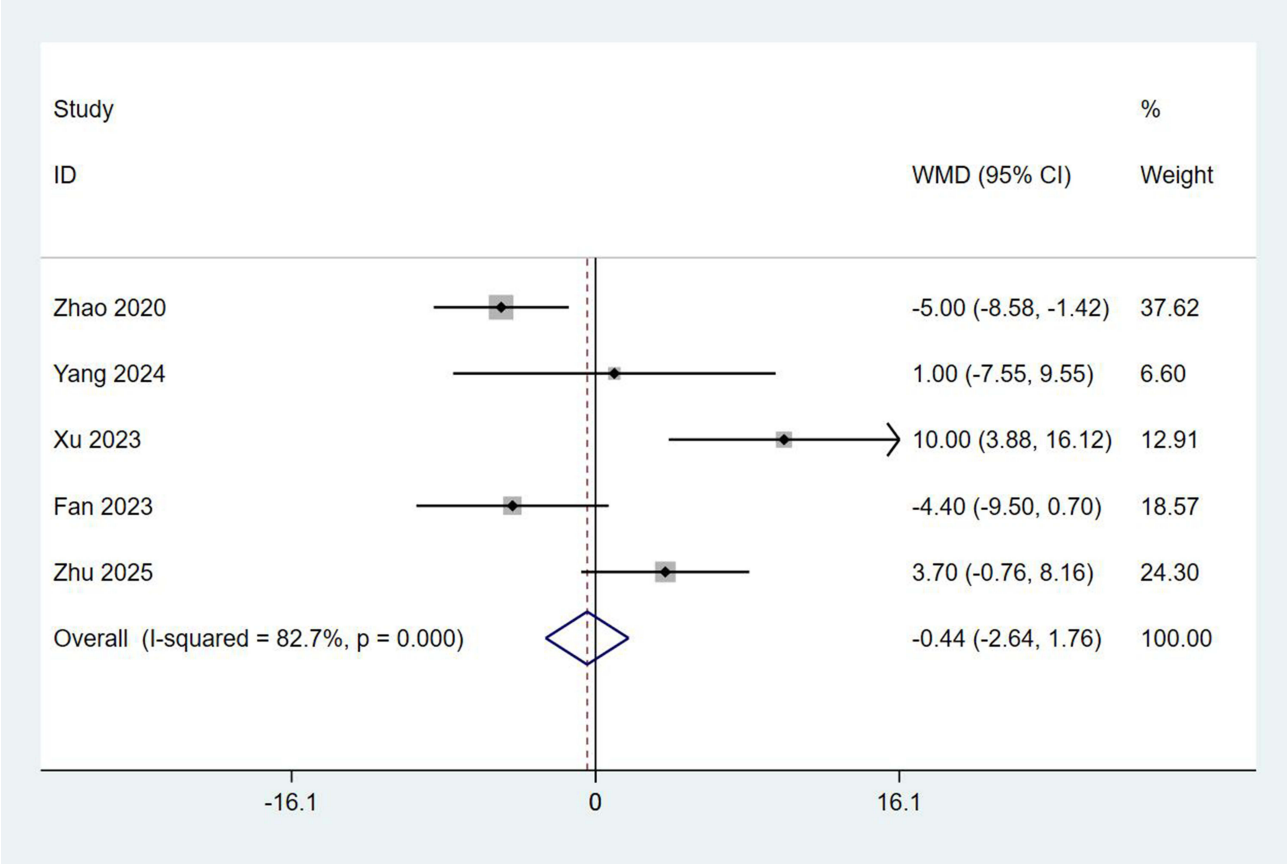

Figure 8 Forest plot of QoR. Zhao 2020.[20] Yang 2024,[47] Xu 2023,[48] Fan 2023,[49] Zhu 2025.[27]
Abbreviation: WMD, weighted mean difference.

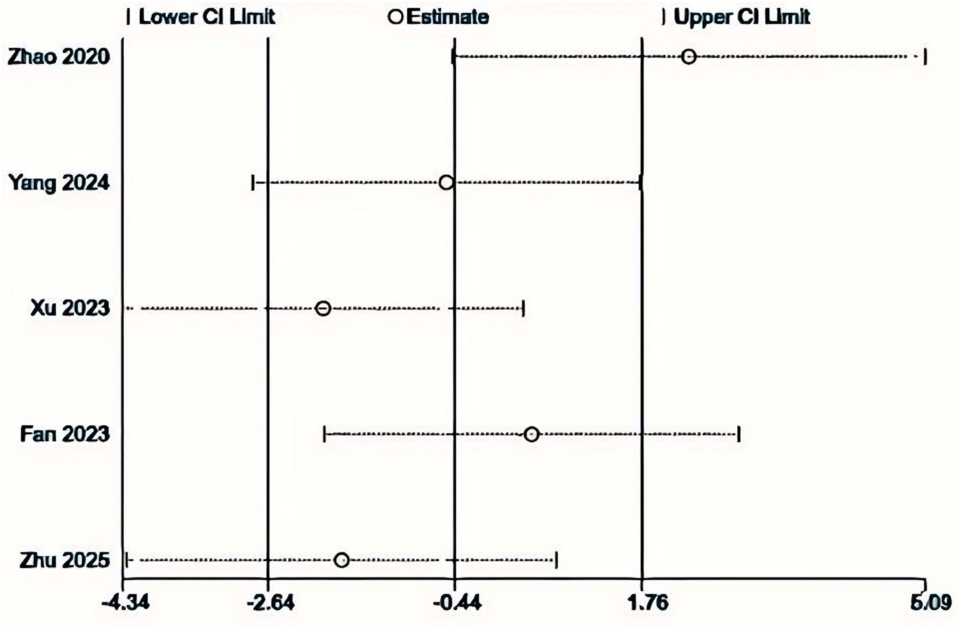

Figure 9 Sensitivity analysis of QoR. Zhao 2020.[20] Yang 2024,[47] Xu 2023,[48] Fan 2023,[49] Zhu 2025.[27]

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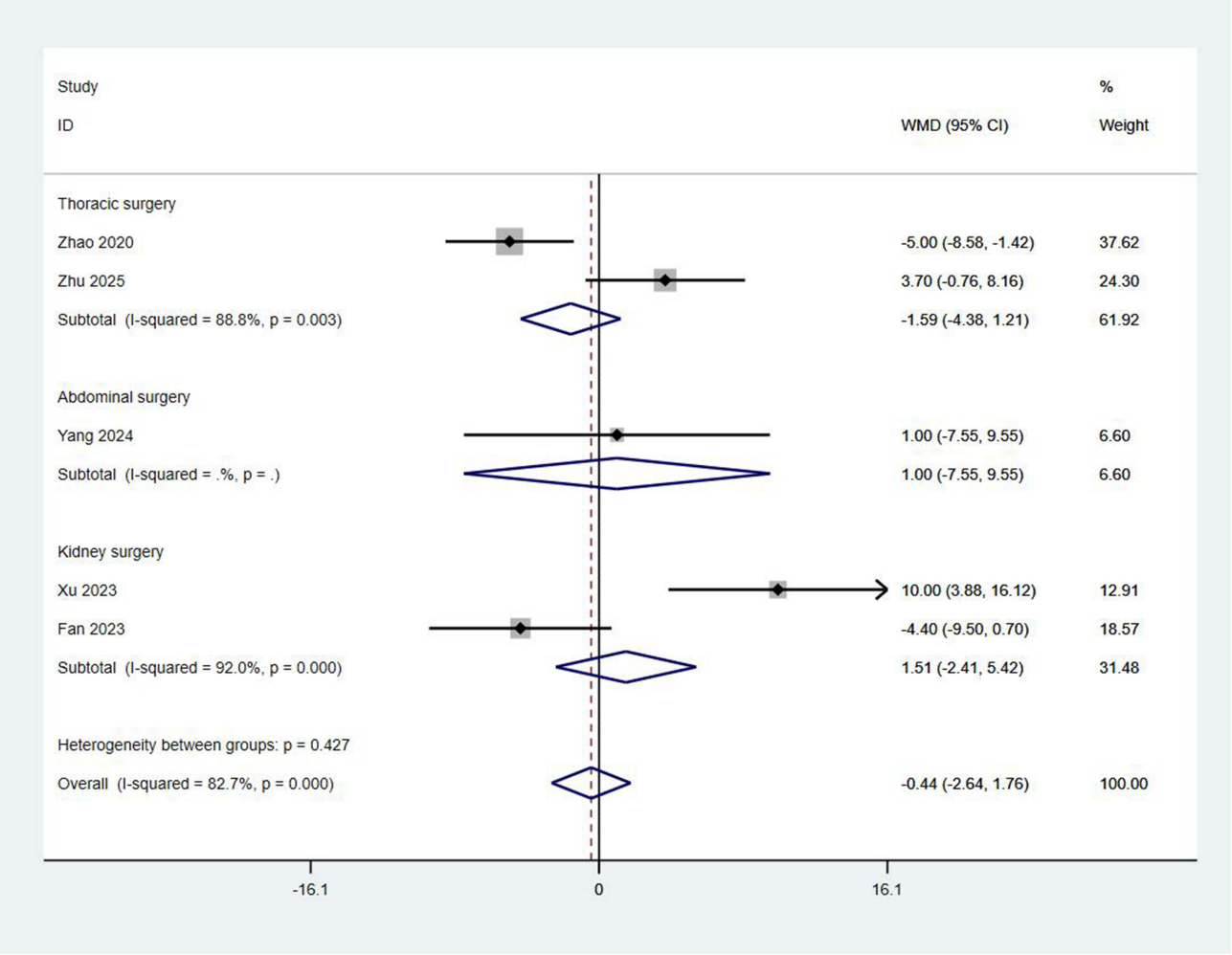

Figure 10 Subgroup analysis of QoR. Zhao 2020.[20] Zhu 2025,[27] Yang 2024,[47] Xu 2023,[48] Fan 2023.[49]
Abbreviation: WMD, weighted mean difference.

to 15 minutes or longer, particularly for multi-level blocks.[42] Identifying specific vertebral levels and accurately placing the needle in the paravertebral space requires a higher level of skill and experience. The complex anatomy of the paravertebral area, along with the need to confirm correct needle placement, can extend the procedure time. While ultrasound-guided PVB is generally considered safe, potential complications may arise, including pneumothorax, hematoma, and neural injury.[2]

Table 2 Secondary Outcomes for ESPB versus PVB

Outcome	Patients (Trails)	Effect Size	95% CI	I^2	*p* Value	Certainty (GRADE)
Resting VAS at 12 h	1066(17)	MD −0.15	−0.27, −0.02	87.1%	<0.001	⊕⊕⊕◯ moderate
Resting VAS at 24 h	1072(17)	MD −0.03	−0.15, 0.09	79.6%	<0.001	⊕⊕⊕◯ moderate
Movement VAS at 6 h	643(9)	MD −0.11	−0.25, 0.03	94.1%	<0.001	⊕⊕⊕◯ moderate
Movement VAS at 12 h	643(9)	MD −0.09	−0.23, 0.06	96.2%	<0.001	⊕⊕⊕◯ moderate
Movement VAS at 24 h	709(10)	MD −0.00	−0.14, 0.13	89.1%	<0.001	⊕⊕⊕◯ moderate
Morphine consumption	1547(24)	MD 0.23	0.13, 0.33	85.2%	<0.001	⊕⊕◯◯ low
Time of first rescue analgesia	1166(17)	MD 0.04	−0.11, 0.19	86.1%	<0.001	⊕⊕◯◯ low
LOS	800(10)	MD −0.05	−0.16, 0.06	46.6%	0.051	⊕⊕⊕◯ moderate
PONV	1043(16)	RR 0.92	0.69, 1.23	0%	0.65	⊕⊕⊕◯ moderate

Abbreviations: ESPB, erector spinae plane block; PVB, paravertebral block; LOS, length of hospital stay (d). PONV, postoperative nausea and vomiting; MD, mean difference; CI, confidence interval.

Limitations

Our meta-analysis had several potential limitations. Firstly, as the included studies did not provide sufficient data, we did not evaluate the success rate, onset time and range of sensory blockade. Secondly, the included studies exhibited considerable variability in postoperative analgesia protocols. This increased the heterogeneity of the results and complicated direct comparisons between the PVB and ESPB. Thirdly, we made subgroup analysis for every outcome, but it was not ignored that the discrepancies in the implementation of both PVB and ESPB, including differences in the volume of LAs, the number of injection sites, and the specific techniques employed. These variations might impact the overall effectiveness and applicability of the findings. Additionally, some subgroup analyses include only a single study, so we need to interpret the results with caution. Fourthly, our study focused on short-term postoperative outcomes, such as pain relief and recovery within 24 hour. There was a lack of data on long-term analgesia and functional outcomes, which may be important for assessing the overall effectiveness of each block.

Conclusions

Our systematic review and meta-analysis suggested that ESPB and PVB provided similar effectiveness for analgesia and recovery. The ESPB was favored for its quicker execution time and greater ease of using, particularly for those less experienced in regional anesthesia. Further, high-quality, multicenter RCTs were needed to determine the long-term effectiveness of PVB and ESPB.

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Disclosure

The authors declare that they have no competing interests.

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