BMC Anesthesiology

SYSTEMATIC REVIEW

Open Access

Erector spinae plane block for laparoscopic surgeries: a systematic review and meta-analysis

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Abstract

Background Erector spinae plane block (ESPB) is a novel analgesic technique that can reduce post-operative pain and postoperative opioid consumption in laparoscopic surgeries.

Methods We searched PubMed, Scopus, and Web of Science on November 17th, 2023 for clinical trials comparing ESPB with other analgesic techniques or placebo for laparoscopic surgeries. We meta-analyzed post-operative pain at rest, postoperative opioid consumption, time to first rescue analgesic request, and postoperative nausea and vomiting using a random effects model.

Results ESPB significantly reduced opioid consumption compared to placebo (SMD, (95CI), *p*-value; -1.837, (-2.331, -1.343), < 0.001) and also compared to transversus abdominis plane block (TAPB) (SMD, (95CI), *p*-value; -1.351, (-1.815, -0.887), < 0.001) but not quadratus lumborum plane block (QLB) (SMD, (95CI), *p*-value; 0.022, (-0.241, 0.286), 0.869). ESPB also significantly reduced participant-reported pain scores at rest at 24h post-operation compared to placebo (SMD, (95CI), *p*-value; -0.612, (-0.797, -0.428), < 0.001) and TAPB (SMD, (95CI), *p*-value; -0.465, (-0.767, -0.162), < 0.001), however, there was a significant increase in pain score compared to QLB (SMD, (95CI), *p*-value; 1.025, 0.156, 1.894), 0.021). A statistically significant increase in time to first rescue analgesic in ESPB groups compared to placebo and TAPB groups was observed in our meta-analysis. There was a lower post-operative nausea and vomiting rate in the ESPB groups compared to placebo groups, yet a comparable rate with QLB and TAPB groups was observed in the meta-analysis.

Conclusion ESPB is an effective and safe analgesic technique for managing post-operative pain and opioid consumption in laparoscopic surgeries compared to placebo, reducing postoperative nausea or vomiting as well. Compared to other techniques, ESPB has a similar efficacy to QLB, except for the pain score at 24 h post-operation, but appears to be superior to TAPB as an analgesic technique in laparoscopic surgeries, with a similar safety profile.

Trial registration Prospero registration ID: CRD42024508363.

Link: https://www.crd.york.ac.uk/PROSPERO/#recordDetails

Keywords Erector spinae block, Erector spinae plane block, Laparoscopic surgeries, Laparoscopy, Postoperative pain

Introduction

Laparoscopic surgery has gained popularity over the past decade due to smaller incisions, shorter periods of hospital stay, and decreased pain compared to conventional surgeries [1, 2]. However, postoperative pain remains a significant challenge, contributing to delayed discharges and lower patient satisfaction [3–5]. Opioids have been

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the main mode of post-operative analgesia but they are associated with several side effects including nausea, constipation, sedation, and respiratory depression [6, 7].

Several other methods including multimodal analgesia are used for postoperative analgesia in laparoscopic surgeries in order to reduce opioid consumption. Among the techniques included in multimodal analgesia, plane blocks have shown promise [8]. They consist of erector spinae plane block (ESPB), transversus abdominis plane block (TAPB), quadratus lumborum plane block (QLB), and other techniques as well [9, 10].

ESPB was initially elucidated by Forero et al. as an innovative approach to thoracic analgesia and consists of the ultrasound-guided injection of anesthetics into the fascial plane between the tips of the vertebral transverse processes and erector spinae muscle [11]. ESPB has become more popular in recent years, due to its heightened analgesic efficacy and reduced side effects and other complications compared to other techniques [12, 13]. It inhibits the function of the spinal nerves' dorsal and ventral branches and permeates the interfacial plane, enabling its dispersion in the cranial and caudal directions [14] and a resultant somatic and visceral analgesia [15].

With this in mind, we aim to synthesize all evidence regarding the analgesic efficacy and safety of ESPB in laparoscopic surgeries. To do so we will compare post-operative opioid consumption, pain scores at rest, time to first rescue analgesic, and postoperative nausea and vomiting in ESPB arms of randomized controlled trials compared to placebo, QLB, TAPB, and other analgesic arms.

Methods

This systematic review and meta-analysis was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16]. The protocol for this systematic review was prospectively submitted to the International Prospective Register of Systematic Reviews (PROSPERO, registration ID: CRD42024508363).

Search strategy

We searched Pubmed, Scopus, and Web of Science on November 17th, 2023 with keywords and MeSH terms synonymous to "erector spinae block" and "laparoscopy". No publication date or language limitations were used.

Study selection

Studies were included if they met the following PICOS inclusion criteria:

> Participants: patients who have undergone a type of laparoscopic surgery. Pediatric populations were excluded.
>
> Intervention: Erector Spinae Plane Block. Studies involving the continuous administration of analgesic through the Erector spinae plane were excluded.
>
> Comparator: Placebo and/or any kind of analgesic technique including other fascial plane blocks and/or intrathecal morphine.
>
> Outcomes: Cumulative opioid consumption 24 h post-operation, and/or participant reported pain scores at rest within 24 h after the operation, and/or time to first rescue analgesic, and/or incidence of postoperative nausea or vomiting. Studies that did not report any of the following outcomes — pain scores, postoperative opioid consumption, or time to first rescue analgesic — were excluded.
>
> Study design: Only randomized clinical trials (RCTs) were included in this systematic review. Any observational studies were excluded.

Articles were screened by two independent reviewers. Screening had two phases, title and abstract screening followed by full text evaluation. Inconsistencies were resolved by a third reviewer.

Data extraction

Relevant data from the selected articles was extracted by two independent reviewers under the supervision of a third reviewer. The following data were extracted from the included studies: author, year of publication, country, total participants, ESPB group participants, comparator group participants, type of comparator, type of laparoscopic surgery, ESPB details (dosage, drug, block level), timing of ESPB (preoperative (pre-induction, post-induction), postoperative), age and gender of participants, pain measurement scale (visual analogue scale or numerical rating scale) and type of opioid used post operation.

Outcomes

Cumulative opioid consumption 24 h post-operation, participant reported pain scores during rest within 24 h post-operation, post-operative nausea or vomiting (PONV), and time to first rescue analgesia were chosen as the outcomes for our review.

Quality assessment

Two independent reviewers assessed the risk of bias in the included studies, with a third reviewer consulted to resolve any discrepancies, using the Cochrane Risk of Bias 2 (RoB 2) tool [17]. This tool examines five domains that could influence the results of randomized controlled trials, including bias from the randomization process, deviations from the intended intervention, missing outcome data, outcome measurement, and the selection of reported results. Each domain was rated as having a

"High," "Some concerns," or "Low" risk of bias based on a series of signaling questions, with responses such as "yes," "probably yes," "probably no," "no," or "no information." A visual representation of the quality assessment for the included RCTs was created using the Risk Of Bias Visualization (ROBVIS) tool [18].

Certainty of Evidence

Confidence in the evidence was assessed using the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) approach. In the GRADE approach, the overall quality of evidence is categorized into one of four grades: high, moderate, low, and very low certainty that the observed true effect lies close to our estimated effect [19].

Randomized studies start off with a high level of evidence. Depending on a number of factors, this may be downgraded or upgraded. The factors that lower the level of evidence include the risk of bias, inconsistency, indirectness, imprecision, and publication bias. Factors that might upgrade the level of evidence include large effect, where all plausible confounders reduce the observed effect, and a dose–response gradient.

Statistical analysis

Meta-analysis of all four outcomes was conducted using the Comprehensive Meta-Analysis software (CMA, version 3, NJ, USA) with means and standard deviations being used as data entry forms for post-operation opioid consumption, participant reported pain scores, and time to first rescue analgesic. For these three outcomes Standardized mean difference (SMD) was chosen as the effect size. SMD was chosen over the mean difference due to variability in pain scores, the scales used to measure them, and differences in the types of opioids and rescue analgesics used across studies. The mean difference could not be applied because the pain scores were reported using different scales [20]. Number of events were used as data entry forms regarding post-operative nausea or vomiting and risk ratio (RR) was chosen as the effects size. The random-effects model was utilized due to variations in the studies, including differences in pain measurement methods, postoperative pain control techniques, and the types of surgeries. Heterogeneity was assessed using the I^2 statistic, with an $I^2 > 50\%$ signifying substantial heterogeneity [21]. Meta-regression was conducted to investigate heterogeneity based on the mean age of participants in the ESPB group and the level of ESPB. Medians and interquartile ranges were converted to means and standard deviations for the meta-analyses using Luo et al. and Wan et al.'s methods [22, 23]. A subgroup analysis based on time point and type of comparator was conducted. Sensitivity analysis was done using the leave-one out method and publication bias was assessed using Egger's regression test (p-value less than 0.05 as an indicative of significant publication bias) and funnel plot symmetry. Data from graphs was extracted using PlotDigitizer [24].

Results

Five hundred records were founded in initial search. After removing duplicates 281 records were chosen for title-abstract screening. 68 studies were selected for full text evaluation and 64 were successfully retrieved, of which 43 met our inclusion criteria and 21 were excluded (Fig. 1). The excluded studies were due to the following reasons: cohort study design, involvement of other types of surgeries (not laparoscopic), inclusion of pediatric populations, continuous administration of analgesics through the erector spinae plane, not reporting both pain scores and postoperative opioid consumption, being non-randomized trials, or being duplicates.

The characteristics of the included papers are available in Table 1. 26 RCTs compared ESPB with a placebo, 12 RCTs compared ESPB and TAPB, 5 RCTs compared ESPB and QLB, 2 RCTs compared ESPB and port-site infiltration, 2 RCTs compared ESPB and intrathecal morphine, 1 RCT compared ESPB with thoracic paravertebral block, 1 RCT compared ESPB with wound infiltration, and 1 RCT compared ESPB with retrolaminar block. Type of laparoscopic surgeries were as follows: 20 laparoscopic cholecystectomies, 6 laparoscopic bariatric surgeries, 4 laparoscopic hysterectomies, 3 laparoscopic

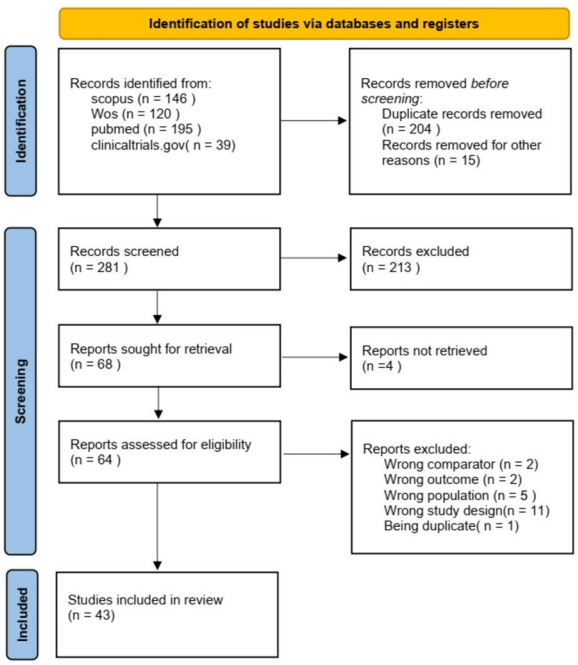

Fig. 1 PRISMA flow diagram

Table 1 Table of characteristics of included studies

Author, Year, Country	Age (mean), Male (%)	Type of laparoscopy	Total Participants	Pain assessment scale, Type of opioid used	ESPB regimen	Type of comparison	Timing of ESPB
Tulgar et al., 2018, Turkey [25]	ESPB = 26.7, 53.6 Placebo = 33, 50.4	Cholecystectomy	32	NRS, Tramadol	20 mL of 0.375% bupivacaine per side at the level of T9 transverse process	Placebo	pre-induction
Aksu et al., 2019, Turkey [26]	ESPB = 26.0, 49.2 Placebo = 30.4, 47.2	Cholecystectomy	46	NRS, Morphine	20 ml 0.25% bupivacaine per side at the level of T8 transverse process	Placebo	pre-induction
Altiparmak et al., 2019, Turkey [27]	ESPB = 52, 47.9 Placebo = 45, 45.9	Cholecystectomy	46	NRS, Tramadol	40 ml of 0.25% bupivacaine at the level of T7 transverse process	Placebo (Saline injection)	pre-induction
Altiparmak et al., 2019, Turkey [28]	ESPB = 51.1, 41.1 TAPB = 53.1, 32.3	Cholecystectomy	72	NRS, Tramadol	20 mL of 0.375% bupivacaine per side at the level of T7 transverse process	TAPB	post-induction
Kang et al., 2019, South Korea [29]	ESPB = 32.9, 44.4 ITM = 36.5, 74.0	Living donor hepatectomy	54	NRS, Fentanyl	20 mL 0.5% ropivacaine with 5 µg/mL epinephrine per side at the level of T8 transverse process	Intrathecal morphine	pre-induction
Abdelhamid et al., 2020, Egypt [30]	ESPB = 37.1, 31.8 TAPB = 35.9, 59.5 Placebo = 35.7, 54.5	Sleeve gastrectomy	66	VAS, Pethidine	bupivacaine (15 ml for each side) 30 ml of 0.25% at the level of T9 transverse process	TAPB and Placebo	preoperative
Aygun et al., 2020, Turkey [31]	ESPB = 51.1, NP QLB = 50.5, NP	Cholecystectomy	80	NRS, Morphine	30 mL of LA per side (30 mL Bupivacaine %0.5, 10 mL lidocaine %2 and 20 mL normal saline half to each side) at the level of T9 transverse process	QLB	post-induction
Ibrahim et al., 2020, Egypt [32]	ESPB = 36.6, 28.5 TAPB = 37.5, 33.3 Placebo = 38.2, 47.6	Cholecystectomy	63	VAS, Morphine	20 mL of 0.25% bupivacaine per side at the level of T8 transverse process	TAPB and Placebo (Saline injection)	post-induction
Verma et al., 2020, India [33]	ESPB = 41.8, 23.8 Placebo = 43.2, 38	Cholecystectomy	85	VAS, Fentanyl	20 mL of 0.375% ropivacaine per side at the level of T7 transverse process	Placebo (Saline injection)	post-induction
Garg et al., 2021, India [34]	ESPB = 34.9, 27.2 Placebo = 39.1, 36.3	Cholecystectomy	70	NRS, Tramadol	20 mL of 0.25% levobupivacaine per side at the level of T7 transverse process	Placebo	pre-induction
Kang et al., 2021, South Korea [35]	ESPB = 38.6, 60.0 ITM = 37.4, 44.8	Living donor hepatectomy	60	NRS, Fentanyl	Initiated with 20 mL 0.375% ropivacaine with 5 µg·mL − 1 epinephrine at the level of T8 transverse process	Intrathecal morphine	pre-induction
Kang et al., 2021, South Korea [36]	ESPB = 52.7, 64.2 QLB = 52.6, 69.7	Hepatectomy	88	NRS, Mepridine	20 mL of 0.375% ropivacaine at the level of T8 transverse process	QLB	post-induction
Li et al., 2021, China [37]	ESPB = 62.4, 60.0 Placebo = 67.8, 60.0	Colon cancer surgery	53	VAS, Sufentanil	20 mL of ropivacaine (0.25%) at the level of T7 transverse process	Placebo (Saline injection)	pre-induction

Table 1 (continued)

Author, Year, Country	Age (mean), Male (%)	Type of laparoscopy	Total Participants	Pain assessment scale, Type of opioid used	ESPB regimen	Type of comparison	Timing of ESPB
Mostafa et al., 2021, Egypt [38]	ESPB = 38.8, 61.6 Placebo = 40.3, 13.3	Bariatric Surgery	60	VAS, Morphine	20 ml bupivacaine 0.25% at the level of T7 transverse	Placebo (Saline injection)	pre-induction
Rao Kadam et al., 2021, Australia [39]	ESPB = 60.5, 48 Wound infiltration = 61.2, 52	Colonic surgery	72	NRS, Fentanyl	40 ml of 0.5% Ropivacaine at the level of T8 transverse process	Wound infiltration	postoperative
Sethi et al., 2021, India [40]	ESPB = 34.9, 27.2 Placebo = 39.1, 36.3	Cholecystectomy	70	NRS, Tramadol	20 mL of 0.25% levobupivacaine *2 at the level of T7 transverse process	Placebo	pre-induction
Shen et al., 2021, China [41]	ESPB = 71.6, 48.3 TAPB = 72.3, 58.0	Colorectal Surgery	62	VAS, Sufentanil	0.25% ropivacaine mixed with normal saline for 20 ml *2 at the level of T9 transverse process	TAPB	post-induction
Vrsajkov et al., 2021, Serbia [42]	ESPB = 55.1, 47 Placebo = 54.4, 44	Cholecystectomy	62	NRS, Tramadol	0.25% levobupivacaine plus dexamethasone 2 mg per side at the level of T7 transverse process	Placebo	post-induction
Yildiz et al., 2021, Turkey [43]	ESPB = 36.8, 23.5 Placebo = 36.5, 29.4	Cholecystectomy	68	NRS, Tramadol	20 mL local anesthetic mixture (10 mL 0.5% bupivacaine, 5 mL 2% lidocaine, and 5 mL isotonic saline) per side at the level of T8 transverse process	Placebo	post-induction
Altinsoy et al., 2021, [44]	ESPB = 61.3 73.3 Placebo = 60.6, 70.0	Inguinal hernia surgery	70	NRS, Tramadol	20 mL of 0.25% bupivacaine unilaterally at different vertebra level	Placebo	post-induction
Choi et al., 2022, South Korea [45]	ESPB = 58.6, 56.6 Placebo = 59.9, 50	Colorectal Surgery	60	NRS, Fentanyl	20 mL of 0.5% ropivacaine per side at the level of T7 transverse process	Placebo	post-induction
Elshazly et al., 2022, Egypt [46]	ESPB = 35.3, NP TAPB = 35.6, NP	Bariatric surgery	60	VAS, Nalbuphine	40 ml of 0.25% bupivacaine (20 ml on each side) at the level of T5 transverse process	TAPB	post-induction
Engineer et al., 2022, India [47]	ESPB = 44, 33.3 TAPB = 44, 43.3	Cholecystectomy	60	NRS, Tramadol	10 ml of 0.375% bupivacaine, 10 and 10 ml of 1.5% lignoadrenaline at the level of T9	TAPB	post-induction
Hassanin et al., 2022, Egypt [48]	ESPB = 45.8, 51.6 TAPB = 47.4, 54.9 Placebo = 43.6, 48.4	Emergency laparotomy	93	VAS, Fentanyl	20 mL of 0.25% bupivacaine at the level of T8	TAPB and Placebo (Saline injection)	post-induction
Huang et al., 2022, China [49]	ESPB = 59.4, 40.0 Placebo = 57.3, 60.0	Hepatectomy	50	VAS, Dezocine	15 ml of ropivacaine 0.5% at the level of T8	Placebo	post-induction

Table 1 (continued)

Author, Year, Country	Age (mean), Male (%)	Type of laparoscopy	Total Participants	Pain assessment scale, Type of opioid used	ESPB regimen	Type of comparison	Timing of ESPB
Liu et al., 2022, China [50]	ESPB = 46.9, 52.3 RLB = 49.5, 43.1	Retroperitoneal laparoscopic surgery	88	VAS, Tramadol	30 mL ropivacaine (0.4%) was injected in the plane of the erector spinae at the T9 level	Retrolaminar Block	post-induction
Ozdemir et al., 2021, Turkey [51]	ESPB = 45, 50.0 TAPB = 45, 62.5	Cholecystectomy	64	NRS, Fentanyl	10 mL of 0.25% bupivacaine and 10 mL of 2% prilocaine at the level of T7	TAPB	pre-induction
Rahimzadeh et al., 2022, USA [52]	ESPB = 45.6, 19.4 Placebo = 40.9, 16.3	Cholecystectomy	62	NRS, Fentanyl	20 mL of 0.2% ropivacaine was injected with increments of 5 mL with negative aspiration each time at the level of T7	Placebo	post-induction
Sifaki et al., 2022, Greece [53]	ESPB = 54, 45.0 Placebo = 49.1, 25.0	Cholecystectomy	60	NRS, Morphine	40 mL of Ropivacaine 0.375% (20 mL at each side). at the level of T7	Placebo (Saline injection)	pre-induction
Warner et al., 2022, India [54]	ESPB = 47.1, 0 TAPB = 42.7, 0	Hysterectomy	78	VAS, Morphine	266 mg Exparel (20 ml) and 60 ml of 0.125% bupivacaine was injected into the patients in the ESP block group. A total of 40 ml was injected on each side, 20 ml at the level of T8 and 20 ml at T12	TAPB	pre-induction
Ashoor et al., 2022, Egypt [55]	ESPB = 33.8, 18.8 QLB = 34.3, 14.7 Placebo = 34.7, 17.1	Sleeve gastrectomy	120	VAS, Nalbuphine	30 mL of 0.25% bupivacaine was injected deep to the erector spinae muscle at the level of T7	QLB and Placebo (Saline injection)	postoperative
Bakeer et al., 2023, Egypt [56]	ESPB = NP, NP TAPB = NP, NP	laparotomy for cancer surgeries	68	NRS, Morphine	NP	TAPB	post-induction
Hassanein et al., 2022, Egypt [57]	ESPB = 37.3, 20 QLB = 34.4, 10 Placebo = 40.6, 35	Cholecystectomy	60	VAS, Fentanyl	20 mL bupivacaine 0.25% (on each side) at the level of T8-T9	QLB and Placebo	post-induction
Jiang et al., 2023, China [58]	ESPB = 51.5, 0 QLB = 50.8, 0 Placebo = 50.7, 0	Hysterectomy	60	NRS, Sufentanil	25 ml of 0.4% ropivacaine at the level of T10	QLB and Placebo	pre-induction
Joshi et al., 2023, India [59]	ESPB = 37.1, 25.7 Port site infiltration = 39.7, 40.0 Placebo = 45.2, 28.5	Cholecystectomy	105	VAS, Fentanyl	20 ml of 0.375% bupivacaine at the level of T7	Port site infiltration and Placebo	pre-induction
Lu et al., 2023, China [60]	ESPB = 49.5, 41.6 Placebo = 47.9, 28.7	Cholecystectomy	220	VAS, NP	20–25 mL of injection containing 0.3% ropivacaine and 5 mg dexamethasone at the level of T7	Placebo (Saline injection)	pre-induction

Table 1 (continued)

Author, Year, Country	Age (mean), Male (%)	Type of laparoscopy	Total Participants	Pain assessment scale, Type of opioid used	ESPB regimen	Type of comparison	Timing of ESPB
Mohammed Mahdy et al., 2023, Egypt [61]	ESPB = 37.8, 18.2 Port site infiltration = 40.0, 13.6	Cholecystectomy	44	NRS, Nalbuphine	20 ml of a mixture of 10 mL of bupivacaine 0.5%, five mL of lidocaine 2%, and 5 mL of normal saline were administered at the level of T9	Port site infiltration	post-induction
Mounika et al., 2023, India [62]	ESPB = NP, 47.8 TAPB = NP, 36.2	Cholecystectomy	138	VAS, Tramadol	20 ml of 0.2% ropivacaine and 1 ml (4 mg) of dexamethasone at the level of T7	TAPB	post-induction
Park et al., 2023, China [63]	ESPB = 60.5, 53.5 Placebo = 67.5, 51.7	Colorectal surgery	62	VAS, Fentanyl	20 mL of 0.25% bupivacaine at the level of T10—T11	Placebo (Saline injection)	pre-induction
Toprak et al., 2023, Turkey [64]	ESPB = 37.6, 20.0 Placebo = 37.5, 20.0	Bariatric surgery	80	NRS, Tramadol	20 ml of bupivacaine 0.25%	Placebo	preoperative
Wang et al., 2023, China [65]	ESPB = 32.8, 13.1 Placebo = 33.0, 10.6	Sleeve gastrectomy	154	VAS, Hydrocodone	30 mL of 0.33% ropivacaine at the level of T7	Placebo (Saline injection)	pre-induction
Xu et al., 2023, China [66]	ESPB = NP, 54.2 Paravertebral Block = NP, 45.7	Nephro-ureterectomy	166	NRS, Sufentanil	0.4 ml/kg ropivacaine 0.375% at the level of T10	Thoracic Paravertebral Block	pre-induction
Zhou et al., 2023, China [67]	ESPB = 49.9, 0 TAPB = 50.9, 0	Radical hysterectomy	154	VAS, Sufentanil	20 ml of injection containing 0.375% ropivacaine at the level of T9	TAPB	postoperative

ESPB Erector spinae plane block, *TAPB* Transversus abdominis plane block, *QLB* Quadratus lumborum plane block, *NRS* Numerical Rating Scale, *VAS* Visual analogue scale, *NP* Not provided

hepatectomies, 5 laparoscopic colorectal and colon related surgeries, 1 laparoscopic inguinal hernia surgery, 1 emergency laparotomy, 1 retroperitoneal laparoscopic surgery, 1 laparotomy for cancer surgeries, 1 laparoscopic nephroureterectomy. Tramadol was the most used opioid in the studies. Other opioids included morphine, fentanyl, sufentanil, hydrocodone, nalbuphine, dezocine, and pethidine. The pain assessment scale was mostly NRS, which was used in 24 studies, while VAS was used in 19 studies.

The number of participants in the RCTs varied significantly, ranging between 32 – 220. The gender of participants in ESPB and comparator arms were similar except for Kang, R et al. [29] and Mostafa, S. F et al. [38]. patients were aged between 18 to 70 years in the included studies.

Comparison 1, ESPB vs Placebo

24 hour post operation opioid consumption

A total of 22 RCTs were pooled in this meta-analysis, including 644 participants in the ESPB arms and 648 participants in the placebo arms. A significantly reduced postoperative opioid consumption was observed in the ESPB arms (SMD, (95CI), *p*-value; -1.837, (-2.331, -1.343), < 0.001) with high heterogeneity (I^2: 47.80%, Fig. 2) and moderate certainty (Table S1). Sensitivity analyses showed our findings to be stable (Figure S1) yet significant publication bias was observed using Egger's regression test (*p*-value < 0.001), with an asymmetric funnel plot (Figure S2). Meta-regression did not show any significant association between opioid consumption and the mean age of participants (coefficient: 0.017, $p = 0.590$) or the level of ESPB at different thoracic levels (T7 to T9) (Table S1).

Participant reported pain scores at rest

A total of 21 RCTs were pooled in this meta-analysis, including 742 participants in the ESPB arms and 750 participants in the placebo arms. A significant reduction in pain scores was noted in the ESPB arms at 24 h post-operation (SMD, (95CI), *p*-value; -0.612, (-0.797, -0.428), < 0.001), with significant heterogeneity (I^2: 71.36%, Fig. 3) and low certainty (Table S1). When analyzing other time points, this reduction in pain scores remained significant at 1, 2, 3, 4, 6, 8, 10, 12, 16-, 18-, 20-, and 24-h post-operation (Fig. 4). Sensitivity analysis showed our findings to be stable (Figure S3) yet publication bias was observed using Egger's regression test (*p*-value < 0.001) but the funnel plot was symmetric (Figure S4). When examining the influence of moderators on 24-h pain scores, no significant associations were found for either participant age (coefficient: 0.013, $p = 0.453$) or level of anesthesia. None of the anesthesia levels (T7, T8, T9) demonstrated significant effects, with T8 (coefficient: -0.34, $p = 0.712$) yielding the largest, though non-significant, coefficient (Table S1).

Time to first rescue analgesic request

A total of 9 RCTs were pooled in this meta-analysis, including 313 participants in the ESPB arms and 321 participants in the placebo arms. A significant increase in time to first rescue analgesic request was observed in the ESPB arms in comparison to Placebo arms (SMD, (95CI), *p*-value; 3.945, (2.516, 5.375), < 0.001) with significant heterogeneity (I^2: 78.30%, Fig. 5) and very low certainty (Table 2). Sensitivity analysis showed our findings to be stable (Figure S5) yet significant publication bias was observed using Egger's regression test (*p*-value < 0.001), with an asymmetric funnel plot (Figure S6).

Post-operative nausea or vomiting

A total of 14 RCTs were pooled in this meta-analysis, including 403 participants in the ESPB arms and 407 participants in the Placebo arms. A significantly lower risk of developing post-operative nausea or vomiting was observed in the ESPB arms (RR, (95CI), *p*-value; 0.491, (0.353, 0.682), < 0.001) with low heterogeneity (I^2: 0%, Fig. 6) and high certainty (Table 2). Sensitivity analysis showed our findings to be stable (Figure S7) and no publication bias using Egger's regression test was observed (*p*-value > 0.1) with a symmetric funnel plot (Figure S8). Meta-regression revealed no significant association with either mean age (coefficient: 0.004, $p = 0.748$) or level of anesthesia (Table S1).

Comparison 2, ESPB vs TAPB

24 hour post operation opioid consumption

A total of 11 RCTs were pooled in this meta-analysis, including 416 participants in the ESPB arms and 413 participants in the TAPB arms. A significantly reduced post-operative opioid consumption was observed in the ESPB arms (SMD, (95CI), *p*-value; -1.351, (-1.815, -0.887), < 0.001), with low heterogeneity (I^2: 10.33%, Fig. 7) and moderate certainty (Table 2). Sensitivity analysis showed our findings to be stable (Figure S9) yet significant publication bias was observed using Egger's regression test (*p*-value = 0.03) with an asymmetric funnel plot (Figure S10). Meta-regression revealed a significant association between opioid consumption and the level of anesthesia at T9 (coefficient: 0.97, $p = 0.030$), suggesting that anesthesia at this level may reduce opioid consumption more effectively compared to other levels. Mean age (coefficient: 0.016, $p = 0.589$) did not significantly affect opioid consumption (Table S1).

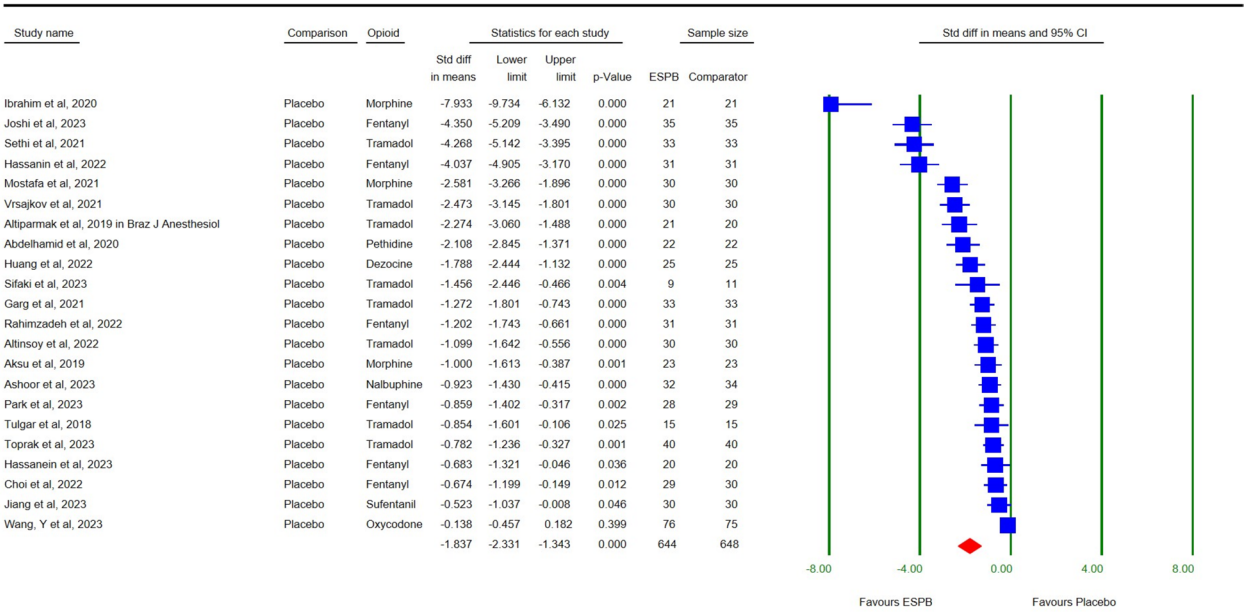

Fig. 2 The forest plot of studies that compared postoperative opioid consumption between ESPB arm and placebo arm

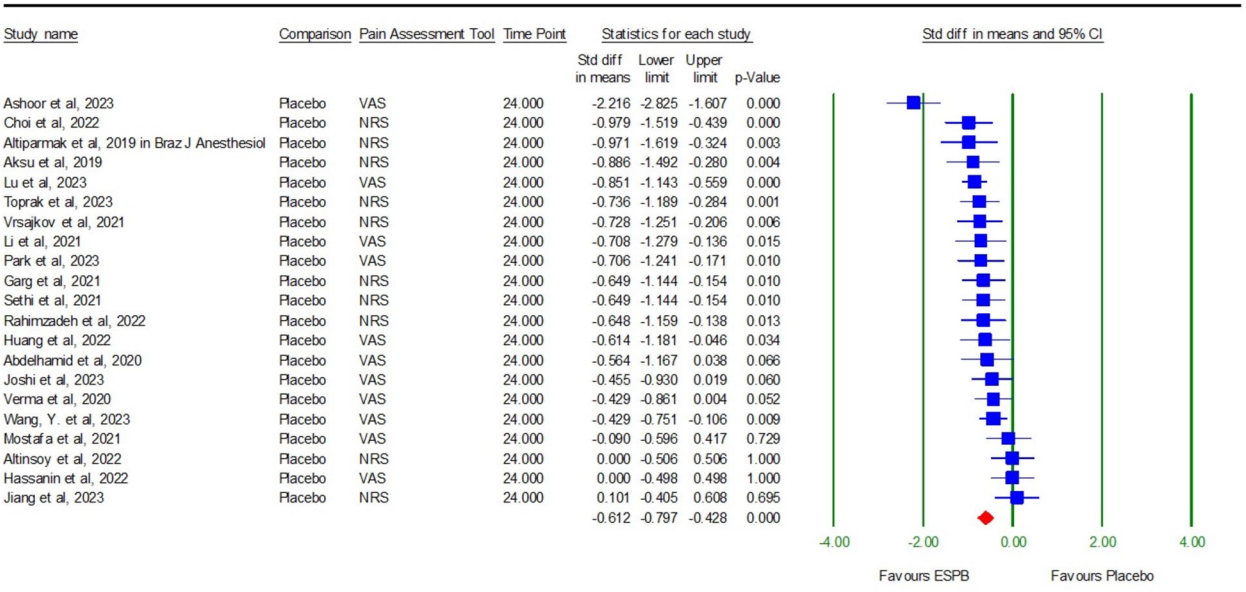

Fig. 3 The forest plot of studies that compared participant reported pain scores at rest at 24 h post-operation between ESPB arm and placebo arm

Participant reported pain scores at rest

A total of 9 RCTs were pooled in this meta-analysis, including 359 participants in the ESPB arms and 362 participants in the TAPB arms. A significant reduction in pain scores was noted in the ESPB arms at 24 h post-operation (SMD, (95CI), *p*-value; -0.465, (-0.767, -0.162), < 0.001), with low heterogeneity (I^2: 0.37%, Fig. 8) and high certainty (Table 2). When analyzing other time points, this reduction in pain scores remained significant at 2, 4, 6, 8, 12, 16, 18, 20, and 24 h post operation, yet was comparable to TAPB at 1 and 10 h post operation (Fig. 9). Sensitivity analysis showed our findings to be stable (Figure S11), and no publication bias using Egger's regression test was observed (*p*-value = 0.155) with a symmetric funnel plot (Figure S12).

Time to first rescue analgesic request

A total of 7 RCTs were pooled in this meta-analysis, including 243 participants in the ESPB arms and 243 participants in the TAPB arms. A significant increase in time to first rescue analgesic request was observed in the ESPB arms in comparison to TAPB arms (SMD, (95CI), *p*-value; 1.456, (0.726, 2.186), < 0.001) with low heterogeneity (I^2: 29.36%, Fig. 10) and moderate certainty (Table 2). Sensitivity analysis showed our findings to be stable (Figure S13), yet publication bias was observed using Egger's regression test (*p*-value = 0.05) with an asymmetric funnel plot (Figure S14).

Post-operative nausea or vomiting

A total of 5 RCTs were pooled in this meta-analysis, including 209 participants in the ESPB arms and 212 participants in the TAPB arms. An insignificant lower risk of developing post-operative nausea or vomiting was observed in the ESPB arms (RR, (95CI), *p*-value; 0.511, (0.235, 1.112), 0.09) with low heterogeneity (I^2: 0%, Fig. 11) and high certainty (Table 2). Sensitivity analysis showed this finding to be unstable (Figure S15), yet no publication bias was observed using Egger's regression test (*p*-value = 0.914) with a symmetric funnel plot (Figure S16).

Comparison 3, ESPB vs QLB

24 hour post operation opioid consumption

A total of 5 RCTs were pooled in this meta-analysis, including 163 participants in the ESPB arms and 168 participants in the QLB arms. A comparable post-operative opioid consumption was observed in the ESPB arms in comparison to QLB arms (SMD, (95CI), *p*-value; 0.022, (-0.241, 0.286), 0.869) with low heterogeneity (I^2: 0.30%, Fig. 12) and moderate certainty (Table 2). Sensitivity analysis showed our findings to be stable (Figure S17), and no publication bias was observed using Egger's regression test (*p*-value = 0.98) with an asymmetric funnel plot (Figure S18).

Participant reported pain scores at rest

A total of 4 RCTs were pooled in this meta-analysis, including 146 participants in the ESPB arms and 150 participants in the QLB arms. A significant increase in pain scores at 24 h post-operation in the ESPB arms in comparison to the QLB arms was observed (SMD, (95CI), *p*-value; 1.025, (0.156, 1.894), 0.021) with low heterogeneity (I^2: 17.63%, Figure S19) and moderate certainty (Table 2). When analyzing other time point, Pain scores in ESPB arms and QLB arms were comparable at 2, 3, 4, 6, 12, 16, 18, and 20 h post operation, yet ESPB arms had significantly higher pain scores 1, 8, 24 h post operation when compared to QLB arms (Figure S20). Sensitivity analysis showed our findings to be stable (Figure S21), and no publication bias was observed using Egger's regression test (*p*-value = 0.169) with an asymmetric funnel plot (Figure S22).

Time to first rescue analgesic request

A total of 2 RCTS were pooled in this meta-analysis, including 52 participants in the ESPB arms and 54 participants in the QLB arms. An insignificant decrease in time to first rescue analgesic request was observed in the ESPB arms in comparison to the QLB arms (SMD, (95CI), *p*-value; -0.285, (-1.310, 1.880), 0.726) with low heterogeneity (I^2: 0%, Figure S23) and low certainty (Table 2). Sensitivity analysis and publication bias assessments were not performed due to the low number of included studies.

Post-operative nausea or vomiting

A total of 3 RCTs were pooled in this meta-analysis, including 114 participants in the ESPB arms and 117 participants in the QLB arms. An insignificant lower odd of developing post-operative nausea or vomiting was observed in the ESPB arms in comparison to QLB arms (RR, (95CI), *p*-value; 0.778, (0.445, 1.360), 0.378) with low heterogeneity (I^2: 0%, Figure S24) and low certainty (Table 2). Sensitivity analysis and publication bias assessments were not performed due to the low number of included studies.

Other comparisons

24 hour post operation opioid consumption

Among the included studies, 2 studies compared 24 h post-operative opioid consumption in ESPB arms with port site infiltration arms, the pooled result of which showed reduced opioid consumption in the ESPB arms (SMD, (95CI), *p*-value; -3.285, (-5.625, -0.945), 0.006) with low heterogeneity (I^2: 0%). 2 studies compared 24 h post-operative opioid consumption in ESPB arms with intrathecal morphine, the pooled result of which showed increased opioid consumption in the ESPB arms in comparison to intrathecal morphine arms (SMD, (95CI), *p*-value; 0.625, (0.247, 1.004), 0.001) with low heterogeneity (I^2: 0%). One study compared 24 h post-operative opioid consumption in ESPB arms with wound infiltration and found a comparable opioid consumption between the ESPB arms and wound infiltration arms (SMD, (95CI), *p*-value;0.049, (-0.43, 0.528), 0.842). One study compared 24 h post-operative opioid consumption in ESPB arms with thoracic paravertebral block and found a significant yet slightly lower opioid consumption in the ESPB arm (SMD, (95CI), *p*-value; -0.310, (-0.616, -0.004), 0.047). the results of the meta-analyses are depicted in Figure S25.

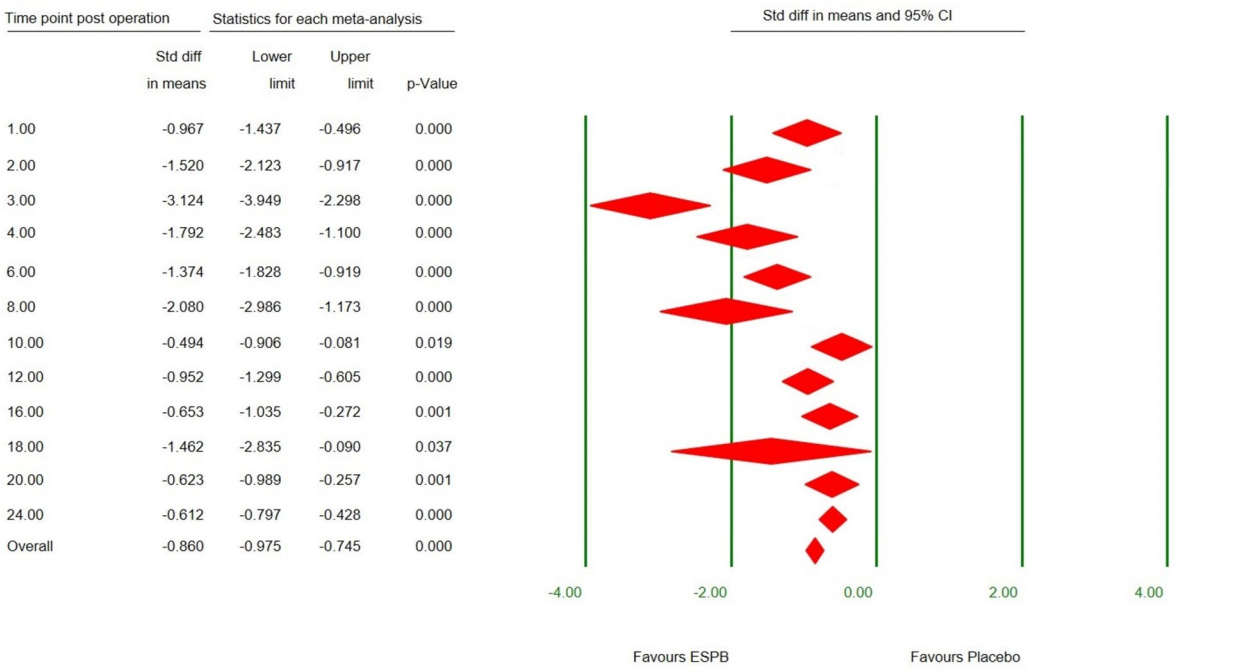

Fig. 4 The forest plot of studies that compared participant reported pain scores at rest between ESPB arm and placebo arm sub grouped based on the time of reported pain scores postoperative

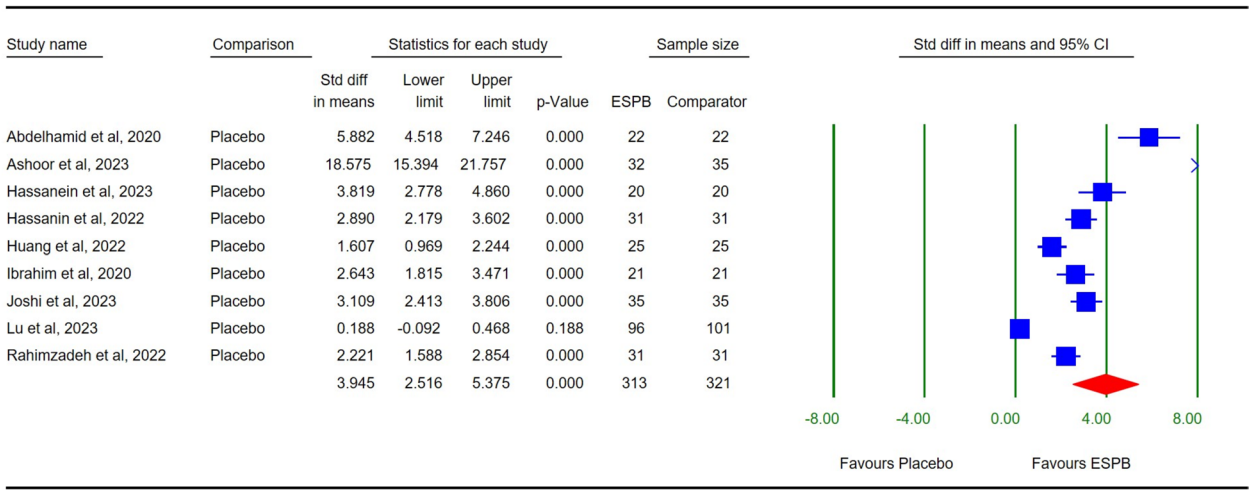

Fig. 5 the forest plot of studies that compared time to first rescue analgesic between ESPB arm and placebo arm

Sensitivity analysis and publication bias assessment were not performed for these meta-analyses due to the low number of included studies.

Participant reported pain scores at rest

Among the included studies, 2 studies compared pain scores at 24 h post-operation in ESPB arms with port site infiltration, the pooled result of which showed an insignificantly lower pain score in the ESPB arms (SMD, (95CI), *p*-value; -0.030, (-0.397, 0.338), 0.121) with low heterogeneity (I^2: 0%). One study compared pain scores at 24 h post-operation in ESPB arms with wound infiltration arms and found an insignificant lower pain score in the ESPB arms (SMD, (95CI), *p*-value; -0.285, (-0.767,

Table 2 GRADE assessments

Certainty assessment							№ of patients		Effect	Certainty
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**ESPB**	**comparison**		
ESPB vs Placebo										
24 h Post Operation Opioid Consumption										
22	randomized trials	not serious	not serious	not serious	not serious	publication bias strongly suspected[a]	644	648	SMD-**1.837**	⊕⊕⊕◯ Moderate[a]
Participant Reported Pain Scores at Rest										
21	randomized trials	not serious	serious[b]	not serious	not serious	publication bias strongly suspected[a]	742	750	SMD-**0.612**	⊕⊕◯◯ Low[a,b]
Time to First Rescue Analgesic Request										
9	randomized trials	not serious	very serious[c]	not serious	not serious	publication bias strongly suspected[a]	313	321	SMD + **3.945**	⊕◯◯◯ Very low[a,c]
Post-Operative Nausea or Vomiting										
14	randomized trials	not serious	not serious	not serious	not serious	none	403	407	RR + **0.491**	⊕⊕⊕⊕ High
ESPB vs TAPB										
24 h Post Operation Opioid Consumption										
11	randomized trials	not serious	not serious	not serious	not serious	publication bias strongly suspected[d]	416	413	SMD-**1.351**	⊕⊕⊕◯ Moderate[d]
Participant Reported Pain Scores at Rest										
9	randomized trials	not serious	not serious	not serious	not serious	none	359	362	SMD-**0.465**	⊕⊕⊕⊕ High
Time to First Rescue Analgesic Request										
7	randomized trials	not serious	not serious	not serious	not serious	publication bias strongly suspected[a]	243	243	SMD + **1.456**	⊕⊕⊕◯ Moderate[a]
Post-Operative Nausea or Vomiting										
5	randomized trials	not serious	not serious	not serious	not serious	none	209	212	RR + **0.511**	⊕⊕⊕⊕ High
ESPB vs QLB										
24 h Post Operation Opioid Consumption										
5	randomized trials	not serious	not serious	not serious	serious[d]	none	163	168	SMD + **0.022**	⊕⊕⊕◯ Moderate[d]
Participant Reported Pain Scores at Rest										
4	randomized trials	not serious	not serious	not serious	serious[d]	none	146	150	SMD + **1.025**	⊕⊕⊕◯ Moderate[d]
Time to First Rescue Analgesic Request										
2	randomized trials	not serious	not serious	not serious	serious[d]	publication bias strongly suspected[a]	52	54	SMD + **0.285**	⊕⊕◯◯ Low[a,d]

Table 2 (continued)

Certainty assessment							№ of patients		Effect	Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	ESPB	comparison		
Post-Operative Nausea or Vomiting										
3	randomized trials	not serious	not serious	not serious	serious[d]	publication bias strongly suspected[a]	114	117	RR + **0.778**	⨁⨁◯◯ Low[a,d]

CI confidence interval, *ESPB* Erector Spinae Plane Block, *TAPB* transversus abdominis plane block, *QLB* quadratus lumborum block, *RR* risk ratio, *SMD* standardized mean difference

Explanations

a. Due to potential publication bias, we decided to downgrade once for strong susceptibility to publication bias

b. Due to a heterogeneity greater than 50%, we decided to downgrade once for serious inconsistency

c. Due to a heterogeneity greater than 75%, we decided to downgrade twice for very serious inconsistency

d. Due to the small sample size or small number of articles, we decided to downgrade once for serious imprecision

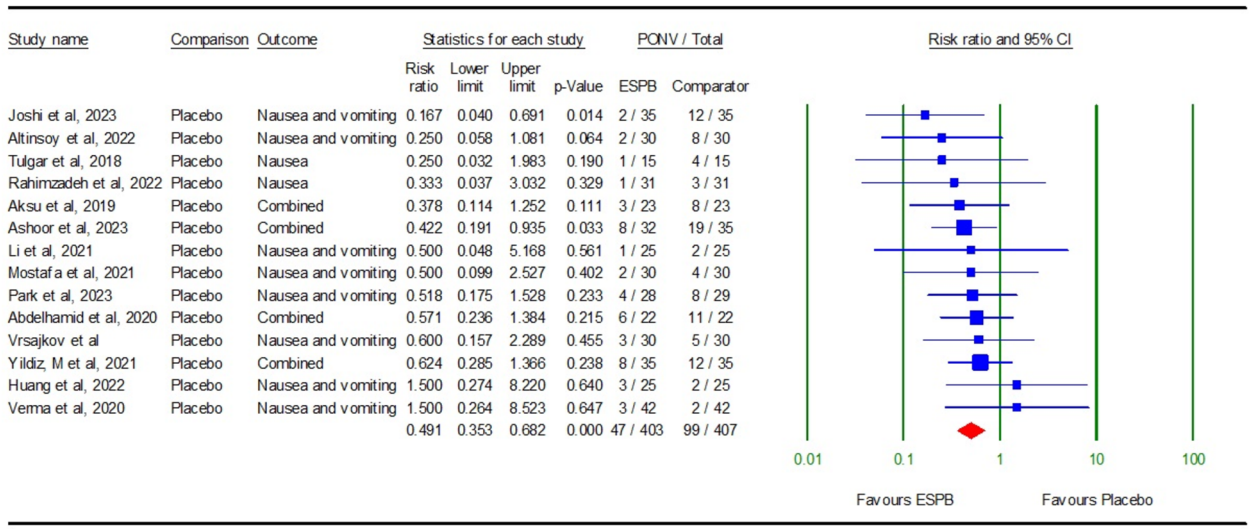

Fig. 6 the forest plot of studies that compared Post-Operative Nausea or Vomiting between ESPB arm and placebo arm

0.196), 0.246). One study compared pain scores at 24 h post-operation in an ESPB arm with an intrathecal morphine arm and found higher pain scores in the intrathecal morphine arm (SMD, (95CI), *p*-value; 1.142, (0.566, 1.717), < 0.001), and another study compared pain scores at 24 h post-operation in an ESPB arm with a retro laminar block arm and found comparable pain scores between the two arms (SMD, (95CI), *p*-value; 0.068, (-0.355, 0.491), 0.753). the results of the meta-analyses are depicted in Figure S26. Sensitivity analysis and publication bias assessment were not performed for these meta-analyses due to the low number of included studies.

Time to first rescue analgesic request

Among the included studies, 2 compared time to first rescues analgesic request in ESPB arms with port site infiltration arms, the pooled result of which showed a longer time to first rescue analgesic request in the ESPB arms (SMD, (95CI), *p*-value; 4.014, (2.425, 5.603), < 0.001) with low heterogeneity (I^2: 0%). One study compared time to first rescues analgesic request in an ESPB arm with a thoracic paravertebral block arm and found a significant yet slightly longer time to first rescue analgesic request in the ESPB arm (SMD, (95CI), *p*-value; 0.335, (0.028, 0.641), 0.032). the results of the meta-analyses are depicted in Figure S27. Sensitivity analysis and publication bias assessment were not performed for these meta-analyses due to the low number of included studies.

Post-operative nausea or vomiting

Among the included studies, 2 compared post-operative nausea or vomiting with intrathecal morphine, the pooled result of which showed a significant lower risk of developing post-operative nausea or vomiting (RR, (95CI), *p*-value; 0.322, (0.177, 0.586), < 0.001) with low heterogeneity (I^2: 0%). 2 studies compared post-operative nausea or vomiting with port site infiltration, the pooled result of which showed a significant lower risk of developing post-operative nausea or vomiting (RR, (95CI), *p*-value; 0.213, (0.077, 0.587), 0.003). One study also compared post-operative nausea or vomiting in an ESPB arm with a retrolaminar block, and found a similar risk of developing post-operative nausea or vomiting (RR, (95CI), *p*-value; 0.873, (0.423, 1.802), 0.713). the results of the meta-analyses are depicted in Figure S28. Sensitivity analysis and publication bias assessment were not performed for these meta-analyses due to the low number of included studies.

Quality assessment

Risk of bias was assessed using Cochrane RoB2 tool. The primary sources of bias in studies stemmed from the lack of blinding of patients, the absence of sham interventions to enhance blinding, and the use of subjective outcomes like pain scores as the primary measure, which are inherently vulnerable to bias. Additionally, not all studies reported all the outcomes they initially outlined in their protocols, further contributing to potential reporting bias. Overall, the quality assessment showed the findings of our included RCTs to be robust (Fig. 13).

Certainty of evidence

The certainty of the evidence was evaluated using the GRADE. The included studies did not have sufficient risk of bias to affect the interpretation of results and directly addressed the review question; therefore, our outcomes

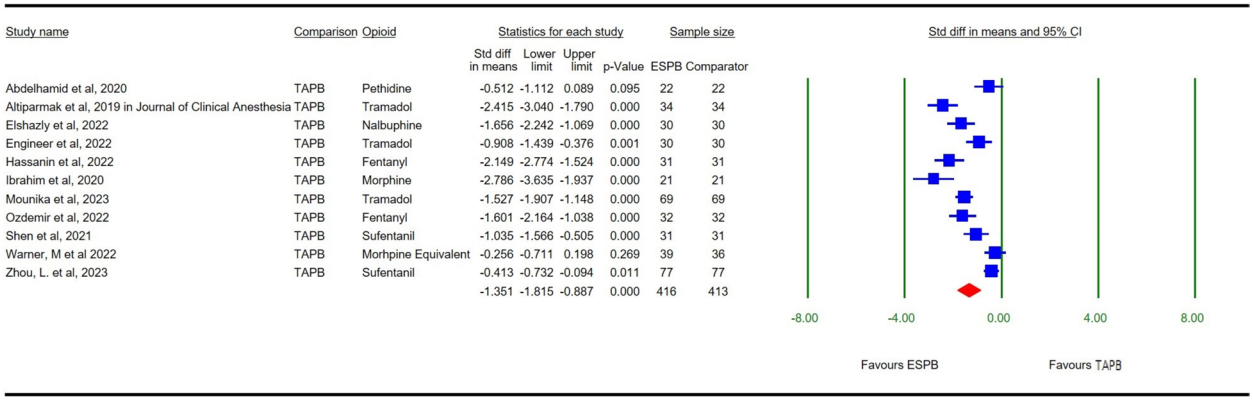

Fig. 7 The forest plot of studies that compared postoperative opioid consumption between ESPB arm and TAPB arm

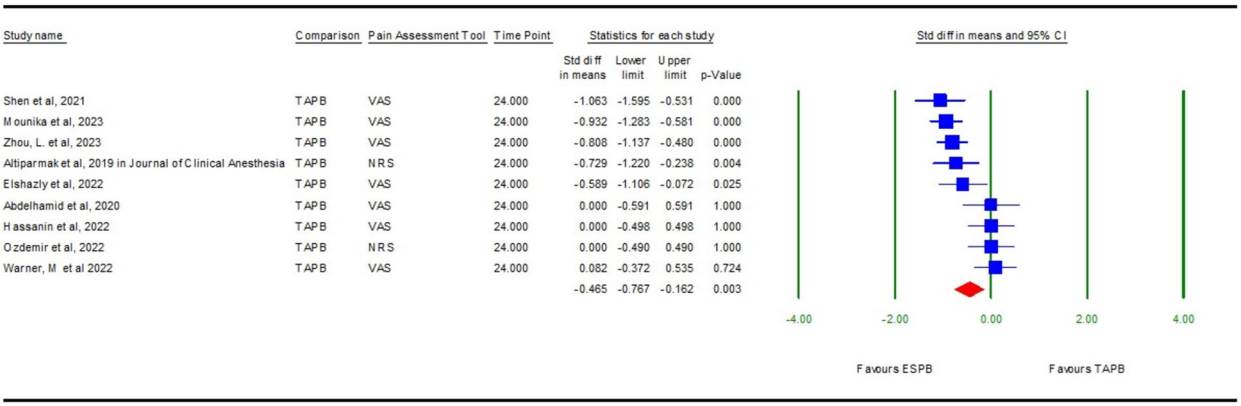

Fig. 8 The forest plot of studies that compared participant reported pain scores at rest at 24 h post-operation between ESPB arm and TAPB arm

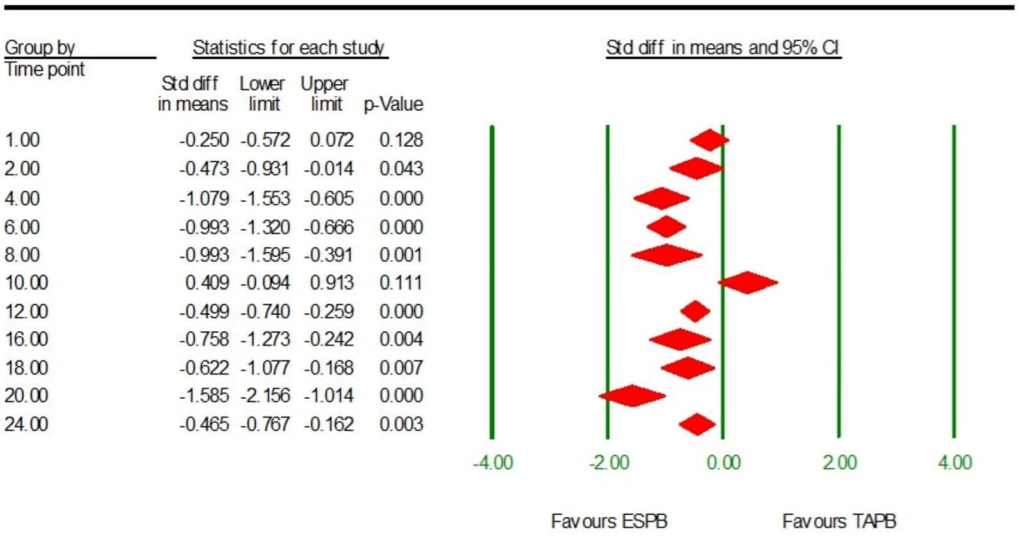

Fig. 9 the forest plot of studies that compared participant reported pain scores at rest between ESPB arm and TAPB arm sub grouped based on the time of reported pain scores

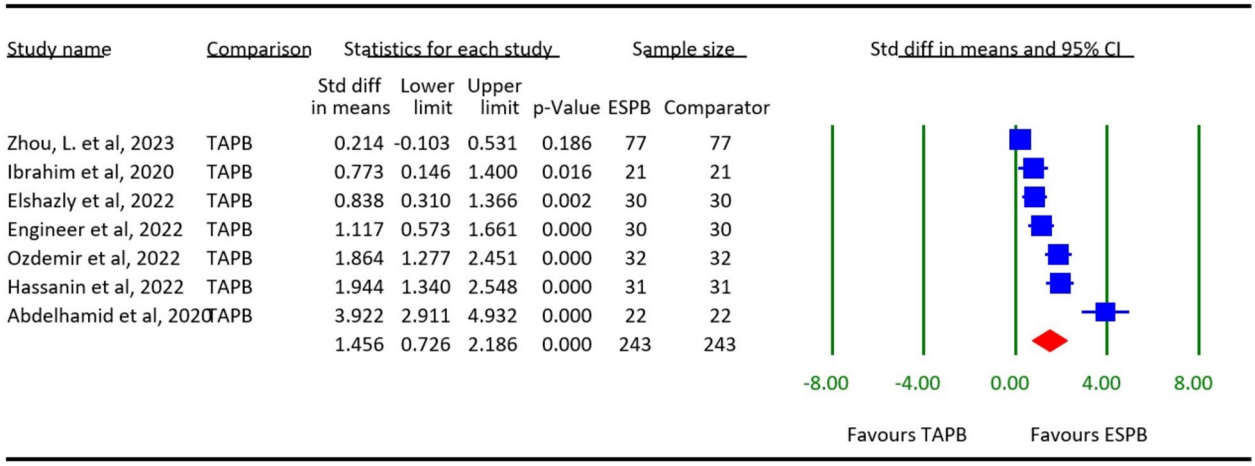

Fig. 10 The forest plot of studies that compared time to first rescue analgesic between ESPB arm and TAPB arm

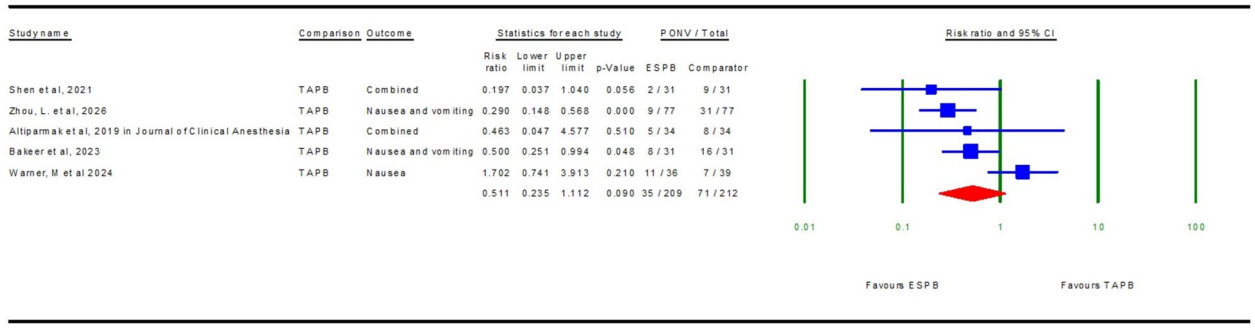

Fig. 11 The forest plot of studies that compared Post-Operative Nausea or Vomiting between ESPB arm and TAPB arm

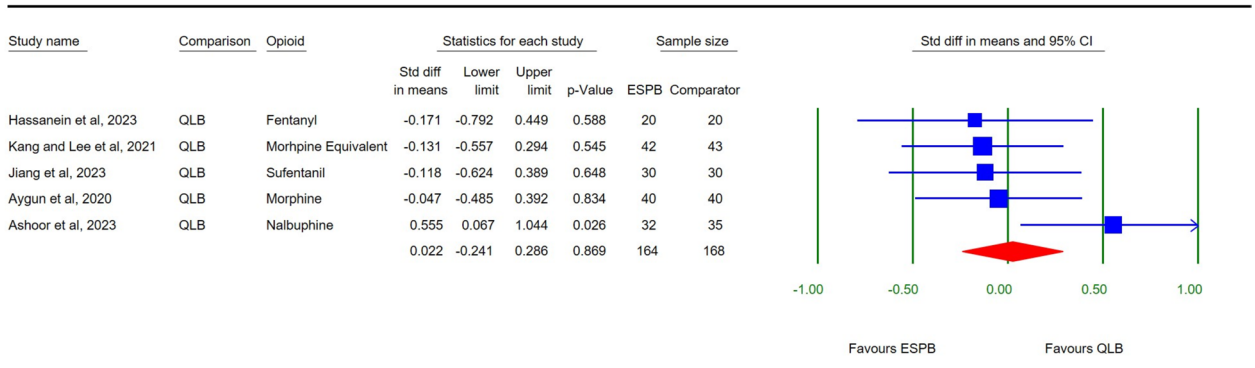

Fig. 12 The forest plot of studies that compared postoperative opioid consumption between ESPB arm and QLB arm

were not downgraded for risk of bias or indirectness. All outcomes showed no inconsistency, except for two: participant-reported pain scores at rest in the comparison of ESPB versus placebo, which were downgraded for inconsistency due to heterogeneity above 50%, and time to first rescue analgesic request, which was downgraded twice due to heterogeneity above 75%. In the ESPB versus QLB comparison, outcomes were downgraded once for serious imprecision due to the small sample size and wide confidence intervals. Additionally, outcomes that showed

publication bias based on Egger's test were downgraded once. A summary of the certainty of evidence is provided in Table 2.

Discussion

This systematic review and meta-analysis evaluated the postoperative analgesic efficacy of ESPB in laparoscopic surgeries by comparing postoperative opioid consumption, participant-reported pain scores, time to first rescue analgesic request, and postoperative nausea or vomiting. Our analyses demonstrated that ESPB's performance was superior to placebo in all of the aforementioned endpoints, and surpassed TAPB's in all areas except for nausea and vomiting. Additionally, ESPB demonstrated a similar efficacy in all areas when compared to QLB except for the pain score at 24 h post-operation, and compared well even against intrathecal morphine with a lower participant-reported pain score and PONV, but not a lower rate of postoperative opioid consumption. Our results can be compared to and contrasted with a recently published Cochrane review analyzing the ability of ESPB to alleviate postoperative pain after any type of surgery requiring general anesthesia. While the review was similar to our results in that it indicated that ESPB can be performed without serious adverse events and decreases requirements for oral pain killers, the authors ultimately concluded that ESPB does not significantly reduce postoperative pain [68]. We believe that the discrepancy observed between our results and those of this review lies in the different nature of the surgical procedures of the included studies, as we included only studies with laparoscopic surgeries.

Conventionally, epidural and paravertebral analgesia methods have been used to alleviate acute or chronic pain after surgeries [69]. While effective, these techniques are expensive, require expertise and are associated with complications such as inadvertent dural puncture, vascular puncture, nerve damage, catheter breakage or catheter site infection [70, 71]. As a result, efforts have been made to find less expensive, less invasive, safer nerve blocking methods for pain relief after surgeries, such as TAPB, QLB, and ESPB.

ESPB involves the injection of analgesics into the interfacial plane between rhomboid major and erector spinae muscles [11]. The effectiveness of ESPB can be attributed to the dispersion of anesthetics across 3–6 vertebral levels in a downward direction along the spine in the paraspinal area, with the likelihood of spreading to adjacent regions [72, 73]. It has also been suggested that negative intrathoracic pressure and the contraction of the erector spinae muscle may enhance this distribution, contributing to the widespread analgesia observed [74]. These mechanisms facilitate both somatic and visceral pain relief within the corresponding spinal nerve territories [15]. In contrast, TAPB has a predominantly anterior spread, relatively little posterior spread and no spread to the paravertebral spaces [75], and thus has only been reported to offer somatic pain relief [76], which may explain ESPB's superior outcomes in decreasing opioid usage, pain levels, and time to request first rescue analgesic, as demonstrated in our meta-analysis. Additionally, QLB alleviates somatic and visceral pain [77], supporting the observed comparability of ESPB and QLB. It should be noted that while QLB does not spread into the paravertebral regions [78], the visceral analgesia is thought to be caused by the spread of anesthetics to the celiac ganglion or sympathetic trunk through splanchnic nerves [77]. However, as reports have deemed QLB to be more time-consuming and more challenging to perform [79–81], and since the efficacies are similar, ESPB can very well be considered as an alternative to QLB.

The statistical differences in pain scores, opioid analgesic doses, and time to first rescue analgesic use, while modest, are clinically important. Small reductions in pain scores can enhance patient recovery by improving comfort, promoting mobility, and reducing risks such as chronic pain [82]. Similarly, reducing opioid consumption minimizes the risk of side effects like nausea, sedation, and respiratory depression, and lowers the chance of opioid dependency, aligning with enhanced recovery protocols [6, 83]. Lastly, a longer time to first rescue analgesic indicates better prolonged pain control, leading to fewer doses and more consistent pain relief [84]. These differences can have meaningful impacts on patient outcomes and recovery quality [82], underscoring the clinical relevance of our findings.

Limitations

Our study has several limitations. First, the comparison of ESPB with placebo in endpoints related to pain entailed both high heterogeneity and significant publication bias, demonstrating the need for more high-quality RCTs with larger sample sizes comparing the two. Second, while we were able to reliably compare ESPB to blocks such as QLB and TAPB, studies comparing ESPB to methods such as port-site infiltration, wound infiltration, intrathecal morphine, and paravertebral blocks were few, making the results of the meta-analysis dubious. We recommend that future research address this gap in the literature. Further, while we were able to compare ESPB with other methods in terms of analgesic efficacy and PONV reduction, factors such as cost-effectiveness and time-consumption have not been investigated as endpoints in studies comparing different blocks. We suggest that these endpoints be vigorously investigated in

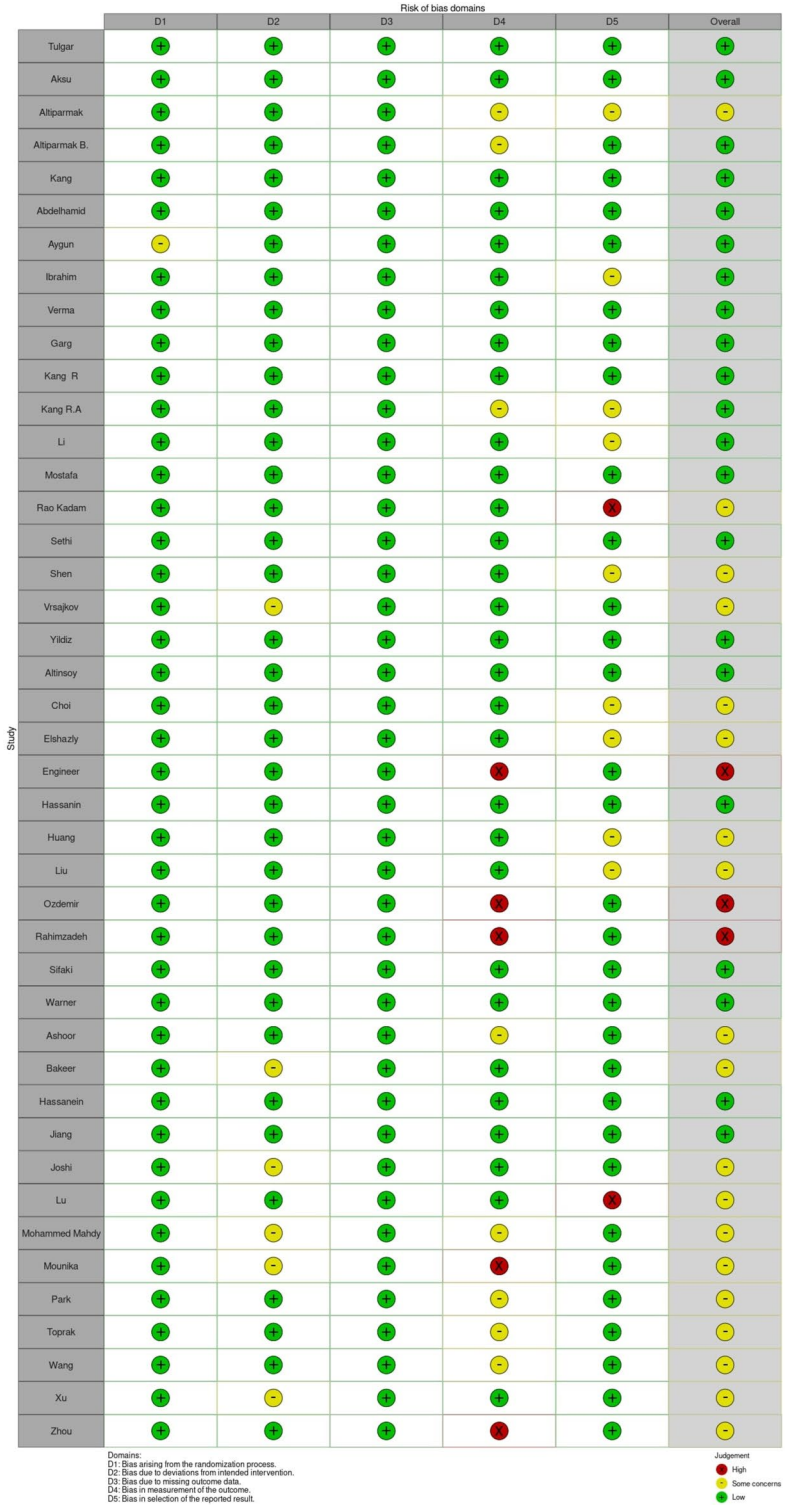

Fig. 13 Quality assessment using Cochrane's RoB2 tool

the future as they are crucial in clinical settings yet often overlooked in research.

Conclusion

Our systematic review and meta-analysis demonstrated that ESPB significantly decreased post operative opioid consumption and pain scores compared to both Placebo and TAPB, and increased time to first rescue analgesic compared to both. There was a significant reduction in post operative nausea and vomiting compared to the placebo group but not the TAPB group. No statistically significant difference between ESPB and QLB were observed in any of the reviewed outcomes, except for the pain score at 24 h post-operation.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-024-02775-4.

Supplementary Material 1.

Acknowledgements
There is nothing to declare.

Authors' contributions
S.O: Data curation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. S.R: Conceptualization, Formal analysis, Software, Writing – original draft, Writing – review & editing. I.M: Validation, Writing – original draft, Writing – review & editing. M.A: Methodology, Writing – original draft, Writing – review & editing H.G: Writing – original draft, Writing – review & editing. S.H: Writing – review & editing.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability
The data used to support the findings of this study are included within the article.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 14 August 2024 Accepted: 18 October 2024
Published online: 29 October 2024

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