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REVIEW

Efficacy and Safety of Erector Spinae Plane Block for Perioperative Pain Management in Lumbar Spinal Surgery: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Meng-Yu Fu[1], Jie Hao[2], Lun-Hui Ye[3], Wei Jiang[2], Ying-Wen Lv[1], Jie-Liang Shen[2], Tao Fu[1]

[1]Department of Orthopaedics, The Thirteenth People's Hospital of Chongqing (The Geriatric Hospital of Chongqing), Chongqing, 400053, People's Republic of China; [2]Department of Orthopaedics, The First Affiliated Hospital of Chongqing Medical University, Chongqing, 400016, People's Republic of China; [3]Department of Anesthesiology, The Thirteenth People's Hospital of Chongqing (The Geriatric Hospital of Chongqing), Chongqing, 400053, People's Republic of China

Correspondence: Jie-Liang Shen; Tao Fu, Email 18996078008@qq.com; cqsdssrmyyft@163.com

Background: Since the application of ultrasound-guided erector spinae plane block (ESPB) in 2016, the approach has been gradually applied to perioperative analgesia in various surgeries. In recent years, more and more studies have focused on the effect of ESPB in perioperative analgesia of lumbar spinal surgery, but its clinical effect remains controversial.

Objective: This systematic review and meta-analysis was designed to explore the efficacy and safety of ESPB used for perioperative pain management in lumbar spinal surgery.

Methods: The Pubmed, Web of Science, Cochrane Library, and EMBASE databases were comprehensively searched for relevant articles from inception to March 2022. Randomized controlled trials (RCTs) comparing ESPB with placebo or without ESPB in lumbar spinal surgery were included. The Review Manager 5.3 software was employed for this meta-analysis.

Results: Nineteen RCTs with 1381 participants were included for final analysis. ESPB group exhibited lower intraoperative consumption of sufentanil and remifentanil, lower total opioid consumption within 24 h and 48 h after surgery, lower incidence of rescue analgesia, longer time to first rescue analgesic and lower number of PCA button presses compared to the control group ($P<0.05$). Moreover, the ESPB group had significantly lower pain scores at rest and on movement within 48 h after surgery compared with the control group ($P<0.05$). In terms of opioid-related adverse reactions, ESPB reduced the incidence of postoperative nausea, vomitting, somnolence and itching in comparison to the control group ($P<0.05$). ESPB-related serious complications were not reported in included studies.

Conclusion: This meta-analysis demonstrated that ESPB used in lumbar spinal surgery was effective in relieving postoperative pain, decreasing the perioperative consumption of opioids, as well as decreasing the incidence of postoperative opioid-related adverse reactions.

Keywords: erector spinae plane block, lumbar spinal surgery, perioperative analgesia, randomized controlled trial, meta-analysis

Introduction

Posterior lumbar spinal surgery is the gold standard for the majority of lumbar spinal diseases. As is well documented, acute severe pain in the surgical area often occurs after lumbar spinal surgery, and the pain lasts for at least 3 days.[1] Not effectively managing postoperative pain leads to a decline in the patient's activity, impacts postoperative rehabilitation, and eventually increases the incidence of various complications such as deep vein thrombosis, pulmonary embolism, and pulmonary infection, thereby prolonging hospital stay.[2,3] Indeed, effective postoperative pain management helps to achieve favorable surgical results.[4] Opioid analgesics are generally used to manage acute postoperative pain. However, although they exert strong analgesic effects, they are often associated with adverse reactions such as nausea and

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vomiting, skin itching, dizziness, lethargy, and urinary retention, and may even lead to respiratory depression and drug dependence in some cases.[5] Notably, a traditional single analgesic drug or method can not achieve an ideal analgesic effect, and hence, the implementation of multimodal analgesia (MMA) can effectively reduce the incidence of postoperative adverse reactions while enhancing the postoperative analgesic effect.[6] Consequently, regional analgesia has become an essential part of multimodal analgesia, but yet its application in lumbar spinal surgery is still limited.[7]

In recent years, with the popularization and development of ultrasound-guided technology, regional nerve block has been extensively used in clinical practice. Erector spinae plane block (ESPB) is a novel trunk nerve block technology whereby local anesthetics are injected between the deep of the erector spinae muscle and the transverse process and was first reported by Forero et al[8] in 2016 regarding the treatment of severe neuropathic pain in the thorax-back. ESPB functions by local anesthetics diffusing in the thoracolumbar fascia, which blocks the dorsal and ventral branches of spinal nerves in the corresponding areas and alleviates nociceptive pain and visceral pain at the same time.[8] With the increasing demand of clinicians for visualization and accuracy and the in-depth study of the anatomy of the posterior branch of the spinal nerve, the theoretical basis of ultrasound-guided ESPB has been gradually clarified.[9] ESPB is a simple procedure that possesses advantages such as a high safety profile and exerting an extensive analgesic effect[9] and has been progressively applied to perioperative analgesia in thoracic, abdominal, breast, and orthopedic surgeries.[10] Although more and more randomized controlled trials (RCTs) are exploring its role in perioperative analgesia in lumbar spinal surgery, its efficacy and safety remain controversial. Therefore, this study aimed to systematically evaluate the efficacy and safety of ESPB in perioperative pain management for lumbar spinal surgery so as to provide a reference for clinical decision-making.

Materials and Methods

Search Strategy

This study was designed and conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[11] The PubMed, Web of Science, EMBASE, and Cochrane Library databases were comprehensively searched for relevant articles from inception to March 2022. MeSH terms and free-text words were used for the search, including "erector spinae plane block", "erector spinae block", "ESP block", "ESPB", "lumbar", "spine", "spinal", "lumbar spine surgery", "lumbar spinal surgery", "lumbar surgery", "spine surgery" and "spinal surgery" (The search terms and strategy are available in Supplement 1). The search was restricted to the English language. Finally, the systematic review and meta-analysis was registered on the PROSPERO website under the registration number CRD42022371256.

Inclusion and Exclusion Criteria

Inclusion criteria: (1) RCTs; (2) Patients aged more than 18 years old; (3) Patients underwent spinal surgery with general anesthesia; (4) The intervention was ESPB in the experimental group, with no block or sham block in the control group; (5) The studies included at least one outcome that could be used in this meta-analysis. Exclusion criteria: (1) Ongoing RCTs; (2) non-RCTs; (3) Animal experiments or cadaveric studies; (4) Duplicate publications; (5) Reviews, case reports, comments, and conference abstracts; (6) Articles without complete results; (7) Full-text not available.

Articles Selection and Data Extraction

Two researchers (MYF, JLS) independently screened the eligible literature according to the inclusion and exclusion criteria, then two researchers (WJ and LHY) extracted the data and cross-checked. Disagreements between the researchers were resolved by reaching a consensus with a third reviewer (TF). After the retrieved literature was imported into the NoteExpress software for automatic duplicate screening, the title and abstract of each literature were manually examined. After excluding articles that did not meet the inclusion criteria, the full-text of each literature was independently screened to determine whether the literature was eligible to be included in the meta-analysis. If the information provided in included literature was incomplete, the author was contacted to acquire the required information. The following data were extracted from the studies: (1) Characteristics of studies: author, country, year of publication, age of

participants, study design, sample size, type of operation and intervention; (2) Outcomes: intraoperative consumption of opioids, postoperative consumption of opioids, rescue analgesia, time to first rescue analgesic, number of patient-controlled intravenous analgesia (PCIA) button presses, post-operative pain scores at rest and on movement, opioid-related adverse reactions, and ESPB-related complications. Given that the pain score of visual analog scale (VAS) and numerical rating scale (NRS) are both rated on a scale of 0 to 10 points, the assessment of pain was considered equivalent;[12] (3) Information related to the risk of bias assessment and quality assessment. The mean and standard deviation of continuous variables and the event number and total number of discontinuous variables were extracted from the studies. If continuous variables were represented by median, interquartile range, and range, then the approach utilized by Luo et al[13] and Wan et al[14] was used to convert these variables into mean and standard deviation. Notably, the types of opioids used for postoperative analgesia were different in different studies. Thus, in order to standardize outcome measures, postoperative opioid doses were converted to intravenous morphine milligram equivalents (MMA).[15]

Risk of Bias Assessment and Quality Assessment

Two researchers (MYF and JH) and independently evaluated the risk of bias in the included studies, and the results were cross-checked. Discrepancies were resolved by reaching a consensus with a third researcher (YWL). The assessment indicators included 6 aspects and 7 items in total: selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting) and other biases. Finally, each item was evaluated as "low risk", "high risk", or "unclear risk".[16] The risk of bias diagram was drawn using the RevMan 5.3 software.

The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system was employed to assess the quality of evidence for outcomes by two researchers (MYF and JLS).[17] There were five factors that may lower the quality of evidence: risk of bias, inconsistency, imprecision, indirectness, and publication bias. The GRADEpro software was utilized to assess the aforementioned five factors and divide the quality of evidence into the following four levels: high, moderate, low, and very low. The level of evidence represents the strength of evidence.

Statistical Analysis

RevMan 5.3 software provided by Cochrane collaboration was used for this meta-analysis. Continuous variables were represented by mean difference (MD), while discontinuous variables were expressed as risk ratio (RR), and 95% confidence interval (CI) were calculated for each outcome. Heterogeneity among the studies was assessed using the I^2 value and chi-square test. $I^2 \leq 50\%$ and $P > 0.1$ indicated no significant heterogeneity among the studies, then the fixed-effects model was used. In contrast, $I^2 > 50\%$ and $P \leq 0.1$ indicated significant heterogeneity among the studies, and further analysis was conducted to determine the source of heterogeneity, such as subgroup analysis or sensitivity analysis was subsequently carried out. If the source of heterogeneity was not identified, the random-effects model was used for analysis. $P \leq 0.05$ was considered statistically significant. Publication bias was investigated when the number of included studies in an outcome≥10. The RevMan 5.3 software was used to construct the funnel plot, while Stata 12 software was used to draw the Egger's regression chart; publication bias was then assessed according to the symmetry of the funnel chart and Egger's test.[18] If the result of the Egger's test was $P < 0.05$, the Duval and Tweedie trim and fill method was used to evaluate the impact of publication bias on the results of the meta-analysis using the Stata 12 software.

Results

Literature Search and Characteristics

A total of 597 studies were identified by the word search on the four databases, and the NoteExpress software was used to eliminate 249 duplicated studies. After reading the titles and abstracts of the remaining 348 studies, 317 studies that did not meet the inclusion criteria were excluded. Finally, after reading the full-text of the remaining 31 studies, 19 RCTs[19–37] were included in this meta-analysis. The flowchart of the literature screening process is illustrated in Figure 1. A total of 1381 patients were included in this analysis, of which 691 patients were in the ESPB group, and 690 patients were in the control group. The characteristics of the included studies are listed in Table 1.

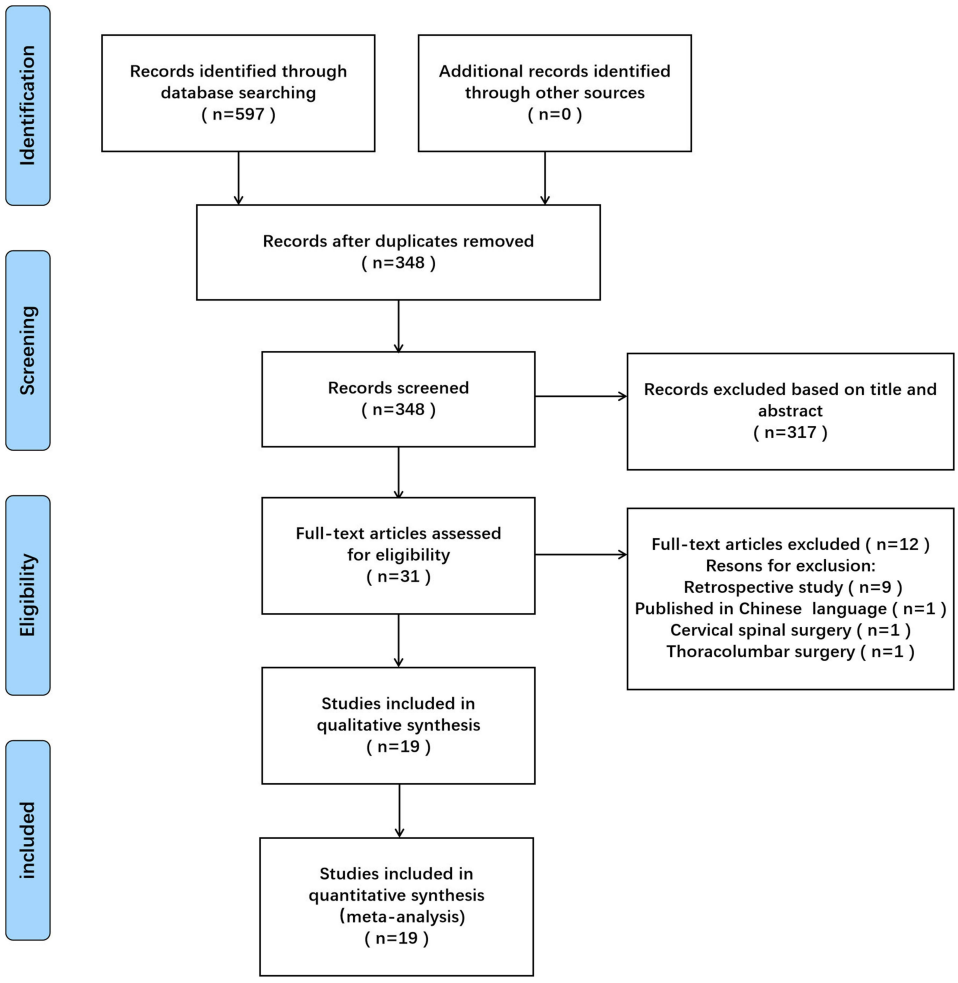

Figure 1 Flowchart of study selection strategy.

Risk of Bias Assessment

The risk of bias of the included 19 RCTs is presented in Table 2 and Figure 2. In terms of random sequence generation, 4 studies only mentioned randomization without providing the randomization process;[21–23,28] the remaining 15 studies reported the randomization method, including random number tables and computer-generated randomization.[19,20,24–27,29–37] Regarding allocation concealment, 8 studies used sealed opaque envelopes,[20–23,27,33,35,37] whereas 11 studies did not report allocation concealment.[19,24–26,28–32,34,36] Concerning blinding of participants and personnel, 3 studies explicitly reported that blinding was not performed,[19,24,25] 10 studies mentioned the blinding method,[20,21,28–30,32–35,37] while blinding was not mentioned in the remaining 6 studies.[22,23,25,27,31,36] Only 16 out of the 19 included studies reported the implementation of blinding for outcome assessment.[19–21,23–25,27–30,32–37] Complete data were available in 8 studies,[21–26,28,35] while the remaining 11 studies exist certain participants failed to be followed up.[19,20,27,29–34,36,37] Selective reporting was identified in one study,[35] given that the study excluded unsatisfied outcomes. Other biases were not unclear in the included studies.

Meta-Analysis Results

Intraoperative Sufentanil Consumption (mg)

4 RCTs reported on intraoperative sufentanil consumption.[21,27,31,33] The pooled effect size of the 4 RCTs revealed that heterogeneity was significantly high (I^2= 96%, P<0.00001). Then, sensitivity analysis was performed, and the result showed that heterogeneity was still high. Thus, the random-effect model was used for the analysis. The result showed that intraoperative sufentanil consumption was significantly lower in the ESPB group compared with the control group (MD=−10.88, 95% CI [−17.14, −4.63], P=0.0006, Figure 3).

Table 1 Characteristics of Included Studies

Author	Year	Country	Study Design	Type of Operation	Age (Years)	Participants (Male/Female)		Intervention			Postoperative Analgesia	Rescue Analgesia	Outcomes
						ESPB Group	Control Group	ESPB Group		Control Group			
								Type and Dose (For Each Side)	Level				
Yayik AM et al[19]	2019	Turkey	RCT	Single- or two-level open lumbar decompression surgery	18–65	30 (17/13)	30 (19/11)	20 mL 0.25% bupivacaine	L3	No block	IV. 400 mg ibuprofen every 12 hourly; PCIA tramadol	25 mg pethidine when VAS ≥ 4	(3) (5) (6) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (20) (21)
Ghamry ME et al[20]	2019	Egypt	RCT	Posterior lumbar interbody fusion with two level	18–60	30 (16/14)	30 (17/13)	20 mL 0.25% bupivacaine	L3	No block	IV. paracetamol 1 gm every 6 hourly; IV. ketorolac 30 mg loading dose then 15 mg every 8 hourly	IV. morphine 0.1 mg/kg when VAS > 3	(3) (6) (22) (23) (25)
Zhang TJ et al[21]	2020	China	RCT	Open posterior lumbar decompression surgery	18–80	30 (13/17)	30 (8/22)	25 mL 0.3% ropivacaine	T12	No block	PCIA morphine	PCIA morphine bolus	(1) (3) (6) (7) (13) (14) (20) (21) (23)
Siam EM et al[22]	2020	Egypt	RCT	Lumbar spine surgery	>18	15 (11/4)	15 (9/6)	20 mL 0.25% bupivacaine	–	IV. ketorolac 0.75 mg/kg and paracetamol 10 mg/kg	–	IV. pethidine when VAS > 4	(5)(6)
Eskin MB et al[23]	2020	Turkey	RCT	Lumbar decompression surgery at one or two levels	18–80	40 (16/24)	40 (15/25)	20 mL 0.25% bupivacain	T12-L5	No block	IV. paracetamol 1000 mg every 8 hourly; IV. dexketoprofen 50 mg every 24 hourly; PCIA tramadol	IV. pethidine when VAS >3	(5)(6) (8) (9) (10) (11) (12) (13) (14) (26)

(*Continued*)

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Table 1 (Continued).

Author	Year	Country	Study Design	Type of Operation	Age (Years)	Participants (Male/Female)		Intervention			Postoperative Analgesia	Rescue Analgesia	Outcomes
						ESPB Group	Control Group	ESPB Group		Control Group			
								Type and Dose (For Each Side)	Level				
Ciftci B et al[24]	2020	Turkey	RCT	Single-level lumbar discectomy and hemilaminectomy surgery	18–65	30 (16/14)	30 (15/15)	20 mL 0.25% bupivacaine	L3	No bock	IV. 1 g paracetamol every 6 hourly; PCIA fentanyl	IV. morphine 0.5 mg/kg when VAS ≥ 4	(2)(3) (5) (6) (8) (9) (10) (11) (13) (15) (16) (17) (18) (20) (22) (23) (26)
Singh S et al[25]	2020	India	RCT	Lumbar spine surgery	18–65	20 (17/3)	20 (18/2)	20 mL 0.5% bupivacaine	T10	No block	IV. diclofenac 1.5 mg/kg every 8 hourly	IV. morphine 3 mg on demand or when NRS ≥ 4	(3) (5) (6) (8) (9) (10) (11) (12) (13)
Yu Y et al[26]	2020	China	RCT	Posterior internal fixation for single-level lumbar fracture	26–67	40 (19/21)	40 (17/23)	30 mL 0.25% bupivacaine	T7	Physiological saline	PCIA sufentanil and flurbiprofen	IM. pethidine hydrochloride when NRS> 4	(2) (4) (7) (13) (14) (19) (21) (22) (23) (26)
Zhang JJ et al[27]	2021	China	RCT	Lumbar spine surgery	18–80	30 (13/17)	30 (8/21)	25 mL 0.3% ropivacaine	T10	No block	PCIA morphine	PCIA morphine bolus	(1) (3) (4) (6) (13) (14) (20) (21)
Zhu L et al[28]	2021	China	RCT	Posterior lumbar fusion surgery	45–70	20 (7/13)	20 (8/12)	20 mL 0.375% ropivacaine	L2	20 mL physiological saline	PCIA oxycodone	IV. 5 μg sufentanil when VAS ≥ 4	(2) (4) (5) (13) (20) (24)
Yeşiltaş S et al[29]	2021	Turkey	RCT	Posterior spinal instrumentation and fusion	>18	30 (11/17)	30 (7/21)	20 mL (1:1) mixture solution of 0.25% bupivacaine and 1.0% lidocaine	–	20 mL physiological saline	IV. 1 g paracetamol thrice/day; PCIA morphine	25 mg pethidine when VAS ≥ 4	(3) (5) (6) (7) (8) (9) (12) (13)

Yörükoğlu HU et al[30]	2021	Turkey	RCT	Single-level lumbar microdiscectomy	18–65	28	26	20 mL 0.25% bupivacaine	L4	20 mL physiological saline	PCIA morphine	IV. 20 mg tenoxicam when NRS > 3	(3) (5) (12) (13)
Wang L et al[31]	2021	China	RCT	Lumbar spine fusion surgery	>18	102 (44/58)	102 (51/51)	30 mL 0.375% ropivacaine	T12	No block	PCIA sufentanil and flurbiprofen	IV. sufentanil 5 μg when NRS > 5	(1) (2) (4) (5) (26)
Wahdan AS et al[32]	2021	Egypt	RCT	Lumbar spine surgery at two levels	18–65	70 (36/34)	70 (38/32)	20 mL 0.25% levobupivacaine	–	20 mL physiological saline	IV. 30 mg ketorolac every 8 hourly; IV. morphine when patients requested; PCIA morphine	PCIA morphine bolus when VAS ≥ 4	(3)(6) (22) (23)
Jin Y et al[33]	2021	China	RCT	Two- or three-level lumbar laminoplasty	>18	30 (12/18)	32 (15/17)	20 mL 0.375% ropivacaine	L2-L5	No block	PCIA sufentanil and dezocine	IV. 40 mg sodium parecoxib and im. 50 mg pethidine VAS ≥ 4	(1) (4) (7) (22) (23) (24) (25)
Goel VK et al[34]	2021	India	RCT	Single-level transforaminal lumbar inter-body fusion surgery	18–78	51 (21/30)	50 (21/29)	20 mL 0.25% bupivacaine	–	No block	IV.1 gm paracetamol every 6 hourly and 30 mg ketorolac every 8 hourly; oral 75 mg pregabalin every 12 hourly	IV. fentanyl 1 mcg/kg when VAS≥5	(8) (9) (10) (12) (13) (14) (26)
Zhang Q et al[35]	2021	China	RCT	Primary open posterior lumbar spinal fusion surgery	20–75	30 (6/24)	30 (9/21)	20 mL 0.4% ropivacaine	L3	Sham blocks (subcutaneous infiltration 1mL 1% lidocaine)	IV. 300 mg flurbiprofen; PCIA sufentanil	PCIA sufentanil bolus when NRS ≥ 4	(2) (3) (4) (5) (24)
Taşkaldıran Y[36]	2021	Turkey	RCT	Lumbar herniated disc surgery	18–75	30 (16/14)	30 (15/15)	20 mL 0.25% bupivacaine	L3	No block	PCIA fentanyl	IM. diclofenac Na when NRS > 4	(3)(12) (13) (19)

(*Continued*)

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Table 1 (Continued).

Author	Year	Country	Study Design	Type of Operation	Age (Years)	Participants (Male/Female)		Intervention			Postoperative Analgesia	Rescue Analgesia	Outcomes
						ESPB Group	Control Group	ESPB Group		Control Group			
								Type and Dose (For Each Side)	Level				
Asar S et al[37]	2022	Turkey	RCT	Open lumbar spine surgery	18–75	35 (6/29)	35 (11/24)	10 mL 0.5% bupivacaine, 5 mL of lidocaine, and 5 mL 0.9% NaCl	T10	No block	IV. 1 gr paracetamol thrice/day; PCIA tramadol	IM. 75 mg diclofenac sodium when NRS > 4	(3) (7) (12) (13) (22) (23) (26)

Notes: Outcomes: (1) Intraoperative sufentanil consumption; (2) Intraoperative remifentanil consumption; (3) Total opioid consumption within 24h after surgery; (4) Total opioid consumption within 48h after surgery; (5) Rescue analgesia; (6) Time to first rescue analgesic; (7) PCIA button pressing number; (8) Postoperative pain score at rest: 0 h; (9) Postoperative pain score at rest: 2 h; (10) Postoperative pain score at rest: 4 h; (11) Postoperative pain score at rest: 8 h; (12) Postoperative pain score at rest: 12 h; (13) Postoperative pain score at rest: 24 h; (14) Postoperative pain score at rest: 48 h; (15) Postoperative pain score om movement: 0 h; (16) Postoperative pain score on movement: 2 h; (17) Postoperative pain score on movement: 4 h; (18) Postoperative pain score on movement: 8h; (19) Postoperative pain score on movement: 12 h; (20) Postoperative pain score on movement: 24 h; (21) Postoperative pain score on movement: 48 h; (22) Nausea; (23) Vomiting; (24) Dizziness; (25)Somnolence; (26) Itching.

Abbreviations: ESPB, erector spinae plane block; RCT, randomized controlled Trials; PCIA, patient controlled intravenous analgesia; VAS, visual analogue scale; NRS, numerical rating scale; L, lumbar; IV, intravenous injection; IM, intramuscular injection.

Table 2 Author's Judgements About Each Risk of Bias for Each Included Study Based on Cochrane Risk of Bias Assessment Items

Included Studies	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting	Other Bias
Yayik AM et al, 2019[19]	+	?	–	+	–	+	?
Ghamry ME et al, 2019[20]	+	+	+	+	–	+	?
Zhang TJ et al, 2020[21]	?	+	+	+	+	+	?
Siam EM et al, 2020[22]	?	+	?	?	+	+	?
Eskin MB et al, 2020[23]	?	+	?	+	+	+	?
Ciftci B et al, 2020[24]	+	?	–	+	+	+	?
Singh S et al, 2020[25]	+	?	–	+	+	+	?
Yu Y et al, 2020[26]	+	?	?	?	+	+	?
Zhang JJ et al, 2021[27]	+	+	?	+	–	+	?
Zhu L et al, 2021[28]	?	?	+	+	+	+	?
Yeşiltaş S et al, 2021[29]	+	?	+	+	–	+	?
Yörükoğlu HU, 2021[30]	+	?	+	+	–	+	?
Wang L et al, 2021[31]	+	?	?	?	–	+	?
Wahdan AS et al, 2021[32]	+	?	+	+	–	+	?
Jin Y et al, 2021[33]	+	+	+	+	–	+	?
Goel VK et al, 2021[34]	+	?	+	+	–	–	?
Zhang Q et al, 2021[35]	+	+	+	+	+	+	?
Taşkaldıran Y, 2021[36]	+	?	?	+	–	+	?
Asar S et al, 2022[37]	+	+	+	+	–	+	?

Notes: "+", Low Risk of Bias; "–", High Risk of Bias; "?", Unclear.

Intraoperative Remifentanil Consumption (μg)

5 RCTs reported on intraoperative remifentanil consumption.[24,28,31,32,35] The pooled effect size of the 5 RCTs showed that heterogeneity was significantly high (I^2= 98%, P<0.00001). Further sensitivity analysis found that heterogeneity was still high; hence, the random-effect model was used for this analysis. The result exposed that intraoperative remifentanil

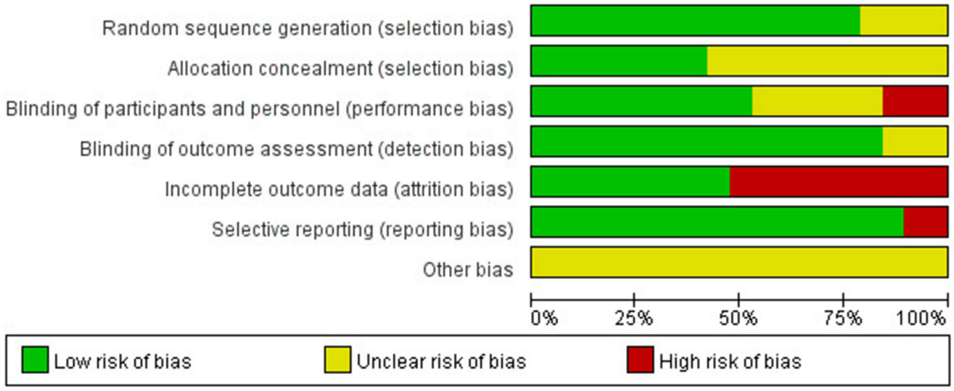

Figure 2 Risk of bias summary of the included studies.

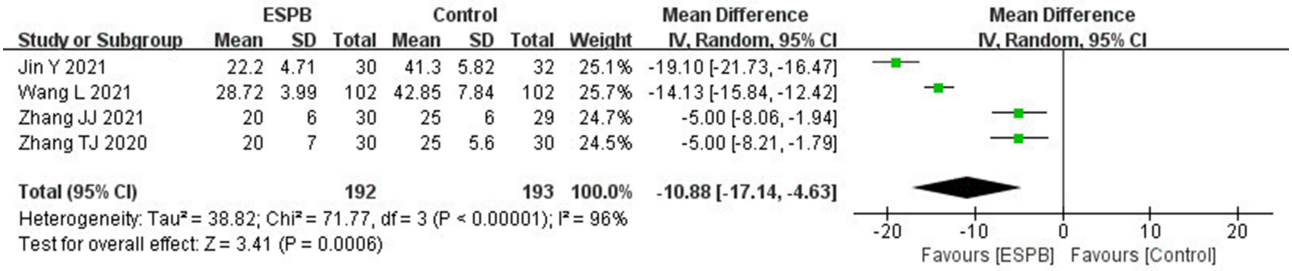

Figure 3 Forest plot for comparison of intraoperative sufentanil consumption between the ESPB group and control group.

consumption was significantly lower in the ESPB group compared to the control group (MD=−286.59, 95% CI [−386.94, −186.25], P<0.00001, Figure 4).

Total Opioid Consumption Within 24 h After Surgery (mg)

13 RCTs reported on total opioid consumption within 24 h after surgery,[19–21,24–27,29,30,32,35–37] of which morphine was administered in 8 RCTs[20,21,25,27,29,30,32,37] and fentanyl was used in 2 RCTs.[24,36] Likewise, sufentanil was given in 2 RCTs,[26,35] and tramadol in 1 RCT.[19] The pooled effect size of the 13 RCTs showed that heterogeneity was significantly high (I^2= 97%, P<0.00001) and remained high after performing sensitivity and subgroup analyses. Therefore, the random-effect model was used for the analysis. The result demonstrated that total opioid consumption within 24 h after surgery was significantly lower in the ESPB group in comparison to the control group (MD=−9.81, 95% CI [−12.64, −6.97], P<0.00001, Figure 5).

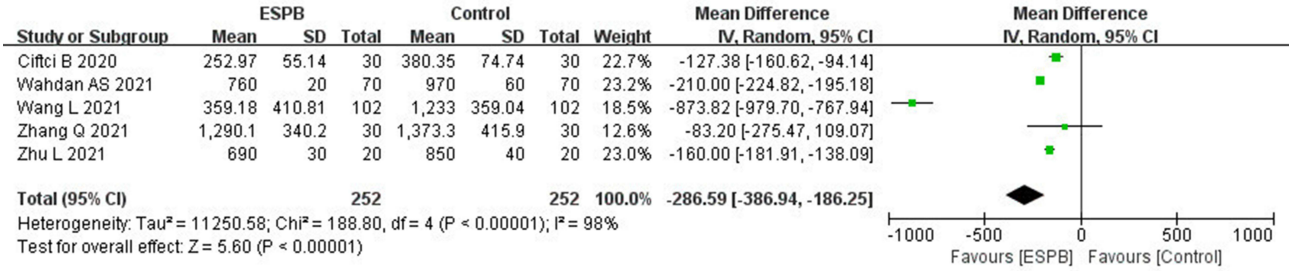

Figure 4 Forest plot for comparison of intraoperative remifentanil consumption between the ESPB group and control group.

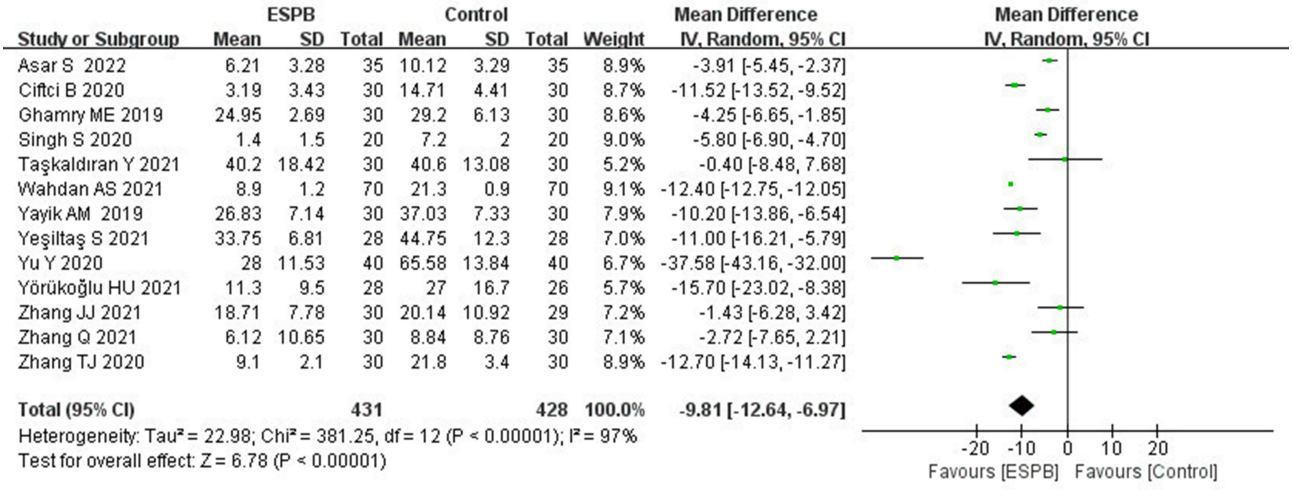

Figure 5 Forest plot for comparison of total opioid consumption within 24 h after surgery between the ESPB group and control group.

Total Opioid Consumption Within 48 h After Surgery (mg)

6 RCTs reported on total opioid consumption within 48 h after surgery,[26–28,31,33,35] of which 2 RCTs used morphine,[27,33] 3 RCTs utilized sufentanil[26,31,35] and 1 RCT used oxycodone.[27] The pooled effect size of the 6 RCTs revealed that heterogeneity was significantly high (I^2= 97%, P<0.00001) and remained high after sensitivity and subgroup analyses were performed. Thus, the random-effect model was used for the analysis. The analysis found that total opioid consumption within 48 h after surgery was significantly lower in the ESPB group compared to the control group (MD=−16.58, 95% CI [−28.99, −4.16], P=0.009, Figure 6).

Rescue Analgesia

A total of 10 RCTs reported on the use of rescue analgesia.[19,22–25,28–31,35] The pooled effect size of the 10 RCTs showed that heterogeneity was significantly high (I^2= 95%, P=0.61). Sensitivity analysis was subsequently conducted, showing that the sources of heterogeneity were predominantly from the studies conducted by Siam et al[22] and Zhang et al.[35] Then, there was no evidence of heterogeneity after excluding the two studies (Siam et al[22] and Zhang et al[35]) (I^2= 0%, P=0.61). Therefore, the fixed-effect model was used for this analysis, and the result showed that the incidence of rescue analgesia was significantly lower in the ESPB group compared to the control group (RR=−0.33, 95% CI [0.25, 0.43], P<0.00001, Figure 7).

Time to First Rescue Analgesic (min)

A total of 9 RCTs reported the time to first rescue analgesic.[19–23,25,27,29,32] The pooled effect size of the 9 RCTs showed that heterogeneity was significantly high (I^2=100%, P<0.00001), and sensitivity analysis was thus performed. Considering that heterogeneity remained high following sensitivity analysis, the random-effect model was used for the

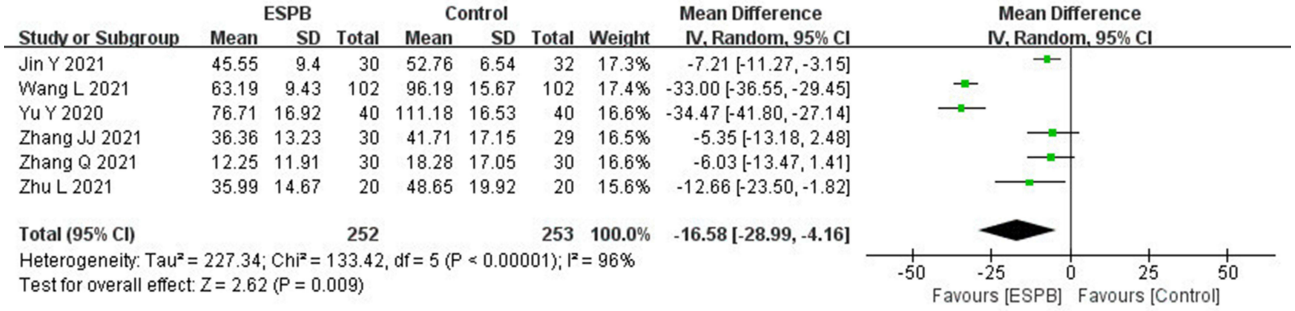

Figure 6 Forest plot for comparison of total opioid consumption within 48 h after surgery between the ESPB group and control group.

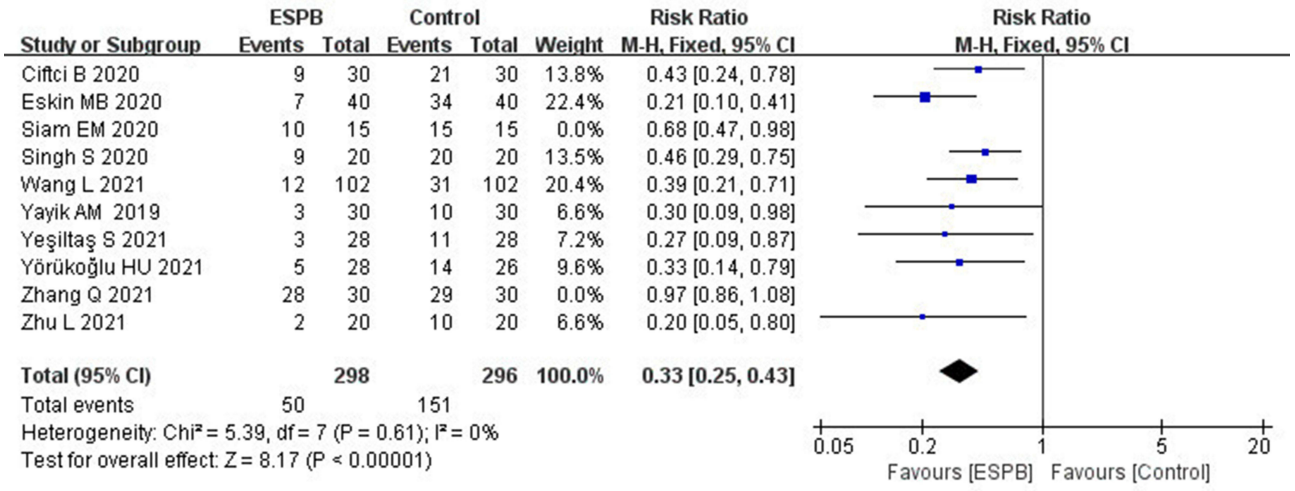

Figure 7 Forest plot for comparison of rescue analgesia between the ESPB group and control group.

analysis. The result exhibited that the time to first rescue analgesic was significantly longer in the ESPB group compared to the control group (MD=373.04, 95% CI [175.76, 570.32], *P*=0.0002, Figure 8).

PCIA Button Pressing Number (Times)

A total of 5 RCTs reported the times of PCIA button presses.[21,26,29,33,37] The pooled effect size of the 5 RCTs found that heterogeneity was significantly high (I^2=98%, *P*<0.00001) and remained high after the sensitivity analysis. Thus, the random-effect model was used for this analysis. The result showed the times of PCIA button presses in the ESPB group was significantly lower compared with the control group (MD=−13.98, 95% CI [−23.49, −4.48], *P*=0.004, Figure 9).

Postoperative Pain Scores (VAS/NRS) at Rest

A total of 13 RCTs reported on postoperative pain scores at rest,[19,21,23–30,34,36,37] of which 6 RCTs utilized VAS[19,23,24,28,29,36] while the remaining 7 RCTs used NRS.[21,25–27,30,34,37] The analysis determined that the postoperative pain scores at rest were significantly lower in the ESPB group in comparison to the control group at 0 h postoperatively (MD=−2.84, 95% CI [−3.06, −2.63], *P*<0.00001; I^2=0%, *P*=0.63), 2 h postoperatively (MD=−1.43, 95% CI [−2.23, −0.63], *P*=0.0005; I^2=94%, *P*<0.00001), 4 h postoperatively (MD=−1.14, 95% CI [−2.05, −0.24], *P*=0.01; I^2=95%, *P*<0.0001), 8 h postoperatively (MD=−1.90, 95% CI [−2.21, −1.59], *P*<0.00001; I^2=0%, *P*=1.00), 12 h postoperatively (MD=−0.46, 95% CI [−0.75, −0.18], P=0.002; I^2=35%, *P*=0.17), 24 h postoperatively (MD=−0.59, 95% CI [−0.73, −0.46], *P*<0.00001; I^2=0%, *P*=0.51) and 48 h postoperatively (MD=−0.30, 95% CI [−0.54, −0.06], *P*=0.02; I^2=51%, *P*=0.09) (Figure 10).

Postoperative Pain Scores (VAS/NRS) on Movement

A total of 7 RCTs described postoperative pain scores on movement,[19,21,24,26–28,36] among which 4 RCTs used VAS[19,24,28,36] and 3 RCTs used NRS.[21,26,27] The result showed that the postoperative pain scores on movement in the ESPB group were significantly lower in comparison to the control group at 0 h postoperatively (MD=−2.79, 95% CI [−3.20, −2.37], *P*<0.00001; I^2=0%, *P*=0.62), 2 h postoperatively (MD=−2.28, 95% CI [−2.84, −1.72], *P*<0.00001; I^2=73%, *P*=0.05), 4 h postoperatively (MD=−1.62, 95% CI [−2.86, −0.39], *P*=0.010; I^2=94%, *P*<0.0001), 8 h postoperatively (MD=−1.71, 95% CI [−2.90, −0.53],

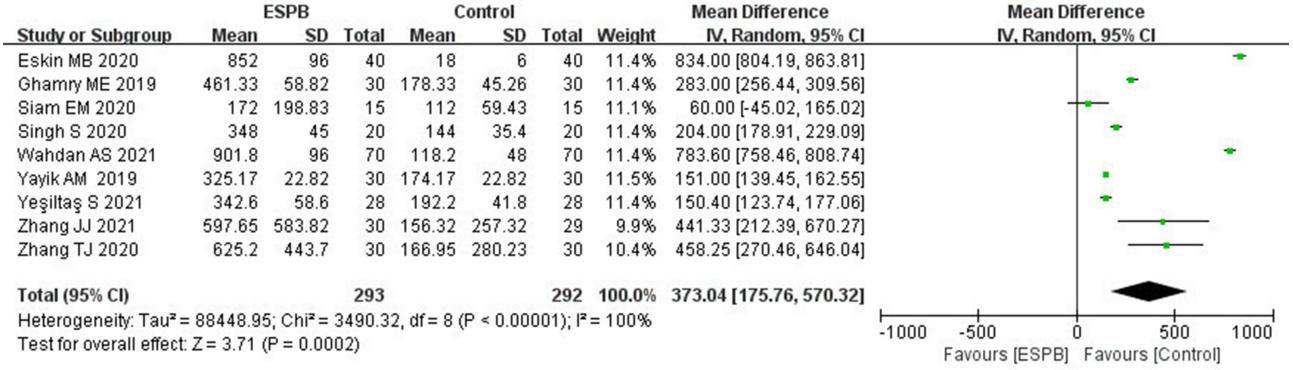

Figure 8 Forest plot for comparison of time to first rescue analgesic between the ESPB group and control group.

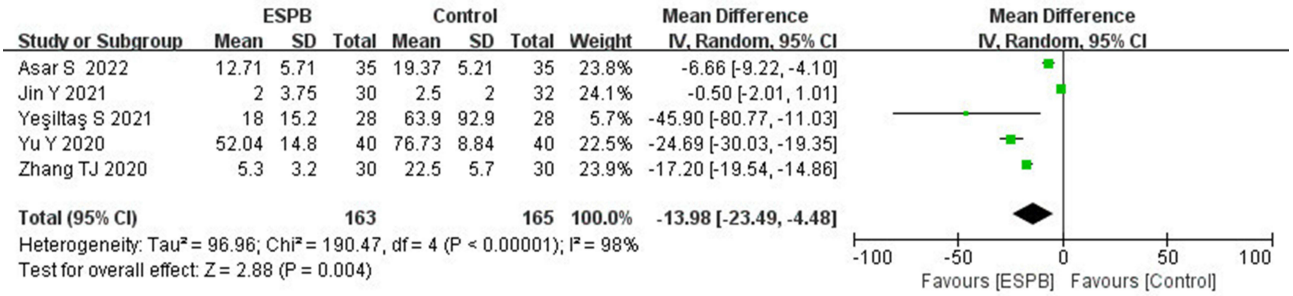

Figure 9 Forest plot for comparison of PCA button pressing number between the ESPB group and control group.

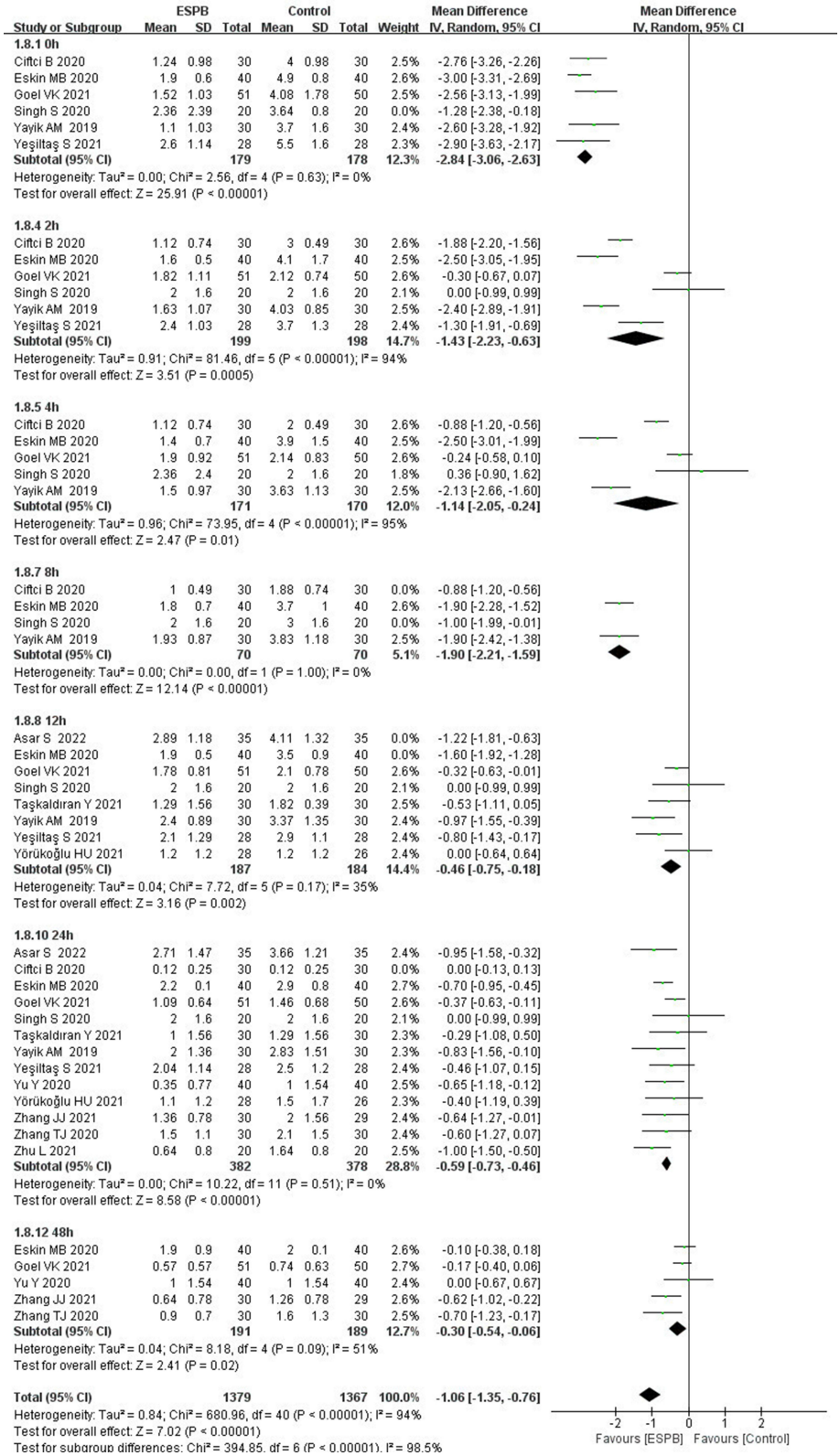

Figure 10 Forest plot for comparison of postoperative pain scores at rest between the ESPB group and control group.

P=0.005; I^2=95%, *P*<0.0001), 12 h postoperatively (MD=−1.07, 95% CI [−1.96, −0.19], *P*=0.002; I^2=88%, *P*=0.0003), 24 h postoperatively (MD=−0.72, 95% CI [−0.95, −0.49], *P*<0.00001; I^2=0%, *P*=0.83) and 48 h postoperatively (MD=−1.19, 95% CI [−1.64, −0.73], *P*<0.00001; I^2=0%, *P*=0.44) (Figure 11).

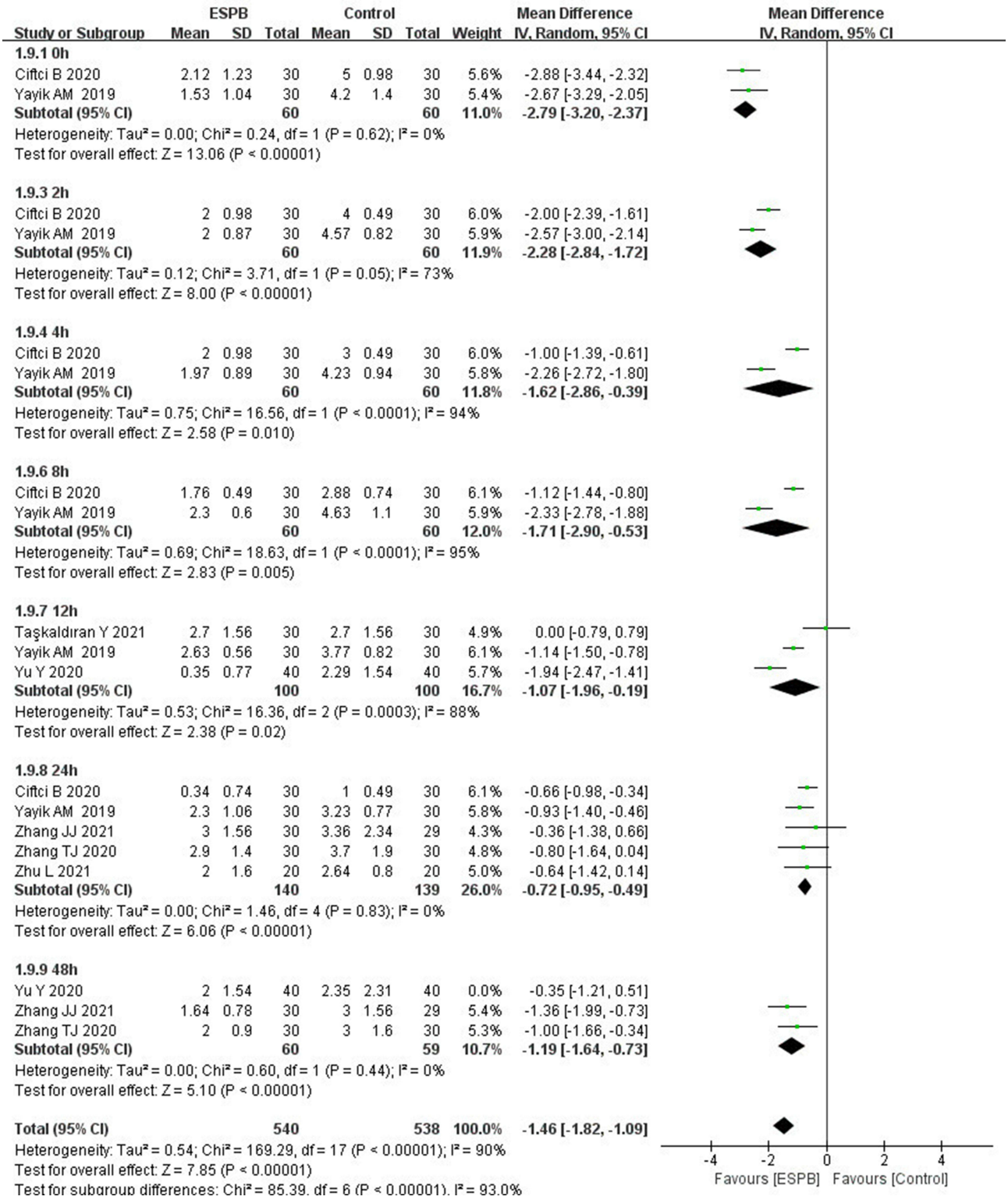

Figure 11 Forest plot for comparison of postoperative pain scores on movement between the ESPB group and control group.

Opioid-Related Adverse Reactions

A total of 13 RCTs reported postoperative opioid-related adverse reactions,[20,21,23,24,26,28,30–35,37] of which 7 RCTs reported nausea,[20,24,26,30,32,33,37] 8 RCTs reported vomiting,[20,21,24,26,30,32,33,37] 3 RCTs reported dizziness,[28,33,35] 3 RCTs reported somnolence,[20,31,33] and 6 RCTs reported itching.[23,24,26,31,34,37] The result showed that there was no significant difference

between the ESPB group and control group in the incidence of postoperative dizziness (RR=0.61, 95% CI [0.20, 1.85], P=0.38; I^2=0%, P=0.94). In contrast, the result revealed that the ESPB group was associated with a lower incidence of nausea (RR=0.40, 95% CI [0.27, 0.60], P<0.00001; I^2=0%, P=0.79), vomiting (RR=0.43, 95% CI[0.26, 0.71], P=0.001; I^2=3%, P=0.41), somnolence (RR=0.28, 95% CI [0.11, 0.74], P=0.01; I^2=0%, P=0.55) and itching (RR=0.46, 95% CI [0.27, 0.77], P=0.003; I^2=36%, P=0.16) (Figure 12).

ESPB-Related Complications

There were no ESPB-related complications reported in all included studies, such as hematoma or infection at the puncture site, injury of the vertebral nerves, and toxicity of local anesthetic.

Sensitivity and Subgroup Analyses

The time to first rescue analgesic was associated with high heterogeneity (I^2=100%, P<0.00001); sensitivity analysis was performed by excluding one study at a time from the meta-analysis to explore the source of heterogeneity. Heterogeneity was still high, indicating that the meta-analysis results were relatively reliable. Afterward, subgroup analysis was conducted on 7 studies using either bupivacaine or levobupivacaine in order to exclude the influence of the type of local anesthetics.[19,20,22,23,25,29,32] Heterogeneity was still high (I^2=100%, P<0.00001), which may arise from differences in drug concentration, block level, type of operation, and study area. Finally, conducting a subgroup analysis on the remaining 2 studies[21,27] using ropivacaine revealed that there was no evidence of heterogeneity (I^2=0%, P=0.91). The pooled effect size of the 5 studies[21,23,26,27,34] with regard to post-operative pain score at rest at 48 h showed that the pain score in the ESPB group was significantly lower than that in the control group (MD=−0.30, 95% CI [−0.54, −0.06], P=0.02; I^2=51%, P=0.09). However, when subgroup analysis was conducted according to the type of local anesthetic, the pooled effect size of 3 studies[23,26,34] that used bupivacaine showed that there was no significant difference between the ESPB and control groups (MD=−0.13, 95% CI [−0.31, −0.04], P=0.14; I^2=0%, P=0.86). However, the pooled effect size of the remaining 2 studies[21,27] that used ropivacaine showed that the postoperative pain score at rest at 48 h in the ESPB group was significantly lower than that in the control group (MD=−0.65, 95% CI [−0.97, −0.33], P<0.001; I^2=0%, P=0.81).

Similarly, sensitivity and subgroup analyses were conducted for intraoperative sufentanil consumption, intraoperative remifentanil consumption, total opioid consumption within 24 h after surgery, total opioid consumption within 48 h after surgery, number of PCIA button presses, postoperative pain scores at rest at 2 h and 4 h, postoperative pain score on movement at 12 h, and heterogeneity was still high, implying that the meta-analysis results were reliable. When sensitivity analysis was performed on rescue analgesia, postoperative pain scores at rest at 0 h, 8 h, 12 h, and 24 h, there was no significant heterogeneity when re-performing the meta-analysis of the remaining studies after excluding the studies one by one, and this did not significantly affect the pooled effect; the model still favored ESPB over control.

Publication Bias Assessment

Funnel plots and Egger's regression charts were constructed for two outcomes, namely total opioid consumption within 24 h after surgery and post-operative pain score at rest at 24 h, while the Egger's test was used to detect publication bias. The funnel plot of total opioid consumption within 24 h after surgery was asymmetric (Figure 13A) and combined with the result of the Egger's test (t= −8.48, P=0.000), indicated possible publication bias (Figure 14A). The Duvaland Tweedie trim and fill method was used to address publication bias by re-computing the pooled effect; the corrected pooled effect was statistically significant [MD= −2.167, 95% CI (−3.049, −1.284), P=0.00], signaling that the result was robust and publication bias had a marginal influence on total opioid consumption within 24 h after surgery. The funnel plot of post-operative pain score at rest at 24 h was relatively symmetrical (Figure 13B) and, in conjunction with the result of the Egger's test (t=0.04, P=0.967), demonstrated that there was a low likelihood of publication bias (Figure 14B).

Grade Assessment

The GRADE system was used to evaluate the quality of evidence, results showed that the quality of evidence for all results was every low to moderate. The summary result of the outcomes and quality of evidence were shown in Table 3.

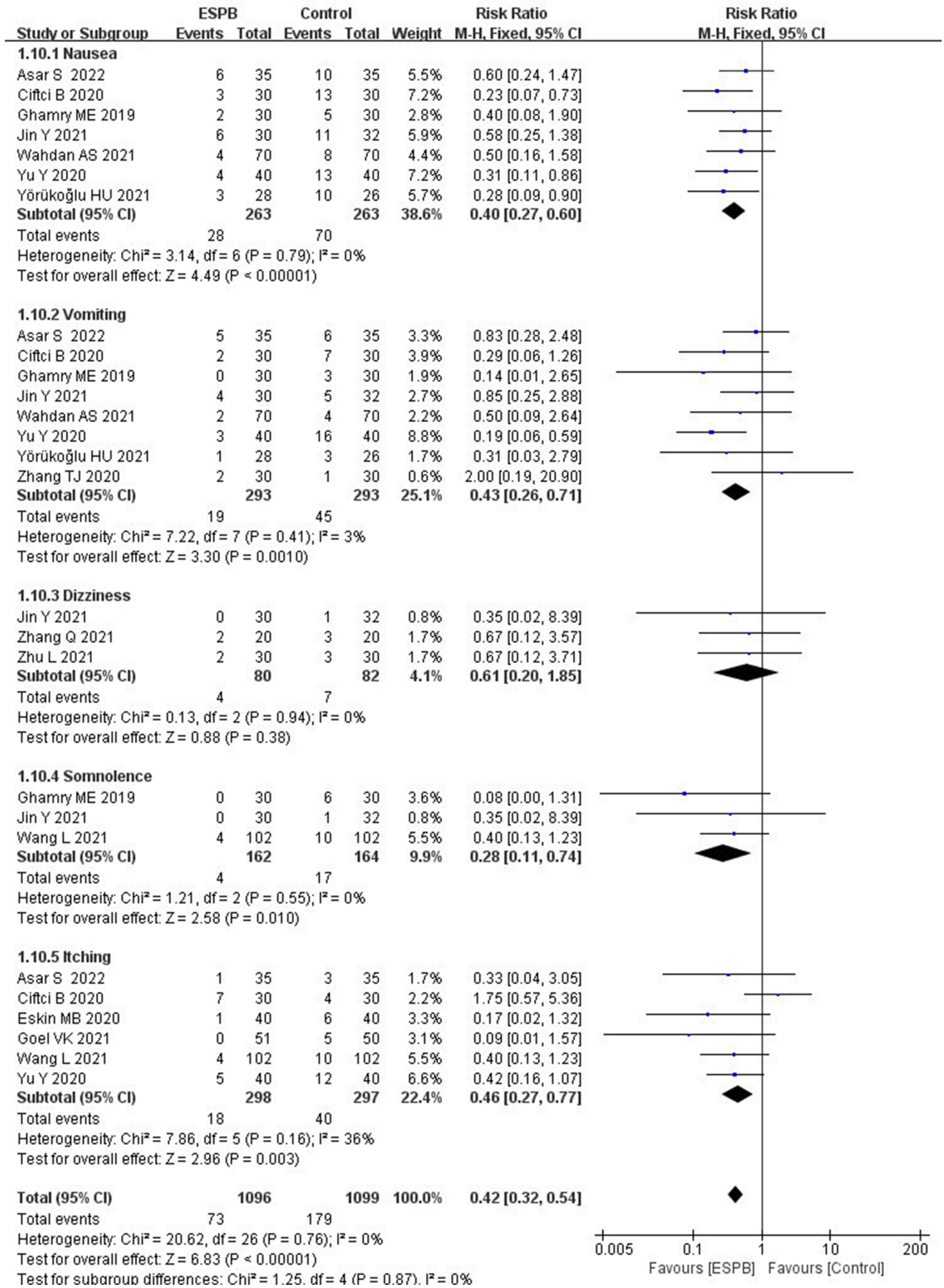

Figure 12 Forest plot for comparison of postoperative complications between the ESPB group and control group.

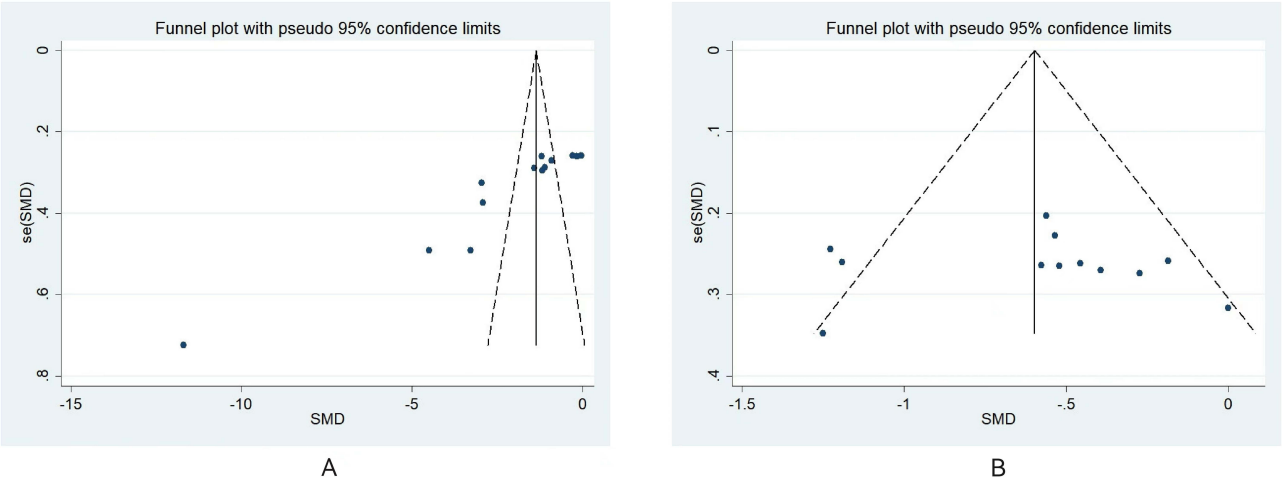

Figure 13 Funnel plot for publication bias assessment of total opioid consumption within 24h after surgery (**A**) and postoperative pain score at rest at 24h (**B**).

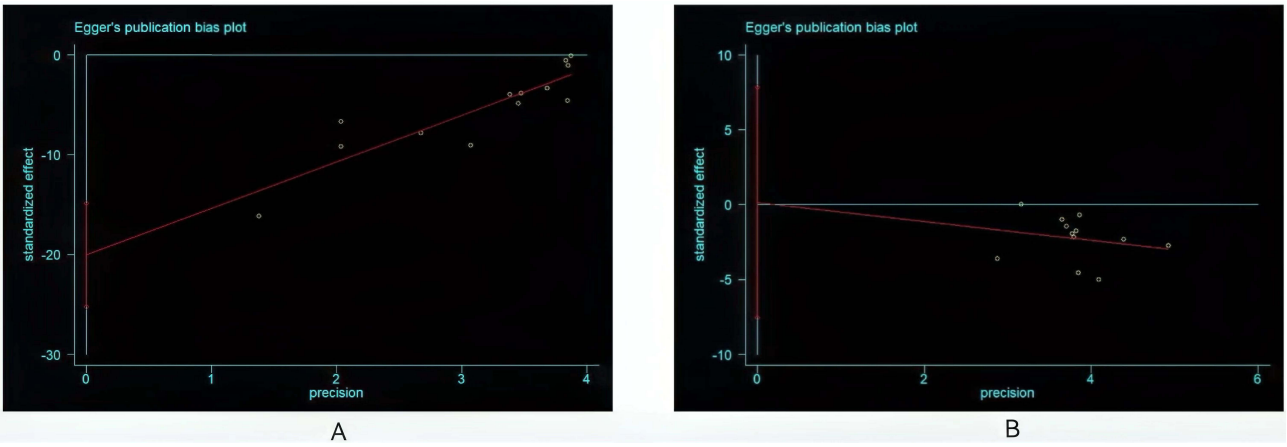

Figure 14 Egger's publication bias plot of total opioid consumption within 24h after surgery (**A**) and postoperative pain score at rest at 24h (**B**).

Discussion

In recent years, the concept of enhanced recovery after surgery (ERAS) has been extensively applied in various surgical modalities, aiming to minimize postoperative complications, shorten hospitalization times, reduce hospitalization costs, improve satisfaction, and accelerate postoperative rehabilitation.[1] Perioperative pain management plays a paramount role in ERAS. The principal source of postoperative pain caused by posterior lumbar spinal surgery is structural damage in the surgical area, such as decollement of paravertebral muscles, discectomy and destruction of bony structures, which generates a large amount of inflammatory mediators in the local area or plasma, and continuously stimulates peripheral receptors, leading to the exacerbation of pain.[38] In addition, central pain is induced by pulling and irritating nerve roots during operation.[38] Numerous drugs and approaches have been used clinically for postoperative analgesia in lumbar spinal surgery, such as non steroidal anti-inflammatory drugs (NSAIDs), opioids, patient-controlled intravenous analgesia, epidural analgesia, and local infiltration analgesia, but they are all associated with adverse reactions.[6] Multiple pain-causing mechanisms work synergistically to cause severe, lasting pain following posterior lumbar spinal surgery. However, the implementation of multimodal analgesia can better manage posterior pain and lower the incidence of adverse reactions.[6,39] As previously mentioned, ESPB has become an integral part of multimodal analgesia, and more and more clinical studies have been conducted on the analgesic effect of ESPB in posterior spinal surgery.[19–37]

Table 3 Summary Result of Outcomes and Quality of Evidence

Outcomes	Number of Studies	RR/ MD	95% CI	*P* value	I^2	Favour	Quality of Evidence					Overall GRADE Quality Score
							Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	
Intra-operative sufentanil consumption (mg)	4	−10.88	−17.14, −4.63	0.0006	96%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
Intra-operative remifentanil consumption (μg)	5	−286.59	−386.94, −186.25	<0.00001	98%	ESPB group	Serious	Serious	Not serious	Not Serious	Undetected	⊕⊕OO, Low
Total opioid consumption after surgery (mg)												
Within 24h	13	−9.81	−12.64, −6.97	<0.00001	97%	ESPB group	Serious	Serious	Not serious	Not Serious	Strong suspected	⊕OOO, Every low
Within 48h	6	−16.58	−28.99, −4.16	0.009	96%	ESPB group	Serious	Serious	Not serious	Not Serious	Undetected	⊕⊕OO, Low
Rescue analgesia	8	−0.33	0.25, 0.43	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Not Serious	Undetected	⊕⊕⊕O, Moderate
Time to first rescue analgesic (min)	9	373.04	175.76, 570.32	0.0002	100%	ESPB group	Serious	Serious	Not serious	Not Serious	Undetected	⊕⊕OO, Low
PCIA button pressing number (times)	5	−13.98	−23.49, −4.48	0.004	98%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
Post-operative pain scores at rest												
0 h	5	−2.84	−3.06, −2.63	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Not Serious	Undetected	⊕⊕⊕O, Moderate
2h	6	−1.43	−2.23, −0.63	0.0005	94%	ESPB group	Serious	Serious	Not serious	Not Serious	Undetected	⊕⊕OO, Low
4h	5	−1.14	−2.05, −0.24	0.01	95%	ESPB group	Serious	Serious	Not serious	Not Serious	Undetected	⊕⊕OO, Low
8h	2	−1.90	−2.21, −1.59	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Serious	Undetected	⊕⊕OO, Low
12h	6	−0.46	−0.75, −0.18	0.002	35%	ESPB group	Serious	Not serious	Not serious	Not Serious	Undetected	⊕⊕⊕O, Moderate
24h	12	−0.59	−0.73, −0.46	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Not Serious	Undetected	⊕⊕⊕O, Moderate
48h	5	−0.30	−0.54, −0.06	0.02	51%	ESPB group	Serious	Serious	Not serious	Not serious	Undetected	⊕⊕OO, Low
Post-operative pain scores on movement												
0 h	2	−2.79	−3.20, −2.37	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Serious	Undetected	⊕⊕OO, Low
2h	2	−2.28	−2.84, −1.72	<0.00001	73%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
4h	2	−1.62	−2.86, −0.39	0.01	94%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
8h	2	−1.71	−2.90, −0.53	0.005	95%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
12h	3	−1.07	−1.96, −0.19	0.02	88%	ESPB group	Serious	Serious	Not serious	Serious	Undetected	⊕OOO, Every low
24h	5	−0.72	−0.95, −0.49	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕O, Moderate
48h	2	−1.19	−1.64, −0.73	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Serious	Undetected	⊕⊕OO, Low
Opioid-related adverse reactions												
Nausea	7	0.40	0.27, 0.60	<0.00001	0%	ESPB group	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕O, Moderate
Vomiting	8	0.43	0.26, 0.71	0.001	3%	ESPB group	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕O, Moderate
Dizziness	3	0.61	0.20, 1.85	0.38	0%	NS	Serious	Not serious	Not serious	Serious	Undetected	⊕⊕OO, Low
Somnolence	3	0.28	0.11, 0.74	0.01	0%	ESPB group	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕O, Moderate
Itching	6	0.46	0.27, 0.77	0.003	36%	ESPB group	Serious	Not serious	Not serious	Not serious	Undetected	⊕⊕⊕O, Moderate

Abbreviations: RR, risk radio; MD, mean difference; CI, confidence interval; GRADE, grading of recommendations assessment, development, and evaluation; NS, not significant; PCIA, patient controlled intravenous analgesia; ESPB, erector spinae plane block.

The posterior branch of the spinal nerve runs backward through the transverse processes of adjacent vertebrae, throwing out branches to innervate the corresponding muscles, bones, ligaments, and other posterior structures,[9] thereby providing an anatomical basis for the application of ESPB in postoperative analgesia for lumbar spinal surgery. Ivanusic et al[40] reported that 20 mL dye was injected between the T5 transverse process and erector spinae muscle, and autopsies revealed that the dye primarily diffused along the deep surface of the erector spinae muscle to the tail side and cranium side and that 25%~70% of the posterior branches of the spinal nerve were stained on the T3-T6 plane. The biggest advantages of ESPB are its simplicity, convenience, and high safety profile. Compared with intraspinal and paravertebral blocks, the target injection point is superficial and far from vital organs and blood vessels, with a low risk of pneumothorax, nerve injury, hematoma, and other complications.[41] Besides, the transverse process and erector spinae muscle are easily identifiable under ultrasound guidance, which is convenient for puncturing and injecting local anesthetics.[42] Herein, none of the 19 included studies reported complications related to ESPB, indicating that it is safe for perioperative analgesia in lumbar spinal surgery.

A total of 19 RCTs were included in this meta-analysis with the purpose of assessing the effectiveness and safety of ESPB for perioperative pain management in lumbar spinal surgery by summarizing the evidence of clinical studies and by describing both the quality of evidence and the strength of recommendations, so as to provide evidence-based medicine for clinical application. This meta-analysis revealed that intraoperative consumption of sufentanil and remifentanil was lower in the ESPB group than that in the control group, suggesting that ESPB for preventive analgesia prior to skin incision in lumbar spinal surgery could block the nociceptive nerve reflex during the surgery, reduce the pain stress reaction, and thus decrease the intraoperative consumption of sufentanil and remifentanil. Pain score is an instrumental index for quantifying postoperative analgesic effects. Our study found that ESPB significantly reduced the pain scores at rest and on movement at every time point within 48 h after lumbar spinal surgery compared with sham block or no block. Previous meta-analyses[3,10,15,43–45] have already established that ESPB can effectively alleviate postoperative pain within 24 hours of spinal surgery, but its efficacy in relieving postoperative pain 48 hours after surgery remains controversial. On the one hand, a meta-analysis conducted by Xiao et al[44] demonstrated that the pain scores at rest and on movement at 48 hours were significantly lower than those in the control group. On the other hand, the meta-analysis performed by Duan et al[45] showed no significant difference in pain scores at rest and on movement at 48 hours between the ESPB and control group. In the present meta-analysis, although no significant differences were noted in pain scores at rest at 48 hours between the ESPB group and control group, the pooled effect was associated with significant heterogeneity. Then, subgroup analysis was conducted according to the type of local anesthetic, and the results showed that ESPB using ropivacaine can prolong the pain relief time to 48 hours after the operation, but there was no significant difference in pain score at 48 hours between the bupivacaine ESPB group and control group. Ropivacaine is a novel type of long-acting amide local anesthetic and is the propyl analog of bupivacaine; it possesses benefits such as lower toxic of cardiovascular and central nervous system compared with bupivacaine.[46] Ropivacaine has the characteristics of separation block in sensory and motor nerves when used at low concentration, chiefly blocking sensory nerve fibers, but has almost no blocking effect on motor nerve fibers; thus, it is convenient for early rehabilitation exercise in orthopedic patients.[47] More importantly, the combination of local anesthetics and adjuvants can further prolong the duration of action of ESPB. De Cassai et al[48] reported that adrenaline constricts local blood vessels so as to reduce the systemic absorption of local anesthetics, thus prolonging the analgesic time of ESPB. Dexmedetomidine is a highly selective α2 adrenergic receptor agonist that activates the α2 adrenergic receptor. It is abundantly distributed in the central nervous and peripheral nerves, thus exerting analgesic, sedative, and anxiolytic effects. Notably, it does not induce respiratory depression.[49] When dexmedetomidine is used locally, it can promote local vasoconstriction and delay the absorption of local anesthetics, thus prolonging its effect.[50] At the same time, it can reduce the production of inflammatory factors and exerts anti-inflammatory effects.[51] Yi-Han et al[52] demonstrated that the combination of dexmedetomidine and ropivacaine for ESPB following posterior lumbar spine surgery could extend the sensory block and enhance the analgesic effect in a recent randomized controlled study.

Considering that ESPB can effectively relieve pain after lumbar spinal surgery, our meta-analysis also determined that ESPB can effectively decrease the postoperative consumption of opioids, number of PCA button presses, and the rate of rescue analgesia as well as extend the time to the first rescue analgesic drug. The main issues regarding the use of opioids

after surgery are related to opioid-related adverse reactions, including postoperative nausea and vomiting, pruritus, somnolence, dizziness, constipation, urinary retention, respiratory depression, and so on.[5] Our meta-analysis demonstrated that ESPB can reduce the incidence of postoperative nausea, vomiting, dizziness, and itching after lumbar spinal surgery, but there was no significant difference in the incidence of postoperative somnolence between the ESPB group and the control group. The occurrence of opioid-related adverse reactions is theorized to be dose-dependent.[43] This study did not explore the impact of ESPB on recovery after surgery, and its role in the recovery of patients following spinal surgery is unclear. A meta-analysis showed no significant difference in the length of hospital stay and time to first ambulation between the ESPB group and control group,[43] but another meta-analysis described that ESPB can effectively shorten hospital stay.[10] There are many factors that affect the rapid recovery of patients after surgery, and these involve preoperative, perioperative, and postoperative management, as well as multidisciplinary cooperation. However, the majority of studies focused on the impact of pain on rapid recovery after surgery.

Different transverse processes can be selected for ESPB according to the surgical requirements to block posterior branch of the spinal nerve in corresponding ranges. Chin et al[53] performed ESPB at the T7 vertebra level, and the sensory block level could reach to L2 or L3. In addition, Alici et al[54] reported that a high volume (40 mL) single injection lumbar ESPB at L3 vertebra level, analgesia distribution was observed from T10 to S2 with the pin-prick test. Currently, we had not searched for a comparative study on the analgesic effects of thoracic spinal ESPB and lumbar spinal ESPB in postoperative analgesia. Lumbar spinal ESPB is different from thoracic spinal ESPB in that local anesthetics can diffuse along the front of the transverse process to enter the psoas major muscle space and intervertebral foramen region, producing a similar effect of lumbar plexus block. Therefore, Julgar S and Balaban O[55] proposed an improved ESPB, which involves injecting a portion of local anesthetic into the deep surface of the erector spinae muscle and then passing the needle tip beyond the transverse process to inject the remaining local anesthetic between the psoas major muscle and transverse process. Our meta-analysis did not explore whether there were differences between thoracic spinal ESPB and lumbar spinal ESPB in perioperative pain management of lumbar spine surgery, as there were many confounding factors. Therefore, more high-quality randomized controlled trials are needed to verify this in future researches.

This study has the following limitations: To begin, because it is challenging to fully implement randomized control and blinding methods in studies, some of the studies did not report the allocation concealment and blinding methods. Thus, selection bias may have occurred during the selection and allocation of patients, thereby affecting the quality of the included literature. Secondly, most outcomes were associated with significant heterogeneity. Common sources of heterogeneity were comorbidities, surgical segment, surgeon, location of ESPB, and local anesthetic concentration and dose, but the sources of heterogeneity were not identifiable despite performing sensitivity and subgroup analyses. Thirdly, the sample sizes of the included studies were small, which led to a small number of included studies for some outcomes in the meta-analysis, thereby affecting the robustness of the results. Finally, the above reasons led to low evidence of GRADE for each outcome. Thus, the results of this meta-analysis should be interpreted with caution. Therefore, more high-quality, multi-center, large-sample randomized controlled trials are warranted to improve the quality of evidence.

Conclusion

In short, our meta-analysis demonstrated that ESPB used in lumbar spinal surgery is effective in relieving postoperative pain, reducing the intraoperative and postoperative consumption of opioids, reducing the rate of rescue analgesia, reducing the number of PCIA button presses, prolonging the time to first rescue analgesic, and reducing the opioid-related adverse reactions. However, there was insufficient evidence to validate the benefits of ESPB in rapid recovery after lumbar spinal surgery.

Abbreviations

ESPB, erector spinae plane block; RCTs, randomized controlled trials; PCIA, patient controlled intravenous analgesia; MD, mean difference; RR, risk ratio; CI, confidence interval; MMA, multimodal analgesia; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; VAS, visual analogue scale; NRS, numerical rating

scale; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; ERAS, enhanced recovery after surgery; NSAIDs, non-steroidal anti-inflammatory drugs.

Data Sharing Statement

True and reliable.

Ethics Approval and Consent to Participate

Ethical approval or patient consent was not required since the present study was a review of previously published literature.

Disclosure

The authors declare that they have no competing interests.

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