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Erector spinae plane block for spinal surgery: a systematic review and meta-analysis

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Background: Although the erector spinae plane block has been used in various truncal surgical procedures, its clinical benefits in patients undergoing spinal surgery remain controversial. The aim of this meta-analysis was to evaluate the clinical benefits of erector spinae plane block in patients undergoing spinal surgery.
Methods: We searched the Cochrane Library, PubMed, EMBASE, and China National Knowledge Infrastructure for randomized controlled trials comparing the erector spinae plane block with a nonblocked control for spinal surgery.
Results: Twelve studies encompassing 696 subjects were included in our systematic review and meta-analysis. We found that the erector spinae plane block decreased postoperative pain scores and opioid consumption in the postoperative and intraoperative periods. Moreover, it prolonged the time to the first rescue analgesic, reduced the number of patients who required rescue analgesia, and lowered the incidence of postoperative nausea and vomiting. However, it did not exhibit efficacy in decreasing the incidence of urinary retention and itching or shortening the length of hospital stays, or the time to first ambulation.
Conclusions: Erector spinae plane block improves analgesic efficacy among patients undergoing spinal surgery compared with nonblocked controls; however, there is insufficient evidence regarding the benefits of erector spinae plane block for rapid recovery.

Key Words: Analgesia; Analgesics, Opioid; Diskectomy; Enhanced Recovery After Surgery; Erector Spinae Plane Block; Laminectomy; Meta-Analysis; Nerve Block; Neurosurgical Procedures; Pain, Postoperative; Postoperative Nausea and Vomiting; Randomized Controlled Trial.

INTRODUCTION

Spinal surgery is a common type of orthopedic surgery. The various surgical procedures used in this context can damage several different tissues [1]. Insufficient management of postoperative pain in patients undergoing spinal surgery hampers the achievement of enhanced recovery after surgery and increases the risk of postoperative complications, such as thrombosis; moreover, it can also lead to chronic pain, which can seriously affect patient satisfaction and increase the financial burden both at the societal and individual level [2]. Therefore, adequate management

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of pain in patients undergoing spinal surgery is a rewarding but challenging task.

Multimodal analgesia is required for the postoperative management of pain in patients undergoing spinal surgery [2]. Owing to their potent analgesic effect, opioids are the mainstay of the drug management strategy in this context. However, they can result in side effects. Thus, other analgesic modalities are warranted to reduce opioid consumption. Regional anesthesia is advocated for spinal surgery. However, its use in spinal surgery has been limited. Although epidural analgesia was once considered the gold standard for analgesia in the context of spinal surgery [3], it is procedurally complex and may lead to complications; in addition, it may impede the assessment of the patients' postoperative motor function by surgeons [4].

The erector spinae plane block (ESPB) is a new technique for regional anesthesia. It achieves analgesia via the injection of local anesthetics below the erector spinae muscle, thus blocking the dorsal and ventral rami [5]. This technique is very easy to perform. All that is required is to first identify the transverse processes of the spine and then inject the local anesthetic between the transverse process and the erector spinae muscles. There are multiple specific ways to identify the transverse process, including ultrasound, fluoroscopy and anatomical landmarks (*e.g.*, 3 cm lateral to the spinous process). The methods mentioned above are currently available for most physicians or hospitals. In recent years, ESPB has gained a lot of attention due to its safety and its ease of application and is used in a wide range of surgical interventions.

The effectiveness of this nerve block technique has been demonstrated in various trunk surgery procedures, including breast, pulmonary, and cardiac surgeries [6]. Moreover, several studies have examined the usefulness of ESPB in spinal surgery; however, its effectiveness and safety remain controversial [7]. Therefore, we performed this systematic review and meta-analysis of randomized controlled trials (RCTs) to identify the benefits of ESPB in spinal surgery.

MATERIALS AND METHODS

We performed this systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and the Cochrane Handbook for Systematic Reviews of Interventions [8].

1. Data sources and search strategy

The databases Cochrane Library, PubMed, EMBASE, and China National Knowledge Infrastructure (CNKI) were searched up to February 1, 2021. Giving consideration to the quality of Chinese papers, the studies included from the CNKI database are limited to articles published in core journals of Peking University. The search strategy was performed using the combined text words and list shown in **Appendix**. We did not limit the search by language or race. Two authors (Liang and Zhou) independently performed the articles' initial inclusion screening based on their titles and abstracts. Included preliminary articles were then screened again by reading the full texts. The two authors discussed controversial articles until they reached a consensus. Otherwise, a third reviewer (Fan) assessed the article to draw a conclusion. The reference lists of all included articles were also hand searched for further identification of eligible trials.

2. Study selection

The inclusion criteria were RCTs comparing ESPB with patients not receiving a block who underwent spinal surgery. Case reports, non-RCT studies, incomplete clinical trials with no results posted, multiple blocks, or studies using adjuvants were excluded. Conference abstracts without sufficient detail regarding study design or data were also excluded.

3. Data extraction and assessment of the risk of bias

The data and assessed the risk of bias were extracted by two authors (Liang and Zhou) independently. Discrepancies were resolved via discussion with a third author (Fan) to reach a consensus. Primary outcomes included cumulative postoperative intravenous morphine equivalent consumption (mg) at 24 and 48 hours as well as pain score (at rest, during movement, overall) at 12, 24, and 48 hours. Secondary outcomes were cumulative intraoperative intravenous morphine equivalent consumption (mg), time to first rescue analgesic (hour), number of patients requiring rescue analgesia, opioid-related complications (sedation, post operative nausea and vomiting [PONV], itching, urinary retention, constipation *etc.*), complications related to ESPB (including local anesthetic toxicity, bleeding, infection *etc.*), length of hospital stay (days) and time to first ambulation (days). Outcomes reported in fewer than two trials were not included in the analysis. We emailed the authors to obtain original data for studies in which data were incomplete or unclear, but no information was returned from the authors.

The software GetData Graph Digitizer (2.25.0.32, S. Fedorov) was used to interpolate data presented as graphs without listing the values. Studies included used the visual analogue scale or numerical rating scale for pain evalua-

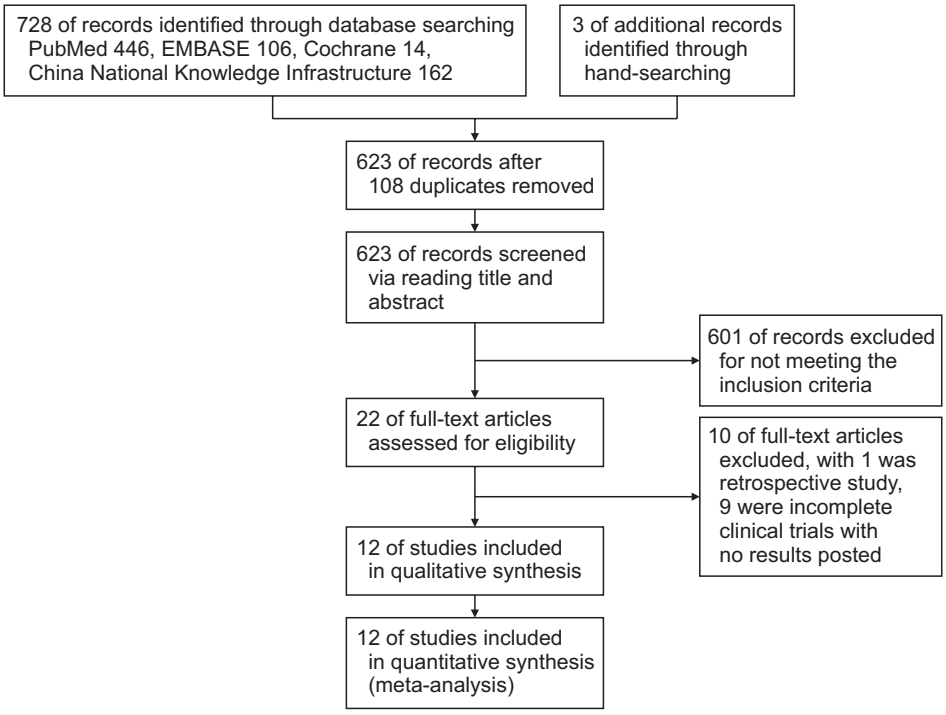

Fig. 1. Study flow diagram.

tion and results were converted to a 0-10 scale for statistical assessment. The dose of analgesic medication used postoperatively was converted to an equivalent dose of intravenous morphine [9]. We converted the median and interquartile range to the mean and standard deviation based on the method reported previously [10]. The methodologic quality and risk of bias of the included trials were assessed following the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) [11]. The Grades of Recommendation, Assessment, Development and Evaluation (GRADE) Working Group [12] was used to assess the quality of evidence of the outcomes.

4. Statistical analyses

We used the Mantel–Haenszel method to analyze dichotomous variables, and the risk ratio with the corresponding 95% confidence interval (CI) was displayed as the effect measure. The mean difference (MD) with the corresponding 95% CI was calculated for units-unified continuous outcomes. All the data were analyzed with a random effect model. We evaluated the heterogeneity between studies via the I^2 statistic with predetermined thresholds for low (25%-49%), moderate (50%-74%), and high (> 75%) levels. To assess publication bias, we created funnel plots of cumulative postoperative intravenous morphine equivalent consumption. We used subgroup analyses for outcomes according to time point of pain measurement. All statistical analyses were performed using Review Manager version 5.3 (Cochrane Collaboration, Software Update, Oxford, UK), and a P value of < 0.05 was considered statistically significant.

RESULTS

We searched the Cochrane Library, PubMed, EMBASE, and CNKI for RCTs comparing ESPB with nonblocked controls for spinal surgery. A total of 728 studies were identified through this search. Three additional potentially relevant articles were found by a hand search of the references. After eliminating duplicates and screening the titles/abstracts of the articles, 22 studies remained for full-text review. Subsequently, one retrospective study and nine incomplete clinical trials lacking results were eliminated. Finally, 12 RCTs [13-24] met the inclusion criteria and were included in the final analysis (**Fig. 1**). Eight articles [13-20] were reported in English and four [21-24] in Chinese.

1. Study characteristics

The characteristics of the studies included in this analysis are presented in **Table 1**. A total of 696 patients were enrolled in this systematic review and meta-analysis: 348 in the ESPB group (patients administered ESPB) and the remaining 348 in the control group (patients administered no block or a sham block). Eleven trials [13-16,18-24] reported the performance of ESPB before the surgery via ultrasound guidance and one trial [17] via intraoperative

Table 1. Characteristics of included studies

Study	Intervention control	No. of patients	Level	Local anesthetics	Confirmation of blocking effect	Type of surgery
Ciftci et al. 2020 [13]	ESPB	30	L3	20 mL 0.25% bupivacaine each side	No	Single-level lumbar discectomy and hemilaminectomy surgery
	No intervention	30	None	None	None	
Eskin et al. 2020 [14]	ESPB	40	T12-L5 single segment	20 mL 0.25% bupivacaine each side	No	Lumbar decompression surgery for one or two vertebral levels
	No intervention	40	None	None	None	
Liu et al. 2019 [21]	ESPB	20	Surgery segments	20 mL 0.4% ropivacaine each side	No	Posterior vertebral surgery
	No intervention	20	None	None	None	
Singh et al. 2020 [15]	ESPB	20	T10	20 mL 0.5% bupivacaine each side	Yes	Prolapsed lumbar intervertebral disk, lumbar stenosis, laminectomy
	No intervention	20	None	None	None	
Wang et al. 2018 [22]	ESPB	30	Surgery segments	15 mL 0.5% ropivacaine each side	No	Posterior lumbar vertebral surgery
	No intervention	30	None	None	None	
Wu et al. 2019 [23]	ESPB	20	L4	20 mL 0.4% ropivacaine each side	Yes	Posterior lumbar interbody fusion
	No intervention	20	None	None	None	
Yayik et al. 2019 [16]	ESPB	30	L4	20 mL 0.25% bupivacaine each side	Yes	Open lumbar decompression
	No intervention	30	None	None	None	
Yeşiltaş et al. 2021 [17]	ESPB	28	Surgery segments	20 mL (1:1) mixture solution of 0.25% bupivacaine and 1.0% lidocaine	No	Posterior spinal instrumentation and fusion for spondylolisthesis
	Saline with no block	28	Surgery segments	20 mL saline	None	
Yu and Guo 2018 [24]	ESPB	30	Surgery segments	20 mL 0.375% ropivacaine each side	No	Lumbar spine surgery
	No intervention	30	None	None	None	
Yu et al. 2021 [18]	ESPB	40	Surgery segments	30 mL 0.25% bupivacaine each side	No	Internal fixation for lumbar spinal fractures
	Saline with no block	40	Surgery segments	30 mL saline each side	None	
Zhang et al. 2021 [19]	ESPB	30	L3	20 mL 0.4% ropivacaine each side	No	Lumbar spinal fusion surgery
	Sham blocks	30	L3	Subcutaneous infiltration (1 mL 1% lidocaine) each side	None	
Zhang et al. 2020 [20]	ESPB	30	T12	25 mL 0.3% ropivacaine each side	Yes	Open posterior lumbar decompression surgery
	No block	30	None	None	None	

ESPB: erector spinae plane block.

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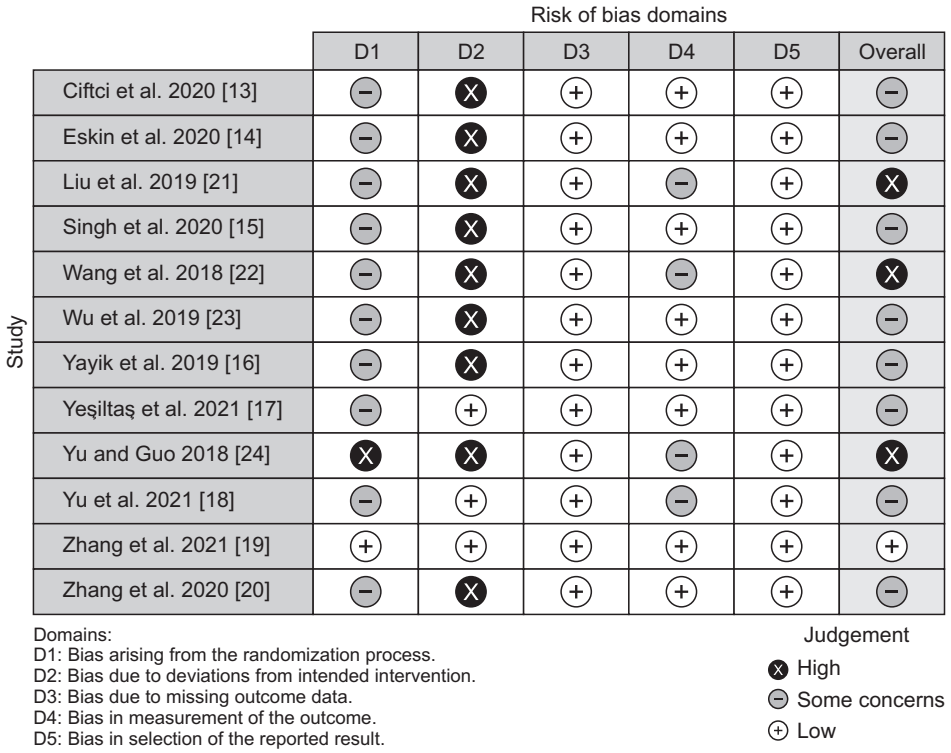

Fig. 2. Risk of bias for each item according to RoB 2 [11].

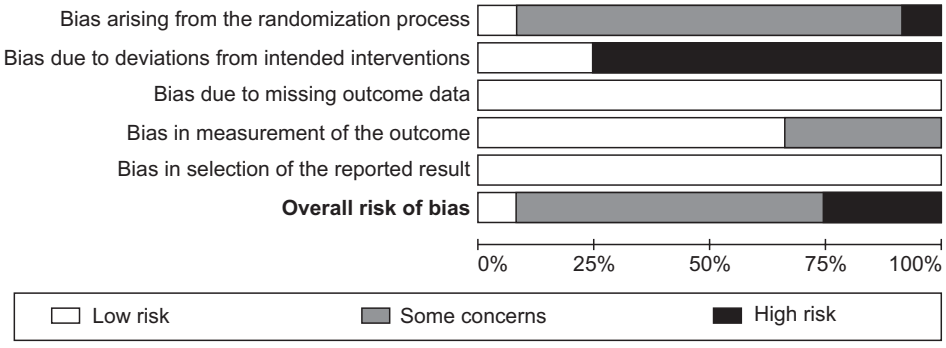

Fig. 3. Summary plot of quality assessment of each study included according to RoB 2 [11].

freehand administration. Four studies [15,16,20,23] confirmed the blocking effect of ESPB.

The risk of bias within the trials according to ROB 2 is presented in **Fig. 2**. The summary plot of quality assessment for each study included according to ROB 2 is presented in **Fig. 3**. In terms of the risk of bias, three studies [14,20,22] did not describe the specific manner in which the randomization sequence was generated; therefore, the risk was unclear in those studies. One study [24] performed sequential randomization via the order of surgery, which did not meet the allocation of randomization, and therefore was at high risk for risk of bias arising from the randomization process. Nine studies [13,15-18,21-24] did not describe whether the allocation sequence was concealed until the participants were enrolled and assigned to interventions, and thus these items created some concerns. Three studies [14,20,22] did not describe the details of their random sequence generation, so these studies created some concerns. Nine trials [13-16,20-24] did not perform a control intervention, and thus the participants were likely to be aware of their assigned intervention during the trial, and these deviations are likely to have affected the outcome. Therefore, these nine trials were at high risk for risk of bias. One trial [19] that performed sham blocks used subcutaneous infiltration (1 mL of 1% lidocaine) as a control, while two trials [17,18] that performed the sham block using saline were at low risk for risk of bias. Four trial [18,21,22,24] did not describe whether outcome assessors were aware of the intervention received by study participants, so the risk of bias in the measurement of the outcome (detection bias) was of some concerns.

We used 24- and 48-hour cumulative postoperative in-

travenous morphine equivalent consumption in the ESPB group versus the control group to construct a funnel plot, which showed some asymmetry in the presence of publication bias (**Fig. 4**). The details of GRADE are presented in **Supplementary Table 1**.

2. Primary outcomes

Eight [13-15,17-20,23] and five [14,18-20,23] RCTs reported the 24- and 48-hour cumulative postoperative intravenous morphine equivalent consumption, respectively. Different types of opioids were converted into intravenous morphine doses. The results showed that ESPB significantly reduced cumulative postoperative intravenous morphine equivalent consumption compared with the control group at 24 hours (MD, –18.69; 95% CI, –27.95 to –9.42; $P < 0.0001$) and 48 hours (MD, –19.67; 95% CI, –31.80 to –7.54; $P = 0.001$); however, a high level of heterogeneity was detected between the studies ($I^2 = 100\%$, $P < 0.00001$ and $I^2 = 99\%$, $P < 0.00001$, respectively) (GRADE = moderate) (**Fig. 5**).

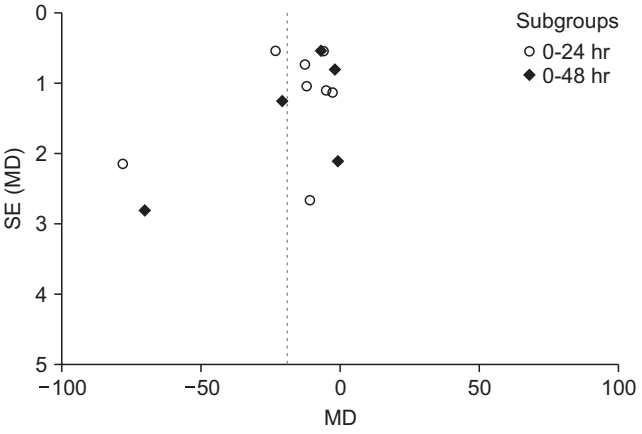

Fig. 4. Funnel plot of 24- and 48-hour cumulative postoperative intravenous morphine equivalent consumption in the erector spinae plane block group versus the control group. SE: standard error, MD: mean difference.

To assess the impact of ESPB on the postoperative pain scores of patients undergoing spinal surgery more comprehensively, we analyzed the pain scores in three contexts: rest, movement, and overall. In addition, we collected data at 0, 2, 4, 6, 8, 12, 24, and 48 hours in each context based on the number of included studies.

The pain score at rest was significantly lower in the ESPB group than in the control group at 0 hour (MD, –2.41; 95% CI, –3.32 to –1.50; $P < 0.00001$; $I^2 = 91\%$, $P < 0.00001$), 2 hours (MD, –2.16; 95% CI, –2.54 to –1.77; $P < 0.00001$; $I^2 = 44\%$, $P = 0.18$), 4 hours (MD, –1.56; 95% CI, –2.31 to –0.81; $P < 0.0001$; $I^2 = 85\%$, $P = 0.001$), 8 hours (MD, –1.36; 95% CI, –1.98 to –0.74; $P < 0.0001$; $I^2 = 76\%$, $P = 0.02$), 12 hours (MD, –1.01; 95% CI, –1.36 to –0.66; $P < 0.00001$; $I^2 = 0\%$, $P = 0.39$) and 24 hours (MD, –0.54; 95% CI, –1.06 to –0.01; $P = 0.04$; $I^2 = 93\%$, $P < 0.00001$), but not at 48 hours (MD, –0.21; 95% CI, –0.47 to 0.06; $P = 0.12$; $I^2 = 51\%$, $P = 0.11$) (GRADE = moderate) (**Fig. 6**).

The pain score during movement was significantly lower in the ESPB group than in the control group at 0 hour (MD,

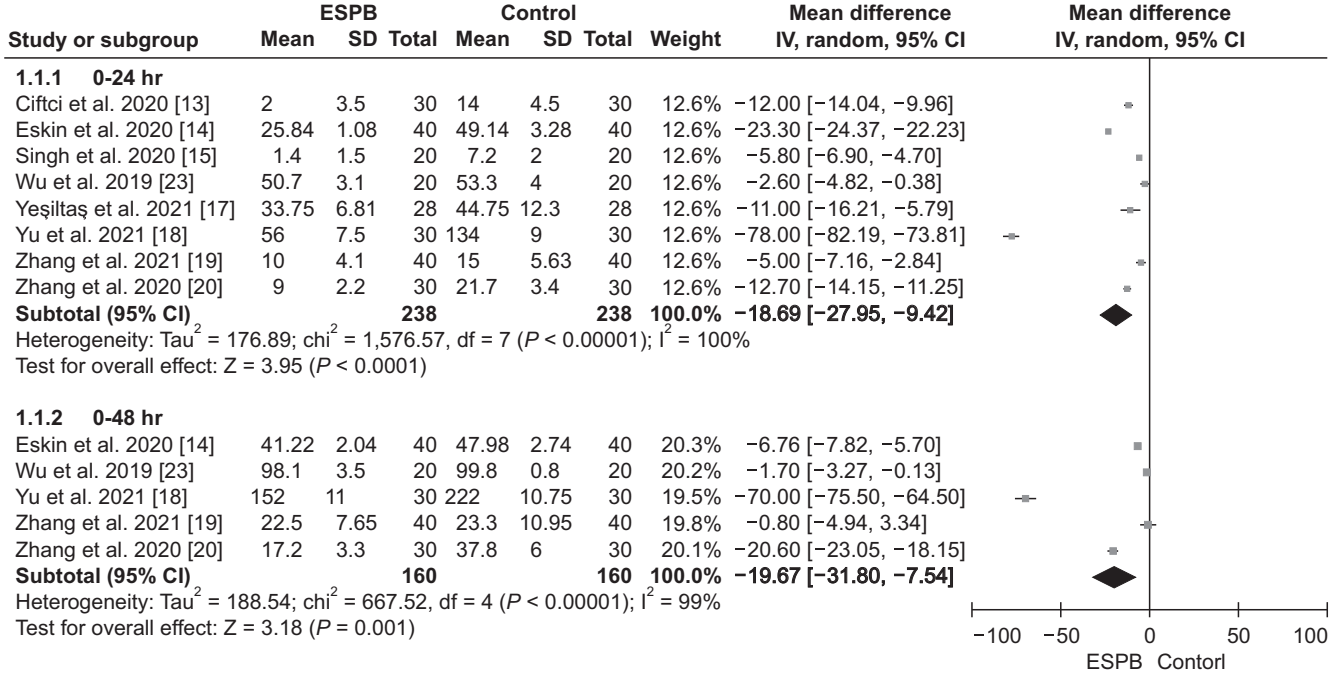

Fig. 5. Forest plot of 24-hour and 48-hour cumulative postoperative intravenous morphine equivalent consumption (mg). ESPB: erector spinae plane block, SD: standard deviation, IV: inverse variance, CI: confidence interval, df: degree of freedom.

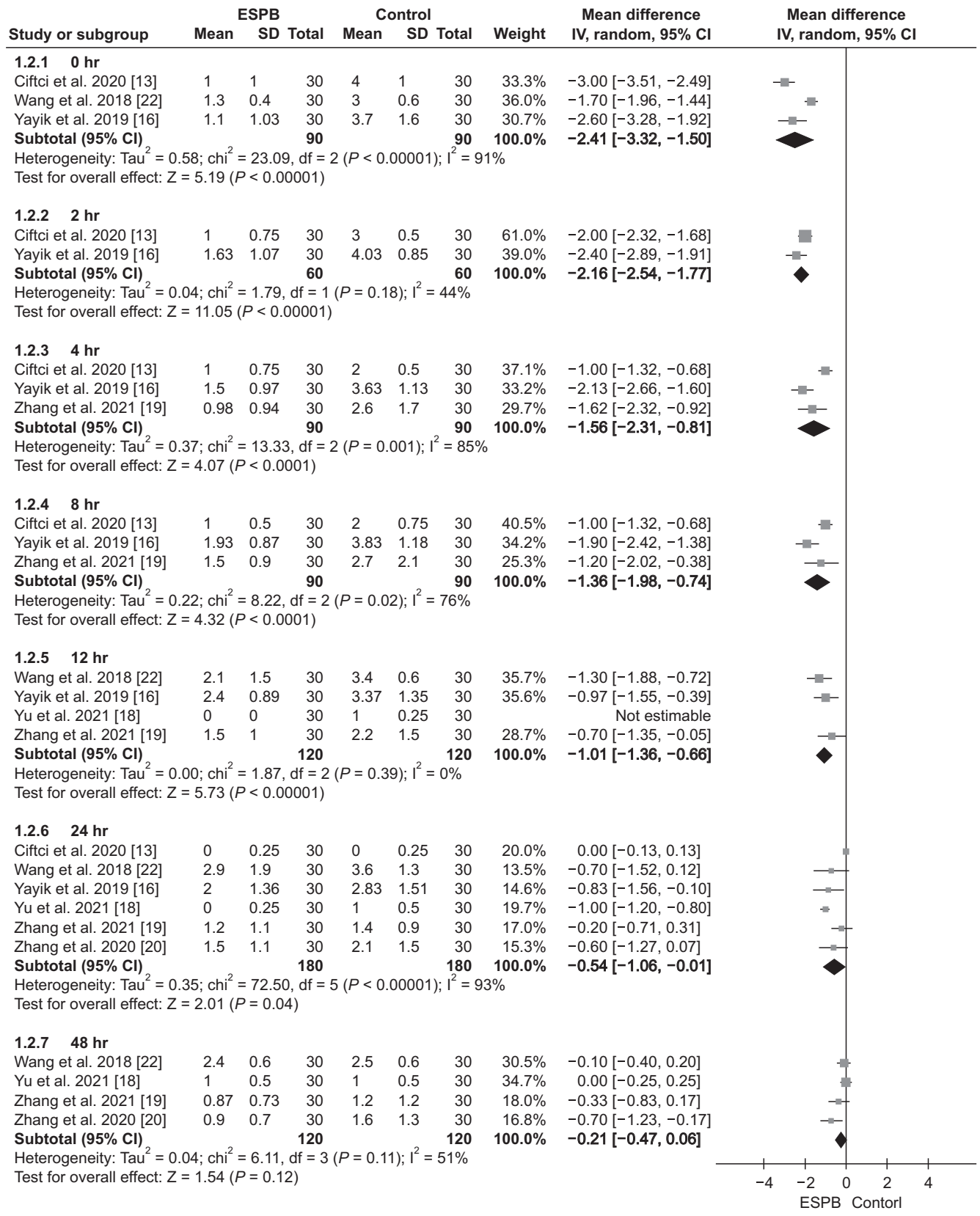

Fig. 6. Forest plot of pain score at rest at 0, 2, 4, 8, 12, 24, and 48 hours. ESPB: erector spinae plane block, SD: standard deviation, IV: inverse variance, CI: confidence interval, df: degree of freedom.

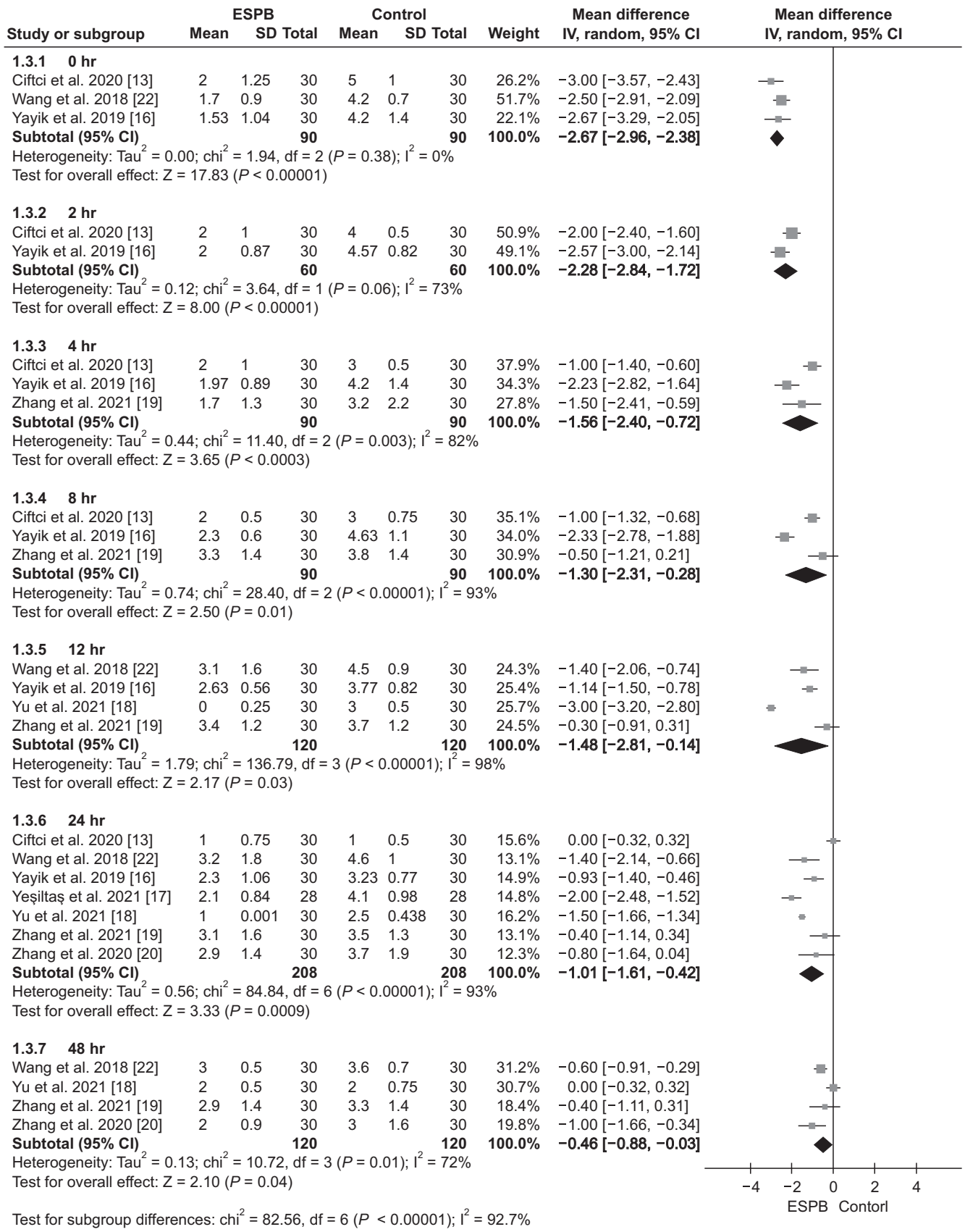

Fig. 7. Forest plot of pain score at movement at 0, 2, 4, 8, 12, 24, and 48 hours. ESPB: erector spinae plane block, SD: standard deviation, IV: inverse variance, CI: confidence interval, df: degree of freedom.

Study or subgroup	ESPB Mean	ESPB SD	ESPB Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, random, 95% CI
1.4.1 0 hr								
Eskin et al. 2020 [14]	1.9	0.6	40	4.9	0.8	40	33.6%	−3.00 [−3.31, −2.69]
Singh et al. 2020 [15]	2.25	0.75	20	3.75	0.25	20	33.4%	−1.50 [−1.85, −1.15]
Wu et al. 2019 [23]	3.2	0.4	20	4.3	0.9	20	32.9%	−1.10 [−1.53, −0.67]
Subtotal (95% CI)			**80**			**80**	**100.0%**	**−1.87 [−3.05, −0.70]**
Heterogeneity: Tau² = 1.04; chi² = 64.38, df = 2 (*P* < 0.00001); I² = 97%								
Test for overall effect: Z = 3.12 (*P* = 0.002)								
1.4.2 2 hr								
Eskin et al. 2020 [14]	1.6	0.5	40	4.1	1.7	40	49.6%	−2.50 [−3.05, −1.95]
Singh et al. 2020 [15]	2	0.5	20	2	0.5	20	50.4%	0.00 [−0.31, 0.31]
Subtotal (95% CI)			**60**			**60**	**100.0%**	**−1.24 [−3.69, 1.21]**
Heterogeneity: Tau² = 3.07; chi² = 60.39, df = 1 (*P* < 0.00001); I² = 98%								
Test for overall effect: Z = 0.99 (*P* = 0.32)								
1.4.3 4 hr								
Ciftci et al. 2020 [13]	1.4	0.7	30	3.9	1.5	30	33.2%	−2.50 [−3.09, −1.91]
Singh et al. 2020 [15]	2.25	0.75	20	2	0.5	20	33.9%	0.25 [−0.15, 0.65]
Yu and Guo 2018 [24]	1.2	0.9	20	3.1	1.2	20	32.9%	−1.90 [−2.56, −1.24]
Subtotal (95% CI)			**70**			**70**	**100.0%**	**−1.37 [−3.21, 0.47]**
Heterogeneity: Tau² = 2.56; chi² = 69.39, df = 2 (*P* < 0.00001); I² = 97%								
Test for overall effect: Z = 1.46 (*P* = 0.14)								
1.4.4 6 hr								
Ciftci et al. 2020 [13]	1.4	0.8	30	3.6	1.3	30	37.4%	−2.20 [−2.75, −1.65]
Singh et al. 2020 [15]	3.25	0.75	20	4.75	0.75	20	42.6%	−1.50 [−1.96, −1.04]
Wu et al. 2019 [23]	13.5	1.3	20	15	1.7	20	20.0%	−1.50 [−2.44, −0.56]
Subtotal (95% CI)			**70**			**70**	**100.0%**	**−1.76 [−2.26, −1.26]**
Heterogeneity: Tau² = 0.10; chi² = 3.99, df = 2 (*P* = 0.14); I² = 50%								
Test for overall effect: Z = 6.91 (*P* < 0.00001)								
1.4.5 8 hr								
Ciftci et al. 2020 [13]	1.8	0.7	30	3.7	1	30	31.7%	−1.90 [−2.34, −1.46]
Singh et al. 2020 [15]	2	0.5	20	3.25	0.25	20	41.1%	−1.25 [−1.49, −1.01]
Wu et al. 2019 [23]	1.7	1	20	2.9	0.7	20	27.2%	−1.20 [−1.73, −0.67]
Subtotal (95% CI)			**70**			**70**	**100.0%**	**−1.44 [−1.87, −1.02]**
Heterogeneity: Tau² = 0.10; chi² = 6.96, df = 2 (*P* = 0.03); I² = 71%								
Test for overall effect: Z = 6.62 (*P* < 0.00001)								
1.4.6 12 hr								
Ciftci et al. 2020 [13]	1.9	0.5	30	3.5	0.9	30	22.3%	−1.60 [−1.97, −1.23]
Liu et al. 2019 [21]	1.5	0.8	20	2.9	1	20	21.0%	−1.40 [−1.96, −0.84]
Singh et al. 2020 [15]	2	0.5	20	2	0.5	20	22.6%	0.00 [−0.31, 0.31]
Wu et al. 2019 [23]	25.6	2.1	20	27.3	2.5	20	13.5%	−1.70 [−3.13, −0.27]
Yeşiltaş et al. 2021 [17]	2.1	1.29	28	2.9	1.1	28	20.5%	−0.80 [−1.43, −0.17]
Subtotal (95% CI)			**118**			**118**	**100.0%**	**−1.04 [−1.85, −0.24]**
Heterogeneity: Tau² = 0.72; chi² = 49.62, df = 4 (*P* < 0.00001); I² = 92%								
Test for overall effect: Z = 2.54 (*P* = 0.01)								
1.4.7 24 hr								
Ciftci et al. 2020 [13]	2.2	0.1	30	2.9	0.8	30	22.3%	−0.70 [−0.99, −0.41]
Liu et al. 2019 [21]	1.2	0.8	20	2.7	0.9	20	18.9%	−1.50 [−2.03, −0.97]
Singh et al. 2020 [15]	2	0.5	20	2	0.5	20	22.0%	0.00 [−0.31, 0.31]
Yeşiltaş et al. 2021 [17]	2.04	1.14	28	2.5	1.2	28	17.6%	−0.46 [−1.07, 0.15]
Yu and Guo 2018 [24]	2.2	0.9	30	2.3	1.1	30	19.2%	−0.10 [−0.61, 0.41]
Subtotal (95% CI)			**128**			**128**	**100.0%**	**−0.54 [−1.03, −0.05]**
Heterogeneity: Tau² = 0.26; chi² = 27.94, df = 4 (*P* < 0.00001); I² = 86%								
Test for overall effect: Z = 2.14 (*P* = 0.03)								
1.4.8 48 hr								
Ciftci et al. 2020 [13]	1.9	0.9	30	2	0.1	30	54.9%	−0.10 [−0.42, 0.22]
Yu and Guo 2018 [24]	2.5	0.6	30	2.4	0.8	30	45.1%	0.10 [−0.26, 0.46]
Subtotal (95% CI)			**60**			**60**	**100.0%**	**−0.01 [−0.25, 0.23]**
Heterogeneity: Tau² = 0.00; chi² = 0.66, df = 1 (*P* = 0.42); I² = 0%								
Test for overall effect: Z = 0.08 (*P* = 0.94)								
Test for subgroup differences: chi² = 65.52, df = 7 (*P* < 0.00001); I² = 89.3%								

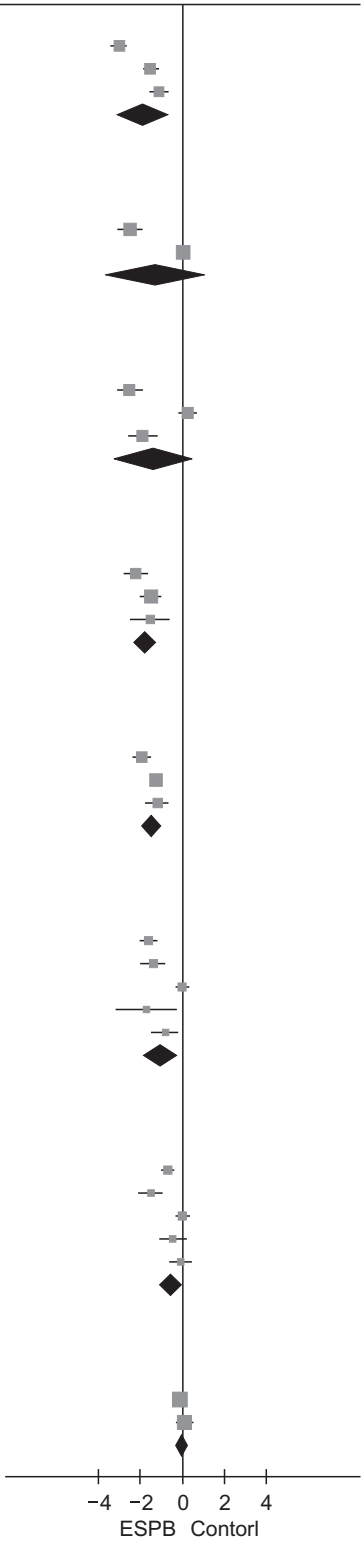

Fig. 8. Forest plot of overall pain score at 0, 2, 4, 6, 8, 12, 24, and 48 hours. ESPB: erector spinae plane block, SD: standard deviation, IV: inverse variance, CI: confidence interval, df: degree of freedom.

−2.67; 95% CI, −2.96 to −2.38; $P < 0.00001$; $I^2 = 0\%$, $P = 0.38$), 2 hours (MD, −2.28; 95% CI, −2.84 to −1.72; $P < 0.00001$; $I^2 = 73\%$, $P = 0.06$), 4 hours (MD, −1.56; 95% CI, −2.40 to −0.72; $P = 0.0003$; $I^2 = 82\%$, $P = 0.003$), 8 hours (MD, −1.30; 95% CI, −2.31 to −0.28; $P = 0.01$; $I^2 = 93\%$, $P < 0.00001$), 12 hours (MD, −1.48; 95% CI, −2.81 to −0.14; $P = 0.03$; $I^2 = 98\%$, $P < 0.00001$), 24 hours (MD, −1.01; 95% CI, −1.61 to −0.42; $P = 0.0009$; $I^2 = 93\%$, $P < 0.00001$), and 48 hours (MD, −0.46; 95% CI, −0.88 to −0.03; $P = 0.04$; $I^2 = 72\%$, $P = 0.01$) (GRADE = moderate) (**Fig. 7**).

In terms of overall pain score, compared with the control group, the ESPB group exhibited a significantly reduced overall pain score at 0 hour (MD, −1.87; 95% CI, −3.05 to −0.70; $P = 0.002$; $I^2 = 97\%$, $P < 0.00001$), 2 hours (MD, −1.24; 95% CI, −3.69 to 1.21; $P = 0.32$; $I^2 = 98\%$, $P < 0.00001$), 4 hours (MD, −1.37; 95% CI, −3.21 to 0.47; $P = 0.14$; $I^2 = 97\%$, $P < 0.00001$), 6 hours (MD, −1.76; 95% CI, −2.26 to −1.26; $P < 0.00001$; $I^2 = 50\%$, $P = 0.14$), 8 hours (MD, −1.44; 95% CI, −1.87 to −1.02; $P < 0.00001$; $I^2 = 71\%$, $P = 0.03$), 12 hours (MD, −1.04; 95% CI, −1.85 to −0.24; $P = 0.01$; $I^2 = 92\%$, $P < 0.00001$) and 24 hours (MD, −0.54; 95% CI, −1.03 to −0.05; $P = 0.03$; $I^2 = 86\%$, $P < 0.0001$), but not at 48 hours (MD, −0.01; 95% CI, −0.25 to 0.23; $P = 0.94$; $I^2 = 0\%$, $P = 0.42$) (GRADE = moderate) (**Fig. 8**).

3. Secondary outcomes

The ESPB group exhibited a lower cumulative intraoperative intravenous morphine equivalent consumption, a longer time to first rescue analgesic, a lower number of patients who required rescue analgesia, and a lower incidence of PONV than the control group. However, the incidence of urinary retention and itching was not significantly different between the ESPB and control groups. Furthermore, ESPB was not correlated with a shorter length of hospital stay (days) and time to first ambulation (days) compared with the control procedures. No block-related complications were reported in any of the included studies (**Table 2**).

DISCUSSION

This systematic review and meta-analysis showed the clinical benefits of ESPB for providing perioperative analgesia and reducing opioid consumption in patients undergoing spinal surgery. Furthermore, it demonstrated that ESPB can prolong the time to the first rescue analgesic, reduce the number of patients requiring rescue analgesia, and lower the incidence of PONV. However, it was not effective in reducing the incidence of urinary retention and itching or shortening the length of hospital stay or the time

Table 2. Secondary outcomes

Outcome	Studies (n)	RR or mean difference (95% CI)	*P* value for statistical significance	I^2	*P* value for heterogeneity	GRADE
Cumulative intraoperative intravenous morphine equivalent consumption (mg)	7 [13, 17, 19-22, 24]	−9.63 (−15.4 to −3.86)	0.001	93%	< 0.00001	Moderate
Time to first rescue analgesic (hr)	5 [14-17, 20]	6.15 (2.19 to 10.12)	0.002	100%	< 0.00001	High
Number of patients requiring rescue analgesia	7 [13-17, 19, 23]	0.39 (0.19 to 0.80)	0.01	90%	< 0.00001	High
Urinary retention	2 [22, 24]	0.50 (0.10 to 2.60)	0.41	0%	1.00	Low
PONV	9 [13, 14, 16-19, 22-24]	0.54 (0.36 to 0.83)	0.005	40%	0.10	High
Itching	5 [13, 14, 18, 22, 24]	0.58 (0.25 to 1.35)	0.21	31%	0.22	Moderate
Length of hospital stay (day)	5 [17-20, 22]	−1.04 (−2.23 to 0.15)	0.09	99%	< 0.00001	Low
Frist time of ambulation (day)	3 [19, 20, 22]	−0.93 (−1.97 to 0.07)	0.07	98%	< 0.00001	Low

PONV: post operative nausea and vomiting, RR: risk ratio, CI: confidence interval, GRADE: Grades of Recommendation, Assessment, Development, and Evaluation.

to first ambulation.

Spinal surgery can cause considerable postoperative pain and suffering. Therefore, a suitable perioperative analgesia program is necessary [2]. Regional anesthesia is an important part of perioperative analgesia in spinal surgery. ESPB, a new regional anesthesia technique reported for the first time in 2016 [5], is attracting the attention of clinical practitioners because of its ease of delivery and relative safety. Several systematic reviews and meta-analyses have been conducted to evaluate ESPB in surgery; however, they were limited to other types of surgery, including breast and thoracic surgeries [25,26] or a combination of spinal surgery and multiple surgical procedures [27], with very few studies of spinal surgery being included. To the best of our knowledge, this is the first systematic review and meta-analysis that assessed the effectiveness of ESPB in spinal surgery. We evaluated the analgesic effect of ESPB in this study in a more comprehensive way in terms of multiple metrics, including pain scores in different states, cumulative perioperative opioid consumption, time to first rescue analgesic, and number of patients requiring rescue analgesia. Moreover, to boost validity and perform an accurate and less-biased assessment of the effect of ESPB [28], we only compared the ESPB group with the unblocked control group.

Our study showed that ESPB reduced postoperative pain in patients undergoing spinal surgery. Interestingly, at 48 hours postoperatively, ESPB reduced pain during movement, but showed no differences from the controls in terms of pain at rest and overall pain. The most likely explanation for this finding is that ESPB is not highly effective in the long term. Conversely, the postoperative spinal pain may have already been reduced at 48 hours and thus the low levels of pain did not reflect the analgesic effect of ESPB. In contrast, the surgical site had not fully healed at 48 hours and any activity increased pain, thus highlighting the analgesic effect of ESPB. Furthermore, the levels of preoperative pain varies in patients undergoing different spinal surgeries because of their own spinal disorders. Therefore, the success of the surgery in resolving the existing disorder and thus reducing the pain caused by the disorder itself may also have interfered with the assessment of the analgesic effect of the intervention.

We found that opioid consumption was reduced in the ESPB group, both postoperatively and intraoperatively. This observation together with the low incidence of PONV detected in the ESPB group suggests that ESPB, to a certain extent, promotes rapid recovery after spinal surgery. However, ESPB did not reduce some complications related to the application of opioids, including urinary retention and itching. This is interesting as other trials found that not all regional anesthesia types could reduce opioid-related side effects [29]. Based on these results, we could argue that once opioid consumption exceeds a certain threshold, the incidence of some opioid-related complications does not decrease as the dose of opioids used decreases. The results also showed that ESPB was not correlated with a shorter length of hospital stay or time to first ambulation; however, it was related to many other clinical factors, including the specific types of spinal surgery and level of expertise of the surgeons and nursing staff. It is possible that ESPB does not outweigh other clinical factors in reducing the length of hospital stay and time to first ambulation among these patients. However, the results of the analysis of these outcomes should be interpreted with caution because of the small number of studies reporting these outcomes and the small sample sizes included in the articles. Notably, none of the included studies assessed the impact of ESPB on the transition from acute to chronic pain and thus on the long-term rehabilitation outcomes of the procedure. Increased attention should be paid to this aspect in future trial designs.

In terms of safety, we attempted to evaluate the complications related to ESPB in the included studies; however, no block-related complications, including local anesthetic toxicity, bleeding, or infection, were reported in any of them, probably because most of the ESPB procedures reported in the included studies were performed under ultrasound guidance (in one study [17] alone, the procedure was performed intraoperatively via freehand delivery). Visualization and the fact that the target site was away from important vessels and nerves may also explain the rarity of associated complications. Furthermore, the sample sizes of the included studies were probably too small to allow the evaluation of this rare outcome. Future controlled trials with larger samples are therefore needed.

It is worth noting that many of the studies included in the present analysis [13-16,20-24] were flawed in their implementation of blinding the participants to the non-interventional operation, as a control. Moreover, in some of the studies, the success of the block was not confirmed without validation of the block effect after its implementation [13,14,17-19,21,22,24], which may have confounded the results. It is difficult to implement blinding of the participants in this type of study of nerve blocks. If the block is confirmed, the participants will know their group attribution, and if it is not validated, there is no guarantee that the block will be effective. These are issues that need to be considered and improved in subsequent controlled experiments.

Our study has several limitations. First, the sample sizes of the included studies were small and few studies reported some of the outcomes, such as urinary retention and time to first ambulation, which to some extent reduced the

validity of the results of this analysis. Second, there was high heterogeneity in the results of many of the analyses; several factors may be the source of this heterogeneity. Different types of spinal surgery were included; thus, there were differences in the difficulty of the surgery and the degree of injury. Different surgical sites result in different block levels and a different anatomy at the block site. In addition, differences in the concentration and dose of the drugs used to perform the block may have an impact on the effectiveness of the ESPB. Finally, differences in intraoperative and postoperative analgesic protocols were also a source of heterogeneity.

In conclusion, our findings suggest that ESPB can provide effective intraoperative and postoperative analgesia and reduce postoperative PONV in patients undergoing spinal surgery; however, there was insufficient evidence that ESPB is beneficial for some indicators related to rapid recovery.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.3344/kjp.2021.34.4.487.

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Appendix

Pubmed

(((((((erector spinae block[Title/Abstract]) OR (ESB[Title/Abstract])) OR (ES block[Title/Abstract])) OR (erector spinae plane block[Title/Abstract])) OR (ESP block[Title/Abstract])) OR (ESPB[Title/Abstract])) OR (erector spinae plane block[MeSH Terms])) OR (erector spinae block[MeSH Terms]) Filters: Clinical Trial, Randomized Controlled Trial

EMBASE

(**'erector spinae plane block'**:ab,ti OR **'erector plane block'**:ab,ti OR **espb**:ab,ti OR **'esp block'**:ab,ti OR **epb**:ab,ti OR **'ep block'**:ab,ti OR **'erector spinae plane block'**/exp OR **'erector plane block'**) AND ([embase]/lim OR [medline]/lim) AND ([controlled clinical trial]/lim OR [randomized controlled trial]/lim) AND ([article]/lim OR [article in press]/lim OR [conference abstract]/lim OR [conference paper]/lim OR [conference review]/lim OR [data papers]/lim) AND [humans]/lim AND [clinical study]/lim AND [2016-2021]/py

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#2 MeSH descriptor: [Spinal Diseases] explode all trees

#1 AND #2