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Efficacy of erector spinae nerve block for pain control after lumbar spinal surgeries: a systematic review and meta-analysis

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Abstract. – OBJECTIVE: The review aimed to examine the evidence on the efficacy of erector spinae nerve block (ESPB) for pain control after lumbar spinal surgeries.

MATERIALS AND METHODS: PubMed, CENTRAL, Embase, and Web of Science were examined for published randomized controlled trials (RCTs) assessing ESPB with control for lumbar spinal surgery patients. The primary review outcome was 24-hour total opioid consumption in morphine equivalents. The secondary review outcomes were pain at rest at 4-6 hours, 8-12 hours, 24 hours and 48 hours, first rescue analgesic timing, needing rescue analgesics number, and postoperative nausea and vomiting (PONV).

RESULTS: 16 trials were eligible. Total opioid consumption was significantly lower with ESPB as compared to controls (MD: -12.68 95% CI: -18.09, -7.28 I^2=99% p<0.00001). Pain scores at 4-6 hours (MD: -1.37 95% CI: -1.98, -0.76 I^2=95% p<0.0001), 8-12 hours (MD: -1.18 95% CI:-1.84, -0.52 I^2=98% p=0.0004), 24 hours (MD: -0.53 95% CI:-1.03, -0.04 I^2=96% p=0.04) and 48 hours (MD: -0.36 95% CI:-0.84, 0.13 I^2=88% p=0.15) were significantly lower in the ESPB group. The meta-analysis found that the ESPB group required a significantly longer time for the first analgesic request (MD: 5.26 95% CI: 2.53, 7.99 I^2=100% p=0.002), had lower demand for rescue analgesics (OR: 0.12 95% CI: 0.07, 0.21 I^2=2% p<0.00001) and fewer incidence of PONV (OR: 0.27 95% CI: 0.15, 0.49 I^2=51% p<0.0001).

CONCLUSIONS: ESPB can be highly efficacious for postoperative analgesia in lumbar surgery patients. The block has the capability of reducing opioid consumption in the first 24 hours and pain scores up to 48 hours along with a significant reduction in the need for rescue analgesics and PONV.

Key Words:
Nerve block, Regional anesthesia, Pain, Analgesia, Vertebral surgery.

Introduction

Methodical research and technological developments have significantly increased the safety of lumbar spinal surgeries resulting in an increased number of procedures worldwide[1]. Nevertheless, like any surgical procedure, immediate pain control after lumbar spinal surgeries assumes priority. Poor analgesia can lead to delayed mobilization, patient dissatisfaction, medical complications, and in turn, higher healthcare costs[2].

While opioids are the mainstay of pain management after any surgery, including lumbar spinal interventions, they are associated with several complications like postoperative nausea and vomiting (PONV), delirium, sedation, constipation, tolerance, and respiratory depression[3]. Furthermore, individuals undergoing lumbar spinal surgery often have pre-existing long-standing pain and are on prolonged opioid medications. Such patients develop tolerance to conventional opioid doses needing higher doses which increases the risk of complications[4]. Research[5] suggests that approximately 9% of spinal surgery patients persist with opioid medication one year after surgery. In the context of such high numbers and the current opioid crisis, there is an increased endeavor to reduce opioid dependence and focus on multimodal analgesia for spinal surgery patients. Over the years, several regional anesthetic modalities have demonstrated their efficacy in lumbar surgical procedures including spinal anesthesia, epidural anesthesia, intravenous lidocaine, and regional nerve blocks like the thoracolumbar interfascial plane block. However, no single technique has emerged as an optimal anesthetic modality to date.

The erector spinae plane block (ESPB) was first put forward by Forero et al[6] in 2016 for the

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management of thoracic neuropathic pain. The block entails the injection of local anesthetic beneath the erector spinae muscle, near the tip of the transverse process of the vertebrae[7]. The solution is deemed to spread along the fascial plane underneath the muscle and tissue compartments to the spinal ventral rami thereby providing analgesia[8]. In recent years, the block has been used for lumbar surgical procedures as well but with mixed results. Two meta-analyses by Liu et al[9] and Oh et al[10] have systematically analyzed evidence on the efficacy of ESPB for lumbar surgical procedures, but these reviews included only six and twelve studies respectively. Given the publication of new studies in literature[11,12], we hereby present an updated review on the efficacy of ESPB for providing analgesia after lumbar surgical procedures.

Materials and Methods

Search

The PRISMA reporting guidelines were used for this review and this included prior registration on PROSPERO (CRD42022373711)[13]. An extensive and systematic literature encompassing PubMed, CENTRAL, Embase, and Web of Science was conducted. Gray literature was additionally searched using Google Scholar. Ongoing clinical trials were also enquired on www.clinicaltrials.gov. The last search date was on October 15th, 2022. Search terms were: "erector spinae nerve block", "spinal surgery", "lumbar surgery", "lumbar fusion", and "vertebral surgery". The search query used was: ((((spinal surgery) OR (lumbar surgery)) OR (vertebral surgery)) OR (lumbar fusion)) AND (erector spinae nerve block). The search results were examined by two reviewers separately. Duplicates were excluded and articles were reviewed by titles/abstracts. Relevant studies underwent full-text analysis before inclusion. Disagreements were resolved by discussion. The search was supplemented in the end by examining the bibliography of selected studies.

Eligibility

The inclusion criteria based on PICOS were:

- Population: Patients undergoing lumbar spinal surgery.
- Intervention: ESPB.
- Comparison: Placebo or no drug.
- Outcomes: Pain scores, opioid consumption, time to first rescue analgesic, PONV.

-Study type: RCTs.

We excluded non-RCTs, review articles, and editorials. There was no language restriction for inclusion in the review.

Data Extraction

Names of studies' authors, publication year, study's location, surgery type, timing of ESPB, sample size, age of participants, protocol in ESPN and control groups, used analgesics, follow-up duration, and outcome data were extracted using a data spreadsheet. For incomplete data, corresponding authors were contacted by email. The primary review outcome was 24-hour total opioid consumption in morphine equivalents. The secondary review outcomes were pain at rest measured on a 10-points scale at 4-6 hours, 8-12 hours, 24 hours, and 48 hours, time to first rescue analgesic, number needing rescue analgesics, and PONV.

The risk of bias was judged using the Cochrane Collaboration risk of bias-2 tool[14]. Studies were marked as low risk, high risk, or some concerns for each domain of the assessment tool. The different domains of the tool included: the randomization method, any variation from intended intervention, loss of outcome data, measurement of outcomes, selection of reported results, and overall risk of bias.

Statistical Analysis

Continuous data were extracted as mean and standard deviations (SD). If studies reported median and interquartile range, it was converted to mean and SD using the standard published calculator[15]. All data were collated to generate mean difference (MD) and 95% confidence intervals (CI). The analysis was conducted using a random effects model. Ordinal data were pooled to generate odds ratio (OR). Total opioid consumption was pooled in morphine equivalents. If the included study reported on some other opioid, data was converted using the formula of the Faculty of Pain Medicine of the Australian and New Zealand College of Anesthetists[16]. A sensitivity analysis was done to assess the stability of the outcomes. The I^2 statistic was used to explore between-study heterogeneity. Funnel plots were used to judge publication bias for the primary outcome. "Review Manager" [RevMan, version 5.3; Nordic Cochrane Centre (Cochrane Collaboration), Copenhagen, Denmark; 2014] was chosen for the meta-analysis. p-value <0.05 was considered statistically significant.

Results

849 articles were found following the literature search (Figure 1). On deduplication, 356 of these were unique. On further initial title/abstract screening, 29 articles full-texts were examined. Of these, 13 were excluded, and 16 RCTs were included in this study[11,12,17-30].

All RCTs were published between 2019-2022 (Table I). The types of surgeries included discectomy, decompression, interbody fusion, and laminoplasty. The total sample size of all RCTs was 930. The mean or median age was more than 30 years in all studies. In two studies[11,30] ESPB was administered after surgery while in one[26] it was done intra-operatively whereas in the rest the block was administered before surgery. Bupivacaine and ropivacaine were the most common anesthetics used. Majority of studies used ultrasound guidance for the block except for one studa[26], which used the free-hand method. The postoperative analgesics used in the trials included morphine, tramadol, pethidine, fentanyl, sufentanil, and paracetamol.

Meta-Analysis

Comparing 24-hour total opioid consumption between ESPB and control groups, it was noted that opioid consumption in morphine equivalents was significantly lower with ESPB (MD: -12.68 95% CI: -18.09, -7.28 I^2=99% p<0.00001) (Figure 2). There was no evidence of publication bias (Figure 3). The results did not change on sensitivity analysis.

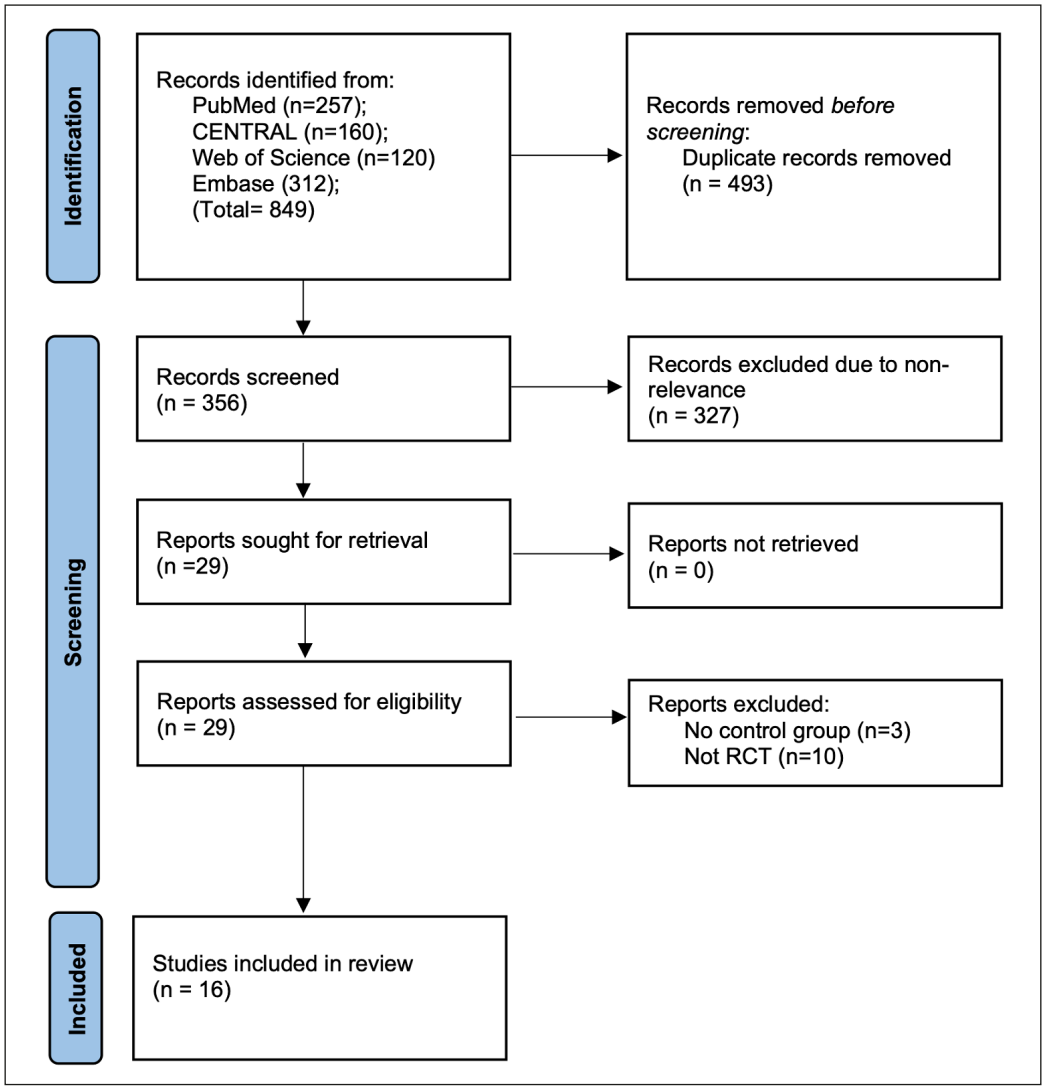

Figure 1. Study flow chart.

Table I. Details of included studies.

Study	Location	Surgery type	Groups	Sample size	Mean age	Timing of block	ESPB group group	Control analgesia	Postoperative (hours)	Follow-up
Asar 2022[11]	Turkey	Open lumbar spine surgery	ESPB Control	35 35	61.9± 9.5 58.5± 8.8	Post-surgery	Ultrasound guided bilateral ESPB with 20 mL of 0.5% bupivacaine and 2% lidocaine at T10 level	No block	Tramadol PCA	24
Avis 2021[12]	France	Lumbar spine surgery	ESPB Control	25 24	67[60-72]* 67[59-70]	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 20 mL of 0.375% ropivacaine at L3 level	Sham block	Paracetamol, ketoprofen, Morphine as rescue	72
Calia 2019[22]	Italy	Open posterior lumbar decompression	ESPB Control	12 17	NR	NR	ESPB with 0,5% levobupivacaine 20 mL	No block	Morphine	24
Chen 2019[21]	China	Lumbar spine surgery	ESPB Control	25 25	NR	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 30 mL of 0.375% ropivacaine at T12 level	Sham block	Sufentanil PCA	48
Cifti 2020[17]	Turkey	Lumbar discectomy	ESPB Control	30 30	46.1± 10.1 45.9± 9.8	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 20 mL 0.25% bupivacaine at L3 level	No block	Fentanyl PCA	24
Eskin 2020[30]	Turkey	Lumbar decompression	ESPB Control	40 40	58± 5.2 57.8± 5.2	Post-surgery	Ultrasound guided bilateral ESPB with 20 mL of 0.25% bupivacaine at a vertebrae level in the mid-point of the incision	No block	Tramadol PCA, Pethidine as rescue	48
Ghamry 2019[20]	Egypt	Posterior lumbar interbody fusion	ESPB Control	30 30	43.9± 9.8 42.8± 10.7	Before induction	Ultrasound guided bilateral ESPB with 20 mL 0.25% bupivacaine at L3 level	Sham block	Morphine IV	24
Jin 2021[28]	China	Elective lumbar laminoplasty	ESPB Control	30 32	56.7± 8.7 56.1± 11.4	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 20 mL of 0.375% ropivacaine at vertebral level of surgery	No block	Sufentanil PCA	48

Continued

Table I (*Continued*). Details of included studies.

Study	Location	Surgery type	Groups	Sample size	Mean age	Timing of block	ESPB group	Control analgesia	Postoperative (hours)	Follow-up
Lin 2022[24]	China	Elective posterior lumbar interbody fusion	ESPB Control	42 42	65[56-70]* 65[61-70]	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 30 mL of 0.375% ropivacaine at L3 level	No block	Morphine PCA	48
Siam 2020[29]	Egypt	Lumbar spine surgery	ESPB Control	15 15	40.2± 10 42± 11.1	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 20 mL of 0.25% bupivacaine at the vertebral level above a predetermined marked surgical incision.	No block	Pethidine IV	8
Singh 2019[19]	India	Lumbar spine surgery	ESPB Control	20 20	35.4± 8.3 34.9± 10.1	Before induction	Ultrasound guided bilateral ESPB with 20 mL 0.5% bupivacaine at T10 level	No block	Morphine IV	24
Yayik 2019[18]	Turkey	Lumbar decompression	ESPB Control	30 30	50.5±8.5 54.3± 8.6	Before induction	Ultrasound guided bilateral ESPB with 20 mL 0.25% bupivacaine at L3 level	No block	Tramadol PCA	24
Yesiltas 2021[26]	Turkey	Open posterior spinal instrumentation and fusion	ESPB Control	28 28	61± 9.4 60.1±11.7	Intra-operative	Freehand, bilateral ESPB with 20 mL (1:1) mixture of 0.25% bupivacaine and 1.0% lidocaine at the spinal instrumented levels	Sham block	Morphine PCA	24
Yu 2021[23]	China	Posterior internal fixation for lumbar fractures	ESPB Control	40 40	55.5± 11.5 57.1±10.6	Pre-surgery After induction	Ultrasound guided bilateral ESPB with 30 mL of 0.25% bupivacaine at fractured lumbar vertebra level	Sham block	Sufentanil PCA	48
Zhang 2020[27]	China	Open posterior lumbar decompression	ESPB Control	30 30	64± 9.4 64±10.3	Before induction	Ultrasound guided bilateral ESPB with 25 mL ropivacaine 0.3% at the T12 level	No block	Morphine PCA	48
Zhang 2021[25]	China	Open posterior lumbar spinal fusion	ESPB Control	30 30	60± 9.6 59.5±11.5	Before induction	Ultrasound guided bilateral ESPB with 20 mL 0.4% bupivacaine at L3 level	Wound infiltration	Sufentanil PCA	48

ESPB, erector spinae plane block; NR, not reported; PCA, patient-controlled analgesia; IV, intravenous, L, lumbar; T, thoracic. *Median and interquantile range.

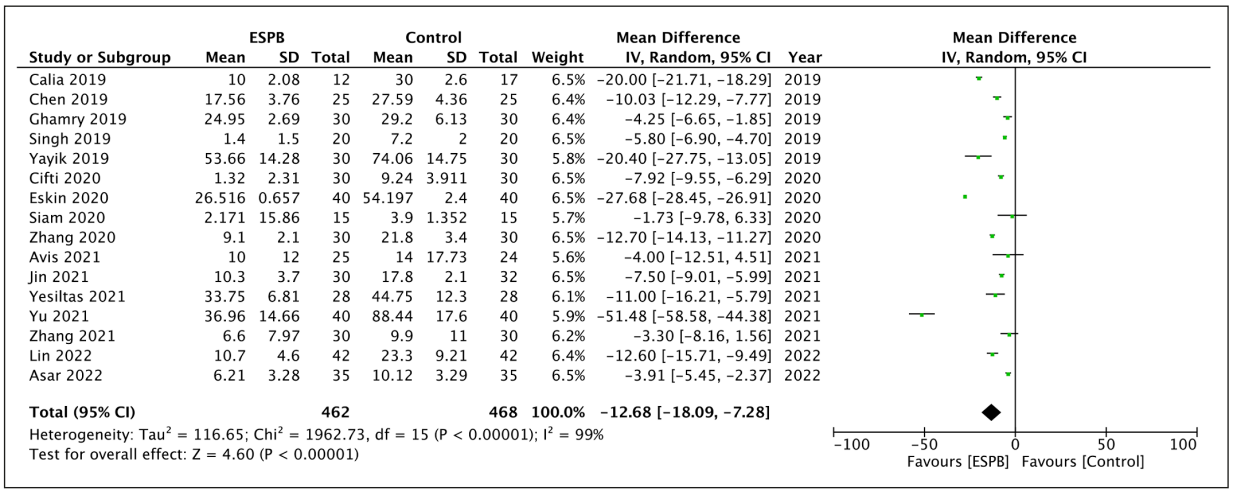

Figure 2. Meta-analysis of 24-hour total opioid consumption between ESPB and control groups.

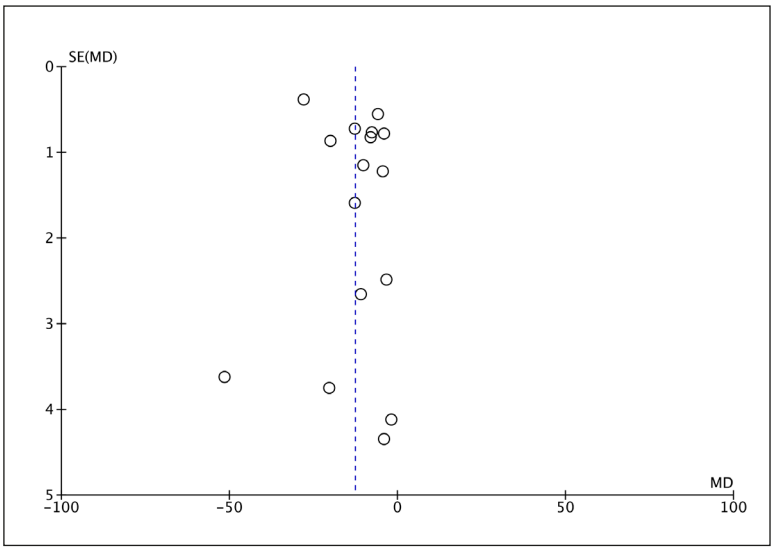

Figure 3. Forest plot for the meta-analysis of 24-hour total opioid consumption.

On analysis of pain scores, it was noted that pain scores at 4-6 hours (MD: -1.37 95% CI: -1.98, -0.76 I^2=95% p<0.0001) (Figure 4) and 8-12 hours (MD: -1.18 95% CI: -1.84, -0.52 I^2=98% p=0.0004) (Figure 5) were significantly lower in ESPB group as compared to controls. These results were stable on sensitivity analysis. Similarly, pain scores at 24 hours (MD: -0.53 95% CI: -1.03, -0.04 I^2=96% p=0.04) (Figure 6) were also significantly lower in the ESPB group, but not pain scores at 48 hours (MD: -0.36 95% CI: -0.84, 0.13 I^2=88% p=0.15) (Figure 7). The 24-hour pain scores turned non-significant on the exclusion of multiple studies during the sensitivity analysis but not the 48-hour pain scores.

Meta-analysis showed that patients in the ESPB group required significantly longer time for first analgesic request (in minutes) (MD: 5.26 95% CI: 2.53, 7.99 I^2=100% p=0.002) (Figure 8). The results remained significant during sensitivity analysis. Similarly, patients demanding rescue analgesics were also significantly less in the ESPB group as compared to the control group (OR: 0.12 95% CI: 0.07, 0.21 I^2=2% p<0.00001) (Figure 9). The number of patients with PONV was also significantly lower in the ESPB group (OR: 0.27 95% CI: 0.15, 0.49 I^2=51% p<0.0001) (Figure 10).

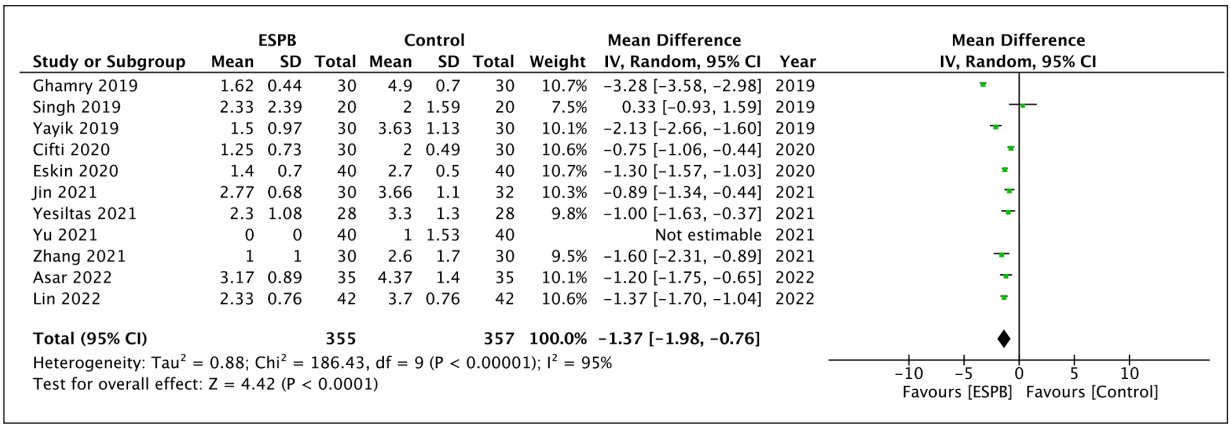

Figure 4. Meta-analysis of 4-6-hour pain scores between ESPB and control groups.

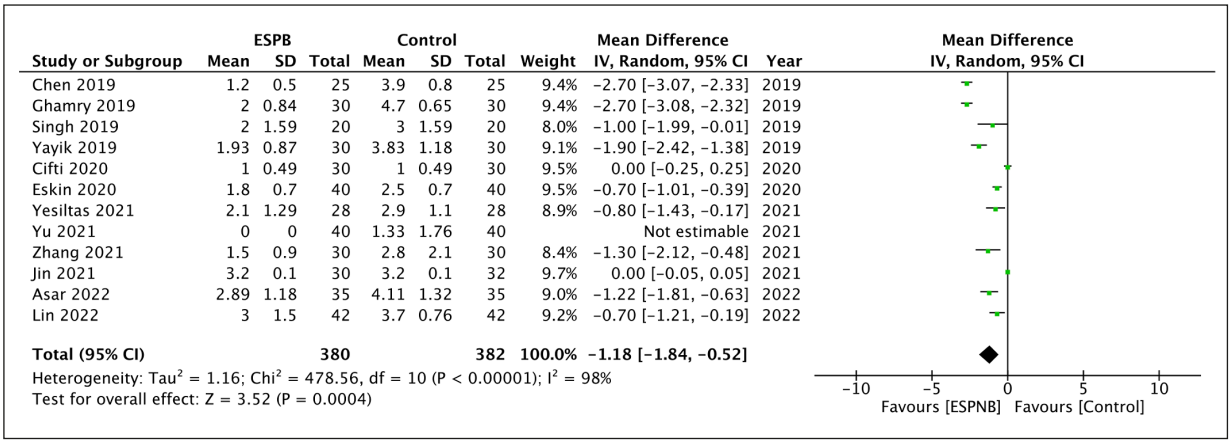

Figure 5. Meta-analysis of 8-12-hour pain scores between ESPB and control groups.

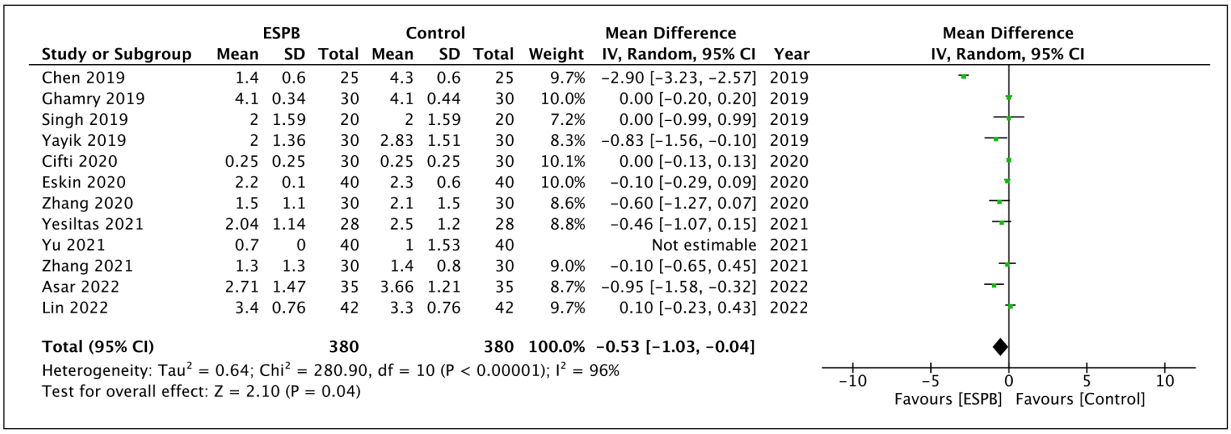

Figure 6. Meta-analysis of 24-hour pain scores between ESPB and control groups.

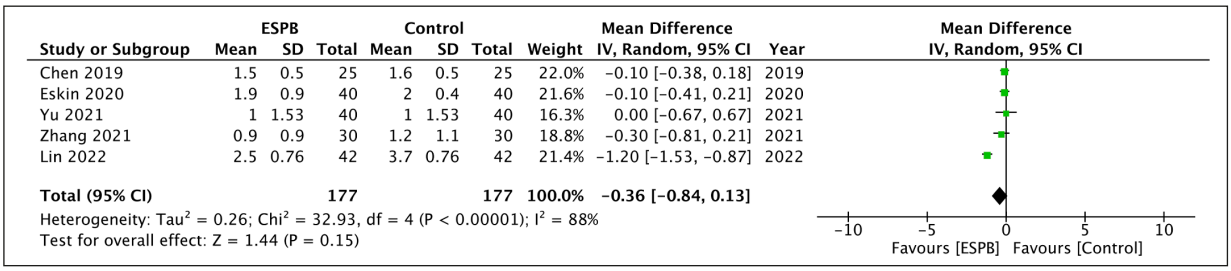

Figure 7. Meta-analysis of 48-hour pain scores between ESPB and control groups.

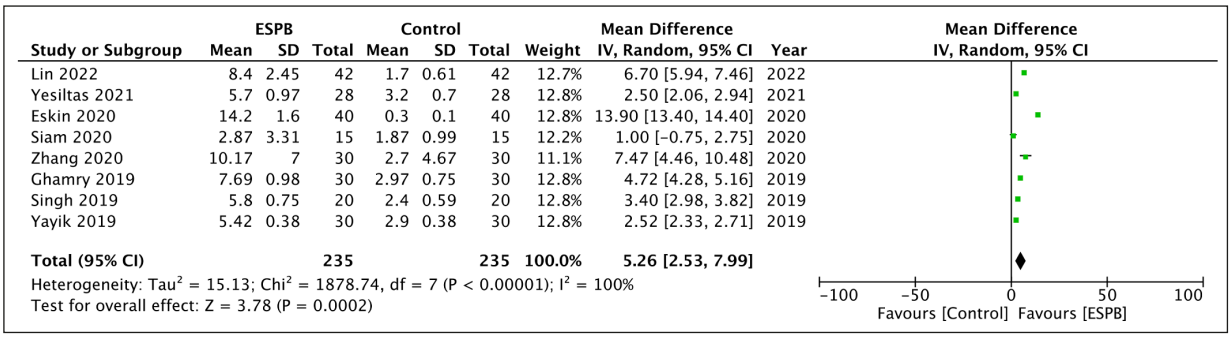

Figure 8. Meta-analysis of time to first analgesic request between ESPB and control groups.

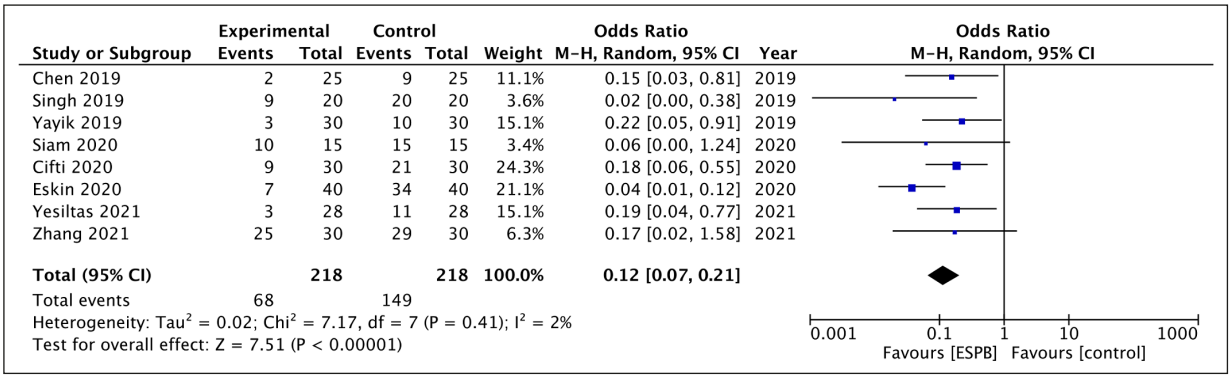

Figure 9. Meta-analysis of need for rescue analgesics between ESPB and control groups.

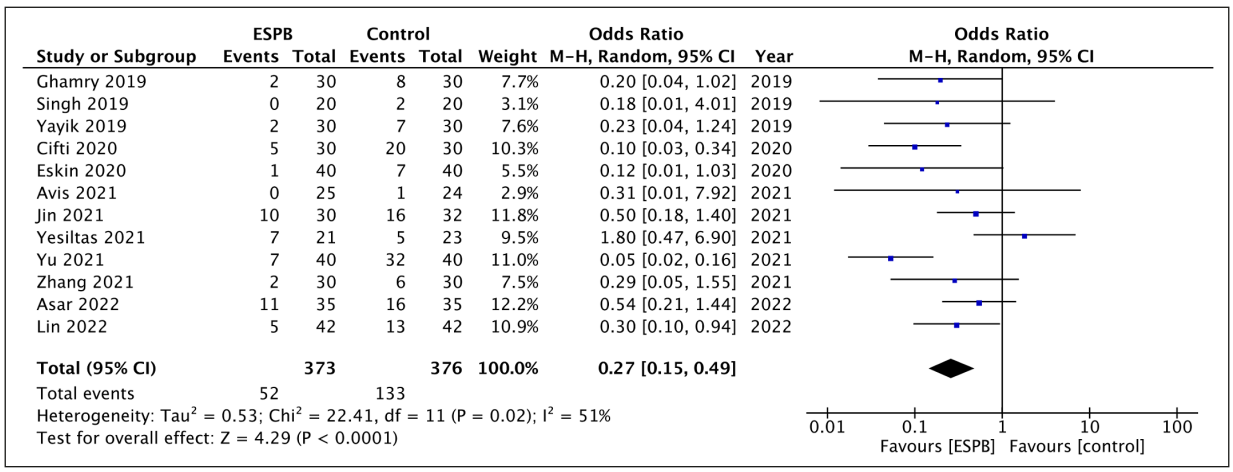

Figure 10. Meta-analysis of PONV between ESPB and control groups.

Risk of Bias

Description of quality assessment is presented in Table II. Four studies[18,19,22,29] had a high risk of bias and five studies[17,21,23,27,30] had some concerns in the overall assessment. The remaining trials had a low risk of bias.

Discussion

The results of our updated systematic review including 16 recently published RCTs show that ESPB is efficacious for postoperative analgesia in lumbar spinal surgery patients. Specifically, it was noted that ESPB not only reduced total opioid consumption but also reduced pain scores at 4-6, 8-12, 24-, and 48-hours post-surgery. The number of patients needing rescue analgesia was significantly less with ESPB and the time to first analgesic request was also prolonged in the ESPB group.

24-hour total analgesic consumption is one of the most important determinants of the analgesic efficacy of any regional anesthetic technique. Since opioids are the primary drugs used in the management of postoperative pain, any reduction in opioid consumption is directly indicative of the analgesic potential of the nerve block. Analyzing this primary outcome in our meta-analysis, it was seen that patients in the ESPB group required 12.68 mg less of intravenous morphine as compared to the control group. Hussain et al[31] in a meta-analysis have shown that a reduction of at least 30 mg of oral morphine consumption in the early postoperative period is considered "clinically significant" for ESPB. Thus, a 12.68 mg reduction in morphine consumption assumes clinical significance as 30 mg of oral morphine corresponds to 10 mg of intravenous morphine[16]. Secondly, other outcomes assessed in the meta-analysis also presented results in favor of ESPB. We noted a 1.4-to-1.2-point diminution of pain scores with ESPB at 4-6 hours and 8-12 hours, respectively. This difference was further decreased to just 0.5- and 0.4-point reduction of pain scores at 24 hours and 48 hours respectively indicating a decreasing efficacy of the block with time. The peak effect can be noted early at 4-6 hours with gradual reduction up to 48 hours.

In any RCT assessing the value of regional anesthesia, patients in the placebo group must have access to rescue analgesics to avoid unrelieved severe pain[32]. Therefore, the need for rescue analgesics and the time to first analgesic request acts as a surrogate marker of the analgesic efficacy of the block. In our meta-analysis, it was noted that 88% fewer patients in the ESPB group needed rescue analgesics with a 95% CI range of 7-21%. Such a significant reduction in the need for rescue analgesics with very narrow CI points out the high analgesic efficacy of ESPB. Nevertheless, though statistically significant, the time difference for the first analgesic request between the two groups was just 5 mins, which may not have much clinical significance.

In terms of complications, no major side-effects were seen with ESPB in any study. None of the patients had local anesthetic toxicity, nerve injury, pneumothorax, or vascular injury due to the use of the block. This can be partly attributed to the safety of ESPB wherein the penetration path, and the needle position are away from major neurovascular structures[33]. Also, it was noted that PONV was reduced in the ESPB group. PONV is a known complication of opioid intake[4] and reduction of the same denoted better analgesic efficacy of the nerve block with higher patient satisfaction.

The results of our review concur with prior published meta-analyses on this subject. In the previously updated meta-analysis, Oh et al[10] also found ESPB to be significantly efficacious in reducing pain after lumbar spinal surgery. Collating data from 12 trials, the authors noted a significant decrease in opioid consumption (14.5 mg) and pain scores at 4-6, 8-12, 24, and 48 hours after surgery. Similar to the current review, the time to first analgesic request was increased with ESPB, and a reduced number of patients required rescue analgesics with lower rate of PONV. However, by adding four new trials, the current review presents updated and comprehensive evidence on the role of ESPB for lumbar spinal procedures. Our results are also in agreement with reviews assessing the efficacy of ESPB for other surgical procedures. Leong et al[34] compiled outcomes from 13 RCTs to demonstrate that ESPB was significantly more effective in decreasing pain and opioid intake after breast surgeries as compared to general anesthesia alone. Similarly, Koo et al[35] have collated data from 17 RCTs to show that ESPB provided significant postoperative analgesia as compared to control after thoracic surgeries.

A few studies[33,36] have called the ESPB similar to the paravertebral block, however, recent research[33,36,37] has shown that the paravertebral block and ESPB are dissimilar techniques with variable methods and diffusion of injectate.

Table II. Risk of bias in included studies.

Study	Randomization process	Deviation from intended intervention	Missing outcome data	Measurement of outcomes	Selection of reported result	Overall risk of bias
Asar 2022[11]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Avis 2021[12]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Calia 2019[22]	Low risk	Some concerns	Some concerns	Some concerns	Some concerns	High risk
Chen 2019[21]	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Cifti 2020[17]	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Eskin 2020[30]	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Ghamry 2019[20]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Jin 2021[28]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Lin 2022[24]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Siam 2020[29]	Low risk	Low risk	Low risk	Some concerns	Some concerns	High risk
Singh 2019[19]	Low risk	Low risk	Low risk	High risk	Low risk	High risk
Yayik 2019[18]	Some concerns	Low risk	Low risk	Low risk	Low risk	High risk
Yesiltas 2021[26]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Yu 2021[23]	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Zhang 2020[27]	Low risk	Low risk	Low risk	Some concerns	Low risk	Some concerns
Zhang 2021[25]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Cadaveric studies[37] assessing the spread of methylene blue dye administered *via* the ESPB have shown cephalocaudal and lateral distribution of dye both superficial and deep to the erector spinae muscles but not involving the paravertebral space and the ventral and dorsal branches of the spinal nerves. It has been shown that ESPB acts primarily by the direct action of the anesthetic on the nerves passing through the fascial compartment at the level of injection with the spread of injectate 1-2 levels higher and lower and only a minimal amount enters the paravertebral and epidural spaces[8].

Limitations and Strengths

The most important limitation of our review was the high heterogeneity between the studies. This was anticipated owing to differences in the study populations, the different levels of blocks, the difference in type and volume of local anesthetic solution, and perioperative analgesic drugs used by the included studies. Further limitations of the review comprise the variable data reporting by the included trials which reduced the number of studies in each meta-analysis. Finally, most studies were not of good quality with many not using double blinding in the study design and this may have caused bias in the overall outcomes.

Strengths of the review include the thorough literature search which led to the inclusion of maximum trials in the meta-analysis thereby providing updated evidence compared to the previous meta-analysis[10]. A large number of outcomes reported by the studies were analyzed along with a sensitivity analysis to present the best available evidence.

Conclusions

ESPB can be highly efficacious for postoperative analgesia in lumbar surgery patients. The block has the capability of reducing 24-hour opioid intake and pain scores up to 48 hours along with a significant reduction in the need for rescue analgesics and PONV. Future trials should use homogenized ESPB and perioperative analgesic protocols to generate better-quality evidence.

Informed Consent

Not applicable.

Authors' Contribution

XC conceived and designed the study, SZ and YL collected data and performed data analysis. XC wrote the draft of this manuscript. YL edited the manuscript.

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Ethics Approval

Not applicable.

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