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 p=0.0001). Pain scores at 4-6 hours (MD: -1.37 95% CI: -1.98, -0.76 p=0.0001), 8-12 hours (MD: -1.18 95% CI: -1.84, -0.52 p=0.0004), 24 hours (MD: -0.53 95% CI: -1.03, -0.04 p=0.04) and 48 hours (MD: -0.36 95% CI: -0.84, 0.13 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 p=0.002), had lower demand for rescue analgesics (OR: 0.12 95% CI: 0.07, 0.21 p=0.0001) and fewer incidence of PONV (OR: 0.27 95% CI: 0.15, 0.49 p=0.001).

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

Methodological research and technological developments have significantly increased the safety of lumbar spinal surgeries resulting in an increased number of procedures worldwide. 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.

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. 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. Research 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 in 2016 for the
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. The solution is deemed to spread along the fascial plane underneath the muscle and tissue compartments to the spinal ventral rami thereby providing analgesia. 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. and Oh et al. have systematically evaluated 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, 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). 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. 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. 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. A sensitivity analysis was done to assess the stability of the outcomes. The F 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 studies11,30 ESPB was administered after surgery while in one26 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 study26, 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 I²=99% p<0.00001) (Figure 2). There was no evidence of publication bias (Figure 3). The results did not change on sensitivity analysis.
Table I. Details of included studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>Surgery type</th>
<th>Groups</th>
<th>Sample size</th>
<th>Mean age</th>
<th>Timing of block</th>
<th>ESPB group</th>
<th>Control analgesia</th>
<th>Postoperative (hours)</th>
<th>Follow-up</th>
</tr>
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<tbody>
<tr>
<td>Asar 2022</td>
<td>Turkey</td>
<td>Open lumbar spine surgery</td>
<td>ESPB Control</td>
<td>35</td>
<td>61.9± 9.5</td>
<td>Post-surgery</td>
<td>Ultrasound guided bilateral ESPB with 20 mL of 0.5% bupivacaine and 2% lidocaine at T10 level</td>
<td>No block</td>
<td>Tramadol PCA</td>
<td>24</td>
</tr>
<tr>
<td>Avis 2021</td>
<td>France</td>
<td>Lumbar spine surgery</td>
<td>ESPB Control</td>
<td>25</td>
<td>67[60-72]*</td>
<td>Pre-surgery</td>
<td>Ultrasound guided bilateral ESPB with 20 mL of 0.375% ropivacaine at L3 level</td>
<td>Sham block</td>
<td>Paracetamol, ketoprofen, Morphine as rescue</td>
<td>72</td>
</tr>
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<td>Open posterior lumbar decompression</td>
<td>ESPB Control</td>
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<td>NR NR</td>
<td>After induction</td>
<td>ESPB with 0.5% levobupivacaine 20 mL</td>
<td>No block</td>
<td>Morphine</td>
<td>24</td>
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<tr>
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<td>China</td>
<td>Lumbar spine surgery</td>
<td>ESPB Control</td>
<td>25 25</td>
<td>NR</td>
<td>Pre-surgery</td>
<td>Ultrasound guided bilateral ESPB with 30 mL of 0.375% ropivacaine at T12 level</td>
<td>Sham block</td>
<td>Sufentanil PCA</td>
<td>48</td>
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<td>Lumbar discectomy</td>
<td>ESPB Control</td>
<td>30 30</td>
<td>46.1± 10.1</td>
<td>Pre-surgery</td>
<td>Ultrasound guided bilateral ESPB with 20 mL 0.25% bupivacaine at L3 level</td>
<td>No block</td>
<td>Fentanyl PCA</td>
<td>24</td>
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<td>Turkey</td>
<td>Lumbar decompression</td>
<td>ESPB Control</td>
<td>40 40</td>
<td>58±± 5.2</td>
<td>Post-surgery</td>
<td>Ultrasound guided bilateral ESPB with 20 mL of 0.25% bupivacaine at a vertebra level in the mid-point of the incision</td>
<td>No block</td>
<td>Tramadol PCA, Pethidine as rescue</td>
<td>48</td>
</tr>
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<td>Posterior lumbar fusion</td>
<td>ESPB Control</td>
<td>30 30</td>
<td>43.9± 9.8</td>
<td>Before induction</td>
<td>Ultrasound guided bilateral ESPB with 20 mL 0.25% bupivacaine at L3 level</td>
<td>Sham block</td>
<td>Morphine IV</td>
<td>24</td>
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<tr>
<td>Jin 2021</td>
<td>China</td>
<td>Elective lumbar laminoplasty</td>
<td>ESPB Control</td>
<td>30 32</td>
<td>56.7± 8.7</td>
<td>Pre-surgery</td>
<td>Ultrasound guided bilateral ESPB with 20 mL of 0.375% ropivacaine at vertebral level of surgery</td>
<td>No block</td>
<td>Sufentanil PCA</td>
<td>48</td>
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</table>
### Efficacy of erector spinae nerve block for pain control after lumbar spinal surgeries

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

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

ESPB, erector spinae plane block; NR, not reported; PCA, patient-controlled analgesia; IV, intravenous, L, lumbar; T, thoracic. *Median and interquartile range.
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 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 $I^2=96\%$ $p=0.0004$) (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 $F=100\%$ $p=0.002$) (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 $F=51\%$ $p<0.0001$) (Figure 10).

![Figure 2.](image-url) Meta-analysis of 24-hour total opioid consumption between ESPB and control groups.

![Figure 3.](image-url) Forest plot for the meta-analysis of 24-hour total opioid consumption.
Efficacy of erector spinae nerve block for pain control after lumbar spinal surgeries

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.
Efficacy of erector spinae nerve block for pain control after lumbar spinal surgeries

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\(^{11}\) 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\(^{19}\). 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\(^{33}\). 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\(^{30}\) 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.

<table>
<thead>
<tr>
<th>Study</th>
<th>Randomization process</th>
<th>Deviation from intended intervention</th>
<th>Missing outcome data</th>
<th>Measurement of outcomes</th>
<th>Selection of reported result</th>
<th>Overall risk of bias</th>
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<td>Low risk</td>
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<td>Low risk</td>
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Efficacy of erector spinae nerve block for pain control after lumbar spinal surgeries

Cadaveric studies\(^3\)\(^7\) 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\(^9\). 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.

**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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