Original Article

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Fluoroscopy-Guided Erector Spinae Plane Block Reduces Early Postoperative Pain Following Lumbar Fusion: A Randomized Controlled Trial

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Abstract

Design: Randomized Controlled Trial.

Objective: Postoperative pain after lumbar spine surgery remains a clinical challenge. Fluoroscopy-guided erector spinae plane block (ESPB) has been proposed as a feasible technique for reducing pain and opioid use, particularly when ultrasound guidance is not available.

Methods: In this double-blind randomized controlled trial, 80 patients undergoing two to five levels of posterior lumbar fusion with single-level discectomy and interbody fusion were assigned to receive either fluoroscopy-guided ESPB with ropivacaine, dexamethasone, and saline or placebo. Pain intensity (Numerical Rating Scale), opioid consumption (Morphine Equivalent Dose), and other postoperative outcomes were assessed at 4, 24, 48, 72 h, and 6 months.

Results: The ESPB group reported significantly lower axial pain scores at 4 and 24 h postoperatively ($P = 0.017$ and $P = 0.0001$, respectively). Opioid consumption was also significantly lower in the ESPB group during the first 48 h ($P < 0.05$). No significant differences were observed in radicular pain, patient satisfaction, time to ambulation, or hospital length of stay. At 6 months, both groups showed similar pain scores and rates of over-the-counter analgesic use. Infection rates were low and comparable between groups.

Conclusion: Fluoroscopy-guided ESPB appears to be a safe and effective adjunct for reducing early postoperative pain and opioid requirements following posterior lumbar fusion. However, its benefits diminish beyond the immediate postoperative period, and it does not significantly impact long-term outcomes.

Keywords

ESPB, fluoroscopy-guided block, lumbar fusion, postoperative pain, opioid consumption

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Introduction

Postoperative pain management following lumbar spine surgery remains one of the major clinical challenges. Inadequate pain control not only increases opioid consumption and its associated adverse effects, but also diminishes patient satisfaction, prolongs hospital stays, and delays early mobilization. In recent years, the erector spinae plane block (ESPB) has gained attention as a promising peripheral nerve block technique and has been used in various surgical procedures, including spine surgeries. By targeting the dorsal rami to induce a sensory blockade, ESPB offers multi-level analgesia and significantly reduces pain intensity and the need for opioid therapy.[1-5]

While several studies have demonstrated the effectiveness of ultrasound-guided ESPB in terms of pain relief and opioid-sparing benefits,[6-8] evidence supporting the use of fluoroscopy-guided ESPB remains limited, largely consisting of retrospective studies and small case series. According to these studies, unlike ultrasound-guided techniques, typically performed by anesthesiologist, fluoroscopy-guided ESPB can be performed by the spine surgeons themselves often within a short timeframe and acceptable efficacy thereby reducing the dependence on the anesthesiology personnel.[9] Moreover, in patients with morbid obesity, where anatomical landmarks are difficult to identify using ultrasound, fluoroscopy offers clear imaging of bony structures and facilitate accurate needle placement.[10,11]

Based on this background, the aim of the current randomized controlled trial (RCT) is to evaluate the efficacy of fluoroscopy-guided ESPB in controlling early postoperative pain in patients undergoing posterior lumbar fusion surgery. Secondary outcomes include length of hospital stay, opioid consumption, time to first ambulation, and pain intensity at 6 months. Given that infection is the most common complication associated with ESPB, patients were followed for 1 year to monitor for infections.

Materials and Methods

Patients and Study Design

This IRB-approved double-blinded randomized controlled trial (RCT) was conducted between February 2023 and April 2024 at two university hospitals (ID Number:[omitted to keep paper anonymous for peer review]). The inclusion criteria required one- or two-level decompression with a single-level discectomy and interbody fusion. In some cases, spinal stability required instrumented fusion of additional adjacent segments. Therefore, the total number of fused levels ranged from 2 to 5, as shown in Table 1, for the treatment of degenerative lumbar spine disorders or Grade I spondylolisthesis. Patients were assigned to receive either an analgesic cocktail (treatment group) or a placebo (control group). The inclusion criteria were age between 18 and 75 years and an ASA score of I or II. Patients with a history of psychiatric disorders, opioid addiction, inflammatory disease requiring treatment, prior lumbar surgery, or a history of previous spondylodiscitis were excluded from the study (Figure 1).

Sample Size Calculation

A sample size calculation was performed based on anticipated differences in NRS pain scores at 24 h, derived from prior studies reporting a minimally clinically important difference of approximately 1.5 points (SD 2.0) on the 0-10 scale.[12] Assuming $\alpha = 0.05$ and $\beta = 0.8$, a total sample size of 72 was required. To account for potential dropouts, we enrolled 80 patients.

Randomization and Blinding

The process and aim of the study, as well as the possible adverse effects of the drug injection, were described to the patients. All of the enrolled patients signed a written informed consent. A computer-generated sequence with a block size of

Table 1. Baseline Characteristics of the Patients. (LBP: Low Back Pain)

	ESPB (n = 40)	Control (n = 40)	*P*-value
Gender (Female: Male)	26:14	22:18	0.493
Age (Mean (SD))	54.9 (13.3)	55.3 (11.5)	0.820
BMI (Mean (SD))	27.1 (5)	27.29 (4.5)	0.859
Diabetes Mellitus	5 (12.5 %)	6 (15 %)	0.999
Hypertension	12 (30 %)	7 (17.5 %)	0.293
Smoker (pack. Year)	3.65 (10.9)	4.61 (11.4)	0.855
LBP Duration before surgery (Months)	19 (15.3)	13.7 (11.9)	0.151
LBP Exacerbation Duration (Weeks)	8.8 (9.6)	8.6 (13.7)	0.104
Number of Fused Levels			0.580
• Two levels	16 (40 %)	21 (52.5 %)	
• Three levels	17 (42.5 %)	12 (30 %)	
• Four levels	5 (12.5 %)	6 (15 %)	
• Five levels	2 (5 %)	1 (2.5 %)	

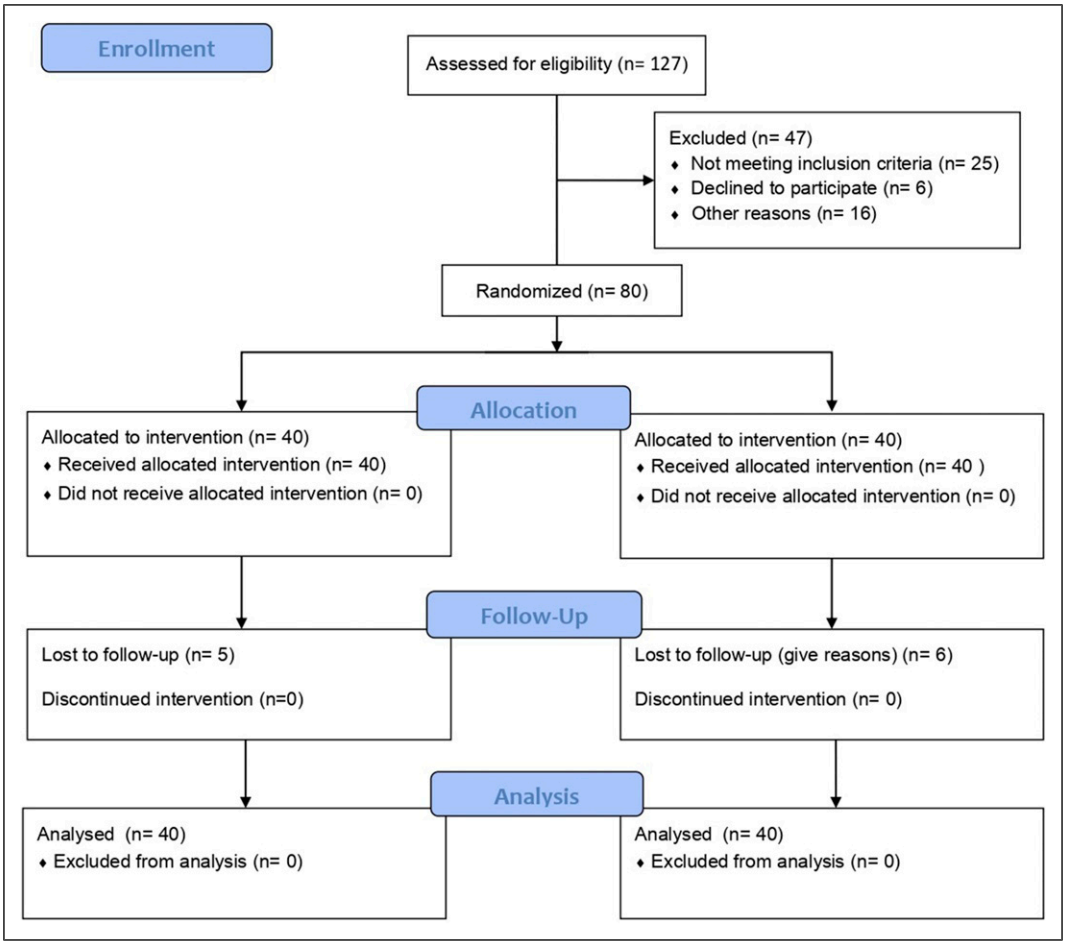


Figure 1. Consort Flow Diagram for Reporting Randomized Trial

four patients was used for randomization. The patients were assigned consecutive numbers based on the order of enrolment in the study. The assigned numbers were sent to a research assistant who was preparing the solutions for the injection. The research assistant was the only one with access to the randomization list. Although both solutions were colorless, syringes were covered using opaque tape to prevent the physician and patients from guessing the contents. Injections were made by a physician who was not aware of the allocation status.

Surgical Procedures and the Early Post Op Period

A senior spine surgeon performed all surgeries. General anesthesia was induced using midazolam (1 mg IV) and fentanyl (2 μg/kg IV), followed by propofol (2 mg/kg IV) and atracurium (0.4-0.5 mg/kg IV) for muscle relaxation and endotracheal intubation. The maintenance anesthesia regimen consists of continuous infusion of propofol (100-150 μg/kg/min) and remifentanil (0.1-1 μg/kg/min). Patients were positioned prone after eye protection.

A midline skin incision was made, followed by bilateral subperiosteal dissection to expose the bony elements, including the targeted facet joints and transverse processes. Pedicle screw instrumentation was performed under fluoroscopic (C-arm) guidance. Decompressive laminectomy was carried out at one or two levels, along with a single-level discectomy and interbody fusion. Following copious irrigation with 500 mL of normal saline, a surgical drain was placed. The fascia and skin were closed in separate layers using a standard technique.

Upon skin closure, neuromuscular blockade was reversed using neostigmine (0.05 mg/kg IV) and atropine (0.01 mg/kg IV). All patients received morphine sulfate (0.1 mg/kg IV) 30 min before the end of surgery and were then transferred to the recovery room. All patients uniformly received acetaminophen (1 g IV) during the first 8 h postoperatively. As soon as the patients were allowed oral intake, they were transitioned to oral acetaminophen 500 mg four times daily for 2 days.

No preoperative analgesics, including NSAIDs or gabapentinoids, were administered; all patients received standard general anesthesia and intraoperative acetaminophen. Postoperatively, acetaminophen was routinely scheduled for all,

while morphine was provided as rescue analgesia for NRS scores >5. NSAIDs were avoided due to institutional protocols. Pain was assessed by nursing staff at rest every 6 h.

ESPB Technique Under Fluoroscopy Guidance

Following general anesthesia and patient positioning in the prone position, surgical site preparation was performed with povidone-iodine. A virtual line was then drawn on the skin from the highest point of the iliac crest toward the spine to approximately localize the L4 vertebra. Using the C-arm in the anteroposterior (AP) view, the transverse processes of the L4 vertebra were recognized. Under AP fluoroscopic guidance, under 45° angulation with skin, a 16G spinal needle was inserted toward the junction of the lateral and middle thirds of the transverse process on each side. This location corresponds to the approximate anatomical position of the dorsal rami.[13] Upon feeling the bone contact by the surgeon, the needle was slightly withdrawn to position it within the subfascial plane. After negative aspiration, the intended injectate was administered slowly (Figure 2). The treatment group received a total of 22 mL per side, consisting of 15 mL of 0.5% ropivacaine, 5 mL of normal saline, and 8 mg (2 mL) of dexamethasone.

Outcome Measurements

Pain intensity in the lumbar region was assessed using the Numerical Rating Scale (NRS) preoperatively and at 4, 24, 48, and 72 h, as well as 6 months postoperatively. Patient satisfaction was evaluated using a 7-point Likert scale at the 6-month follow-up. Opioid consumption was measured using the Morphine Equivalent Dose (MED) at 4, 24, 48, and 72 h postoperatively. The following instructions were used for the prescription of morphine products in the early postoperative period: If any patients reported a pain score greater than five on the NRS, they received 3 mg of morphine. In cases where the pain score exceeded 7, pain was reassessed 6 h later; if the score remained above 5, an additional 3 mg dose of morphine was administered.

Statistical Analysis

All data were analyzed using Graphpad Prism version 8. Repeated measures were analyzed with ANOVA or Friedman based on a normality test with the Kolmogorov-Smirnov test. The independent t-test and Mann-Whitney test based on the normality test with the Kolmogorov-Smirnov test were used to compare continuous variables. In contrast, the chi-square and Fisher's Exact test were applied to assess associations between categorical variables. A *P*-value of less than 0.05 was considered statistically significant.

Results

During the recruitment phase of the study, 127 assessed for eligibility of which 80 patients met the inclusion criteria and

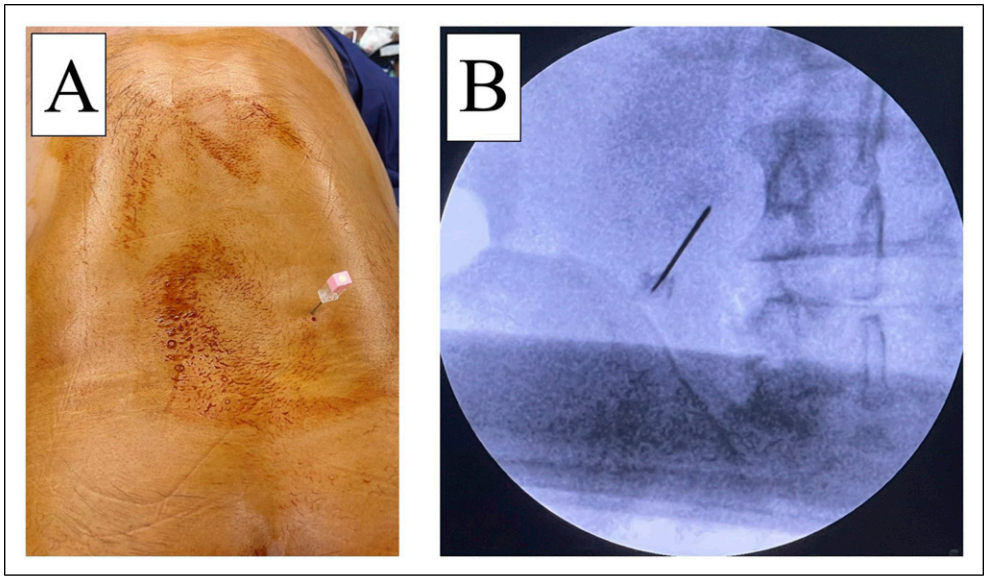


Figure 2. (A) Needle Insertion Point and Orientation Based on Surface Landmarks, Including the Iliac Crest and Midline Reference. After Identifying the Iliac Crest, an Imaginary Line is Drawn From Its Highest Point Toward the Spine Along the Cranio-Caudal Axis. Approximately 6 cm Lateral to the Midline Along the Medio-Lateral Axis, the Spinal Needle is Inserted With a Medial Angulation (B) The C-arm Fluoroscopy AP View Demonstrated the Iliac Crest, Spinous Processes, Pedicles, Transverse Processes, and the Needle Tip Contacting the Lateral Aspect of the Transverse Process. Using C-arm Fluoroscopy, a Hypothetical Line is Drawn From the Highest Point of the Iliac Crest Toward the Midline to Identify the L4–L5 Intervertebral Disc Space. The L4 Vertebra is Then Localized, and the Transverse Process is Marked in Line With the Pedicle. The Needle is Advanced in a Medio-Lateral Direction Toward the Lateral Aspect of the Transverse Process Until Bone Contact is Achieved

agreed to participate in the study. Based on the exclusion criteria, 47 were excluded. Finally, 80 patients (Female: 48 patients) with a mean ± SD age of 55.1 ± 12.36 were randomly assigned into the treatment and control groups. The analysis during the first 72 h was performed on all 40 patients in each group. During follow-up, 5 patients from the intervention (ESPB) group and 6 patients from the control group were lost. Therefore, data from 35 patients in the intervention group and 34 patients in the control group were included in the analysis of pain intensity at 6 months postoperation. (Figure 1). There were no statistically significant differences between the ESPB and control groups in terms of baseline demographic or clinical characteristics, including age, gender, BMI, comorbidities, smoking history, duration of low back pain, or number of fused levels (Table 1).

Pain Scores

Axial pain intensity, as measured by NRS, showed significant reductions over time in both groups ($P < 0.0001$, intragroup analysis). At 4 h (6.02 ± 3 vs 7.7 ± 2.4) and 24 h (4.12 ± 2.4 vs 6.3 ± 2.3) postoperatively, the ESPB group demonstrated significantly lower axial NRS scores compared to the control group ($P = 0.017$ and $P = 0.0001$, respectively). However comparing the postoperative pain intensity at 48 ($P = 0.135$) and 72 h ($P = 0.164$) between the groups, no statistically significant relation was found. Also at the 6-month follow-up, no significant difference in axial pain was observed between groups ($P = 0.385$) (Figure 3, Table 2). Radicular pain decreased markedly in both groups postoperatively ($P < 0.0001$, intragroup). However, no significant difference was detected between the ESPB and control groups at any time point, including the 6-month follow-up ($P > 0.05$ for all comparisons) (Figure 3, Table 2).

Opioid Consumption

Morphine Equivalent Dose (MED) use was significantly lower in the ESPB group at 4, 24, and 48 h postoperatively ($P = 0.011$, < 0.001, and 0.008, respectively). By 72 h, the difference in opioid consumption between groups was no longer statistically significant ($P = 0.087$) (Figure 3, Table 2).

Other Clinical Outcomes

There were no statistically significant differences between groups in terms of time to ambulation ($P = 0.787$), length of hospital stays ($P = 0.548$), or patient satisfaction scores at 6 months ($P = 0.745$). The rate of surgical site infections was low and comparable between the two groups (5% in ESPB vs 2.5% in control, $P = 0.999$). Over-the-counter (OTC) analgesic use at 6 months decreased significantly from preoperative levels in both groups ($P = 0.0002$ in ESPB, $P = 0.0007$ in control), with no difference between groups postoperatively ($P = 0.604$).

Discussion

Posterior lumbar decompression and instrumentation is often associated with significant postoperative pain, particularly in the early recovery period.[14-16] Although opioids remain the mainstay of postoperative pain control, their use is associated with adverse effects such as nausea, vomiting, constipation, and potential for dependence.[17] To address this challenge, regional anesthesia techniques such as the erector spinae plane block (ESPB) have gained traction for their targeted analgesia and minimal systemic side effects.[9] The mechanism of action for ESPB is believed to involve blockade of the dorsal rami adjacent to the transverse processes, resulting in multi-level analgesia. Cadaveric studies have confirmed that injectate can spread to as many as three vertebral levels, making ESPB suitable for lumbar spine surgery. While ultrasound-guided ESPB is more commonly reported, fluoroscopy-guided techniques offer a practical advantage for spine surgeons, particularly in patients with obesity or poor sonographic windows.[13,18]

Our study is the first prospective, double-blind, randomized placebo-controlled trial to evaluate the efficacy of

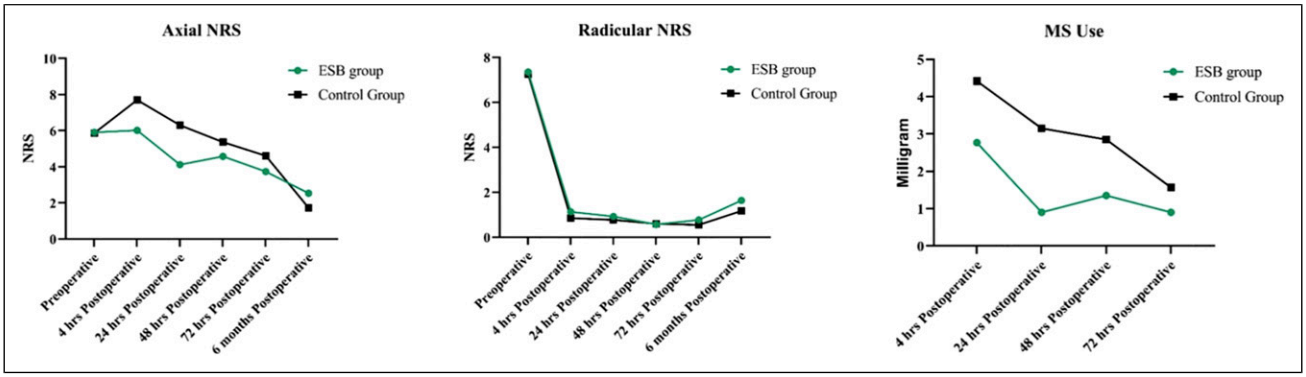


Figure 3. Diagram Comparing the Effect of ESPB on Postoperative Radicular and Axial Pain, and Morphine Sulfate Usage in Patients With and Without ESPB

Table 2. Comparison of the Clinical Outcome and Complication Profile in Patients With and Without ESPB (NRS: Numerical Rating Score, OTC: Over the Counter)

	ESPB (n = 40)	Control (n = 40)	*P*-value
Axial Pain NRS			
• Preoperative	5.91 (2.4)	5.87 (3.3)	0.792
• 4 h postoperative	6.02 (3)	7.7 (2.4)	**0.017***
• 24 h postoperative	4.12 (2.4)	6.3 (2.3)	**0.0001***
• 48 h postoperative	4.58 (2.3)	5.37 (2.5)	0.135
• 72 h postoperative	3.74 (2.5)	4.61 (2.8)	0.164
• 6 months postoperative	2.54 (2.9)	1.73 (2.1)	0.385
Longitudinal P-value	***<0.0001****	***<0.0001****	
Radicular Pain NRS			
• Preoperative	7.35 (2.7)	7.25 (3.2)	0.662
• 4 h postoperative	1.13 (2.6)	0.85 (2.2)	0.468
• 24 h postoperative	0.92 (2.2)	0.77 (1.9)	0.638
• 48 h postoperative	0.57 (1.7)	0.60 (1.5)	0.751
• 72 h postoperative	0.77 (2.1)	0.55 (1.7)	0.599
• 6 months postoperative	1.64 (2.7)	1.17 (2.2)	0.761
Longitudinal P-value	***<0.0001****	***<0.0001****	
Morphine Equivalent Dose (MED)			
• 4 h postoperative	2.77 (2.91)	4.42 (2.45)	**0.011***
• 24 h postoperative	0.90 (2.06)	3.15 (2.44)	**<0.001***
• 48 h postoperative	1.35 (2.14)	2.85 (2.63)	**0.008***
• 72 h postoperative	0.90 (1.94)	1.57 (2.15)	0.087
Longitudinal P-value	***<0.0001****	***<0.0001****	
OTC painkiller usage			
• Preoperative	25 (62.5 %)	24 (62 %)	0.938
• Postoperative	12 (30 %)	10 (25 %)	0.604
Longitudinal P-value	**0.0002***	**0.0007***	
Time to First ambulation (Days)	1.08 (0.28)	1.35 (1.5)	0.787
Time to Discharge (Days)	3.21 (2.7)	3.44 (2.97)	0.548
Satisfaction Score at 6 Month (Likert scale)	5.50 (2.06)	5.76 (1.86)	0.745
Surgical Site Infection	2 (5 %)	1 (2.5 %)	0.999

Bold indicates statistically significant.

fluoroscopy-guided ESPB with a 6-month follow-up. The rigor of our study design including randomization, blinding, and comparable baseline demographics strengthens the reliability of our findings. Our results demonstrate that ESPB significantly reduces axial pain intensity during the first 24 h postoperatively, with a faster onset of pain relief compared to the control group. However, this analgesic effect diminished by 48 and 72 h, and by the 6-month follow-up, no significant difference in axial or radicular pain remained (Figure 3). These findings are consistent with prior reports showing short-term benefits of ESPB, but limited evidence for long-term efficacy.[19] Importantly, we observed a significant reduction in opioid consumption (measured by Morphine Equivalent Dose) in the ESPB group during the first 48 h postoperatively, supporting its opioid-sparing effect.[10,20,21]

We found no significant difference in patient satisfaction, time to ambulation, or length of hospital stay between the two groups. These findings align with previous research indicating that while ESPB can improve pain metrics, it may not translate into functional improvements or shorter hospitalization.[22,23] Although the study was not powered to analyze complications in detail, postoperative infections occurred in a small number of patients (5% in ESPB vs 2.5% in control), within the reported range of 0-9% in spinal surgery,[24,25] As all patients received an injection—either placebo or active drug—it remains inconclusive whether ESPB increases infection risk. Further studies with larger sample sizes and focused infection surveillance are necessary.

An exploratory finding in our study was that ESPB's efficacy appeared to decline with increasing number of fused levels, though this trend did not reach statistical significance. One possible explanation is the use of a single injection level (L4 transverse process) in all cases, which may be insufficient to provide adequate analgesia in multilevel procedures. This observation aligns with anatomical data suggesting limited craniocaudal spread beyond three levels. Future studies should investigate whether multi-level ESPB or alternative injection

sites could enhance analgesic coverage in extensive lumbar instrumentation.[4]

Although ESPB provided significant early pain relief, several factors may explain why this did not translate into improved functional outcomes such as earlier ambulation or reduced hospital stay. First, the analgesic effect was most pronounced within the first 24 h, whereas functional milestones such as ambulation and discharge typically depend on sustained pain control over several days. Second, postoperative recovery following lumbar fusion is multifactorial, involving not only pain but also factors such as perioperative muscle dissection, patient comorbidities, and rehabilitation protocols. Therefore, addressing pain alone may be insufficient to achieve measurable differences in these broader outcomes. Finally, it is possible that a single-level ESPB may not provide adequate analgesia for more extensive, multilevel surgeries.

While the analgesic benefit of ESPB was most pronounced in the first 24 h, whether this justifies the additional time and resource allocation depends on institutional priorities and patient-specific risk profiles. In cases where minimizing opioid exposure is paramount—such as patients with high risk of opioid-related adverse events—the procedure may be justified. However, given the modest duration of benefit observed, routine ESPB for all lumbar fusions may not be cost-effective unless longer-lasting or more extensive blocks can be consistently achieved.

This study has several limitations. First, the population was restricted to patients undergoing two to five levels of posterior lumbar fusion with a single-level discectomy and transforaminal interbody fusion, limiting the generalizability of the findings to other types of spinal procedures such as single-level surgeries, deformity corrections, or anterior approaches. Second, only a single injection level (L4 transverse process) with a fixed volume was used for ESPB in all patients, which may not provide sufficient analgesic coverage in more extensive, multilevel surgeries. Third, the optimal ESPB injection level and volume for extensive fusions (three or more levels) remain to be established, representing an important knowledge gap. Fourth, the reported morphine consumption appears low compared to published literature, raising questions regarding protocol adherence and generalizability. While our administration protocol used intermittent 3 mg morphine boluses in response to NRS scores—in contrast to postoperative patient-controlled analgesia (PCA) approaches—this difference may limit direct comparisons with studies using PCA and reduce the overall generalizability of our findings. Fifth, although our sample size was sufficient for detecting differences in early pain and opioid use, it may not have been powered to detect rare complications or subtle long-term effects. Lastly, despite rigorous blinding efforts, some bias in subjective outcomes such as patient satisfaction cannot be entirely excluded.

Conclusion

Fluoroscopy-guided ESPB is an effective adjunct for reducing early postoperative pain and opioid consumption following posterior lumbar fusion. However, it does not appear to offer long-term pain relief or significantly influence hospital stay, ambulation timing, or patient satisfaction. Additional research is warranted to clarify infection risks and to define the optimal number and location of injection sites for extensive surgeries.

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RCT Registration Number

The Iranian Registry of Clinical Trials (IRCT20230317057745N1).

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