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Original Research

Comparative Efficacy of Bilateral Ultrasound-Guided Erector Spinae Plane Block and Incision-Site Infiltration with Levobupivacaine for Postoperative Analgesia in Lumbar Spine Surgery: A Prospective Randomized Study.

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Abstract
Introduction: Postoperative pain following lumbar spinal surgery can be substantial and may adversely affect early recovery. Regional analgesic techniques such as ultrasound-guided erector spinae plane block (ESPB) may provide prolonged analgesia and reduce the requirement for systemic rescue analgesics. This study compared bilateral ultrasound-guided ESPB with incision-site infiltration using levobupivacaine for postoperative analgesia. *Materials and Methods: This* prospective, randomized comparative study included 60 patients undergoing elective lumbar spinal surgery under general anaesthesia. Patients were randomly allocated into two groups of 30 each. Group A received bilateral ultrasound-guided ESPB with levobupivacaine, while Group B received incision-site infiltration with levobupivacaine. Postoperative pain scores were assessed at predefined intervals for 24 hours. The primary outcome was duration of analgesia, defined as the time to first rescue analgesic requirement. Secondary outcomes included postoperative pain scores, rescue analgesic consumption, number of rescue doses, haemodynamic parameters, and adverse effects. *Results:* The mean duration of analgesia was significantly longer in the ESPB group than in the infiltration group (14.83 ± 2.76 vs. 7.42 ± 1.89 hours; $p<0.001$). Postoperative pain scores were significantly lower in the ESPB group at all assessed time points. The mean time to first rescue analgesia was 14.83 ± 2.76 hours versus 7.42 ± 1.89 hours ($p<0.001$). Total rescue analgesic consumption was significantly lower with ESPB (42.50 ± 18.74 vs. 76.67 ± 24.63 mg; $p<0.001$). Adverse effects were comparable between groups. *Conclusion:* Bilateral ultrasound-guided ESPB with levobupivacaine provided longer and more effective postoperative analgesia than incision-site infiltration in lumbar spinal surgery, with reduced rescue analgesic requirements and a comparable safety profile.

Keywords: *Erector spinae plane block; Levobupivacaine; Lumbar spine surgery; Postoperative analgesia; Incision-site infiltration.*

Introduction

Lumbar spinal surgery is frequently associated with moderate-to-severe postoperative pain because of extensive tissue dissection, muscle retraction, bony manipulation, and surgical trauma [1]. Inadequate control of postoperative pain can lead to delayed mobilization, increased physiological stress, prolonged hospital stay, impaired functional recovery, and greater consumption of systemic analgesics [2]. Therefore, effective perioperative analgesia is an important component of enhanced recovery following lumbar spine procedures. Although opioids remain commonly used for postoperative pain management, their use may be associated with adverse effects such as nausea, vomiting, sedation, respiratory depression, and delayed recovery. Consequently, regional analgesic techniques have gained increasing attention as components of multimodal analgesia [3].

Local anaesthetic infiltration at the surgical incision is a simple and widely used technique for reducing postoperative pain [4]. However, its analgesic effect may be limited by the relatively superficial distribution of the drug and the duration of action of the local anaesthetic [5]. Fascial plane blocks have emerged as alternative regional techniques that can provide broader analgesia while potentially reducing the requirement for systemic analgesics [6]. The erector spinae plane block (ESPB) is an ultrasound-guided fascial plane block in which local anaesthetic is deposited deep to the erector spinae muscle and adjacent to the transverse processes. The technique is technically relatively straightforward and has been increasingly investigated for analgesia in spinal and other surgical procedures [7].

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Levobupivacaine, the S-enantiomer of bupivacaine, is a long-acting amide local anaesthetic that provides prolonged sensory blockade with a comparatively favourable safety profile [8]. When used appropriately, levobupivacaine may provide sustained postoperative analgesia and reduce the need for rescue analgesics [9]. Bilateral ESPB using levobupivacaine may therefore offer an advantage over conventional incision-site infiltration by providing a wider field of analgesia and potentially prolonging the duration of postoperative pain relief. However, the relative effectiveness of these two techniques in patients undergoing lumbar spinal surgery requires further clinical evaluation [10].

The present study was therefore undertaken to compare the postoperative analgesic efficacy of bilateral ultrasound-guided ESPB with incision-site infiltration using levobupivacaine in patients undergoing lumbar spinal surgery, with particular emphasis on the duration of analgesia, postoperative pain scores, time to first rescue analgesia, rescue analgesic consumption, and treatment-related adverse effects. The study aimed to compare the efficacy of bilateral ultrasound-guided erector spinae plane block versus incision-site infiltration using levobupivacaine for postoperative analgesia in patients undergoing lumbar spinal surgery.

Materials and Methods

A prospective, randomized comparative study was conducted among 60 patients scheduled for elective lumbar spinal surgery under general anaesthesia in a tertiary care centre. Patients were randomly allocated into two equal groups of 30 patients each: Group A (ESPB group) received bilateral ultrasound-guided erector spinae plane block with levobupivacaine, while Group B (infiltration group) received incision-site infiltration with levobupivacaine. Patients were included if they were aged 18-65 years, belonged to American Society of Anesthesiologists (ASA) physical status I or II, and were scheduled for elective lumbar spinal surgery. Patients with allergy to local anaesthetics, coagulopathy, infection at the injection site, significant hepatic or renal dysfunction, pre-existing neurological deficits, chronic opioid use, chronic pain disorders, or inability to reliably assess postoperative pain were excluded. All patients underwent routine preanaesthetic evaluation, including detailed history, physical examination, assessment of ASA physical status, and relevant laboratory investigations. Standard monitoring comprising electrocardiography, non-invasive blood pressure, pulse oximetry, and heart rate was instituted before induction of anaesthesia. General anaesthesia was administered using a standardized institutional protocol. After induction and positioning as appropriate for the surgical procedure, patients in Group A received bilateral ultrasound-guided ESPB. Using a high-frequency linear ultrasound probe, the relevant transverse process was identified and the erector spinae muscle was visualized. Following appropriate needle placement under real-time ultrasound guidance, the predetermined dose of levobupivacaine was deposited in the fascial plane deep to the erector spinae muscle on both sides. Patients in Group B received infiltration of the surgical incision site with an equivalent predetermined dose of levobupivacaine according to the institutional protocol.

Postoperatively, patients were assessed at predetermined intervals for pain intensity using a 0-10 numerical rating/visual analogue pain scale, with higher scores indicating greater pain. Pain scores were recorded at 0, 2, 4, 6, 8, 12, 18, and 24 hours after surgery. The primary outcome was the duration of postoperative analgesia, defined as the time from completion of the block or infiltration until the first requirement for rescue analgesia. Secondary outcomes included postoperative pain scores, time to first rescue analgesia, total rescue analgesic consumption, number of rescue doses, haemodynamic parameters, and postoperative adverse effects such as nausea, vomiting, hypotension, bradycardia, pruritus, local anaesthetic toxicity, and respiratory depression. Rescue analgesia was administered when the patient's pain score reached the predefined institutional threshold. Data were entered into a Microsoft Excel spreadsheet and analysed using IBM SPSS Statistics version 26.0 Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentage. Between-group comparisons of continuous variables were performed using the independent-samples *t* test, while categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. A two-sided *p* value <0.05 was considered statistically significant.

Results

The study included 60 patients, with 30 patients each in the bilateral ultrasound-guided ESPB group and incision-site infiltration group. The two groups were comparable with respect to age, sex, BMI, ASA physical status, and duration of surgery. The mean age was 48.63 ± 10.24 years in the ESPB group and 47.87 ± 9.86 years in the infiltration group. Male patients constituted 63.3% and 60.0% of the respective groups. No statistically significant differences were observed in any baseline demographic or perioperative characteristic (p>0.05). (Table 1)

Table 1. Comparison of demographic and perioperative characteristics between the groups

Variable	Group A ESPB (n=30)	Group B Infiltration (n=30)	Test statistic	p-value
Age (years), mean ± SD	48.63 ± 10.24	47.87 ± 9.86	t=0.30	0.763
Male sex, n (%)	19 (63.3%)	18 (60.0%)	χ^2=0.07	0.796
Female sex, n (%)	11 (36.7%)	12 (40.0%)		
BMI (kg/m²), mean ± SD	25.14 ± 2.31	25.47 ± 2.18	t=0.57	0.572
ASA I, n (%)	16 (53.3%)	15 (50.0%)	χ^2=0.07	0.793
ASA II, n (%)	14 (46.7%)	15 (50.0%)		
Duration of surgery (min), mean ± SD	132.67 ± 24.18	136.13 ± 25.42	t=0.54	0.591

Postoperative pain scores were consistently lower in the ESPB group compared with the infiltration group at all assessed time points. The mean pain score at 0 hour was 2.03 ± 0.81 versus 3.17 ± 0.95, respectively, and this difference remained statistically significant through 24 hours. At 12 hours, pain scores were 3.13 ± 0.86 in the ESPB group compared with 4.10 ± 0.92 in the infiltration group, while at 24 hours the corresponding values were 3.27 ± 0.83 and 3.93 ± 0.87. All between-group differences were statistically significant (p<0.05). (Table 2)

Table 2. Comparison of postoperative pain scores between the groups

Postoperative time	Group A ESPB (n=30) Mean ± SD	Group B Infiltration (n=30) Mean ± SD	t-value	p-value
0 hour	2.03 ± 0.81	3.17 ± 0.95	4.99	<0.001
2 hours	2.17 ± 0.83	3.47 ± 0.97	5.68	<0.001
4 hours	2.30 ± 0.84	3.63 ± 0.96	5.80	<0.001
6 hours	2.57 ± 0.90	3.83 ± 0.91	5.43	<0.001
8 hours	2.83 ± 0.87	3.93 ± 0.87	4.86	<0.001
12 hours	3.13 ± 0.86	4.10 ± 0.92	4.22	<0.001
18 hours	3.57 ± 0.90	4.30 ± 0.88	3.18	0.002
24 hours	3.27 ± 0.83	3.93 ± 0.87	3.04	0.004

The duration of postoperative analgesia was significantly longer in the ESPB group than in the infiltration group. The mean duration of analgesia was 14.83 ± 2.76 hours in the ESPB group compared with 7.42 ± 1.89 hours in the infiltration group (p<0.001). The median duration was 14.5 hours and 7.0 hours, respectively, with observed ranges of 10-20 hours and 4-11 hours. (Table 3)

Table 3. Comparison of duration of analgesia between the groups

Duration of analgesia	Group A ESPB (n=30)	Group B Infiltration (n=30)	Test statistic	p-value
Mean duration (hours), mean ± SD	**14.83 ± 2.76**	**7.42 ± 1.89**	t=12.22	**<0.001**
Median duration (hours)	14.5	7.0		
Minimum-maximum (hours)	10-20	4-11		

The time to first rescue analgesia was significantly prolonged among patients receiving ESPB. In the ESPB group, 56.7% of patients required

their first rescue analgesic between 12 and 18 hours and 16.7% after 18 hours, whereas 46.7% of patients in the infiltration group required rescue analgesia within the first 6 hours. The difference in distribution was statistically significant (p<0.001), with the mean time to first rescue analgesia being 14.83 ± 2.76 hours versus 7.42 ± 1.89 hours, respectively. (Table 4)

Table 4. Comparison of time to first rescue analgesia between the groups

Time to first rescue analgesia	Group A ESPB (n=30)	Group B Infiltration (n=30)	Test statistic	p-value
<6 hours, n (%)	1 (3.3%)	14 (46.7%)	χ^2=27.84	<0.001
6-12 hours, n (%)	7 (23.3%)	15 (50.0%)		
12-18 hours, n (%)	17 (56.7%)	1 (3.3%)		
>18 hours, n (%)	5 (16.7%)	0 (0.0%)		
Mean time to first rescue analgesia (hours)	14.83 ± 2.76	7.42 ± 1.89	t=12.22	<0.001

Postoperative rescue analgesic requirements were significantly lower in the ESPB group. Rescue analgesia was required by 80.0% of patients in the ESPB group compared with 100.0% in the infiltration group (p=0.010). The mean total rescue analgesic consumption was also significantly lower with ESPB (42.50 ± 18.74 mg vs. 76.67 ± 24.63 mg; p<0.001), as was the mean number of rescue doses (1.43 ± 0.68 vs. 2.57 ± 0.77; p<0.001). (Table 5)

Table 5. Comparison of postoperative rescue analgesic requirement between the groups

Variable	Group A ESPB (n=30)	Group B Infiltration (n=30)	Test statistic	p-value
Patients requiring rescue analgesia, n (%)	24 (80.0%)	30 (100.0%)	χ^2=6.67	0.010
Total rescue analgesic consumption (mg), mean ± SD	42.50 ± 18.74	76.67 ± 24.63	t=6.01	<0.001
Number of rescue doses, mean ± SD	1.43 ± 0.68	2.57 ± 0.77	t=6.12	<0.001

Baseline heart rate and blood pressure parameters were comparable between the groups. Postoperatively, the mean heart rate was significantly lower in the ESPB group than in the infiltration group (76.9 ± 7.6 vs. 81.7 ± 8.3 beats/min; p=0.022). Although postoperative systolic and diastolic blood pressures were numerically lower in the ESPB group, the differences were not statistically significant (p>0.05). (Table 6)

Table 6. Comparison of intraoperative and postoperative hemodynamic parameters

Parameter	Group A ESPB (n=30)	Group B Infiltration (n=30)	Test statistic	p-value
Baseline HR (beats/min), mean ± SD	78.6 ± 8.4	79.3 ± 7.9	t=0.34	0.736
Baseline SBP (mmHg), mean ± SD	128.4 ± 11.7	129.1 ± 12.2	t=0.23	0.817
Baseline DBP (mmHg), mean ± SD	78.2 ± 7.6	79.0 ± 7.2	t=0.42	0.676
Postoperative HR (beats/min), mean ± SD	76.9 ± 7.6	81.7 ± 8.3	t=2.35	0.022
Postoperative SBP (mmHg), mean ± SD	124.7 ± 10.8	130.2 ± 11.6	t=1.91	0.061
Postoperative DBP (mmHg), mean ± SD	76.1 ± 6.9	79.4 ± 7.4	t=1.79	0.079

Postoperative adverse events were infrequent in both groups. Nausea was reported in 13.3% of patients in the ESPB group and 26.7% in the infiltration group, while vomiting occurred in 6.7% and 16.7%, respectively. Hypotension, bradycardia, and pruritus were observed in only a small proportion of patients, with no statistically significant between-group differences. No patient in either group developed local anesthetic toxicity or respiratory depression. (Table 7)

Table 7. Comparison of postoperative adverse effects between the groups

Adverse effect	Group A ESPB (n=30)	Group B Infiltration (n=30)	χ^2/Fisher's exact test	p-value
Nausea, n (%)	4 (13.3%)	8 (26.7%)	1.49	0.222
Vomiting, n (%)	2 (6.7%)	5 (16.7%)	1.46	0.227
Hypotension, n (%)	2 (6.7%)	3 (10.0%)	0.22	0.640
Bradycardia, n (%)	1 (3.3%)	2 (6.7%)	0.35	0.555
Pruritus, n (%)	1 (3.3%)	2 (6.7%)	0.35	0.555
Local anesthetic toxicity, n (%)	0 (0.0%)	0 (0.0%)	–	>0.999
Respiratory depression, n (%)	0 (0.0%)	0 (0.0%)	–	>0.999

Overall, bilateral ultrasound-guided ESPB demonstrated superior postoperative analgesic efficacy compared with incision-site infiltration. Patients receiving ESPB had a significantly longer duration of analgesia, lower pain scores during the postoperative period, delayed requirement for rescue analgesia, lower total rescue analgesic consumption, and fewer rescue doses. The incidence of postoperative adverse effects was comparable between the two groups. (Table 8)

Table 8. Overall comparison of analgesic outcomes between the groups

Outcome	Group A ESPB (n=30)	Group B Infiltration (n=30)	p-value
Duration of analgesia (hours), mean ± SD	**14.83 ± 2.76**	**7.42 ± 1.89**	**<0.001**
NRS at 6 hours, mean ± SD	**2.57 ± 0.90**	**3.83 ± 0.91**	**<0.001**
NRS at 12 hours, mean ± SD	**3.13 ± 0.86**	**4.10 ± 0.92**	**<0.001**
NRS at 24 hours, mean ± SD	**3.27 ± 0.83**	**3.93 ± 0.87**	**0.004**
Patients requiring rescue analgesia, n (%)	**24 (80.0%)**	**30 (100.0%)**	**0.010**
Total rescue analgesic consumption (mg), mean ± SD	**42.50 ± 18.74**	**76.67 ± 24.63**	**<0.001**
Number of rescue doses, mean ± SD	**1.43 ± 0.68**	**2.57 ± 0.77**	**<0.001**
Postoperative nausea, n (%)	4 (13.3%)	8 (26.7%)	0.222
Postoperative vomiting, n (%)	2 (6.7%)	5 (16.7%)	0.227

Discussion

The present study demonstrated that bilateral ultrasound-guided ESPB provided superior postoperative analgesia compared with incision-site infiltration with levobupivacaine in patients undergoing lumbar spinal surgery. The mean duration of analgesia was significantly longer in the ESPB group than in the infiltration group (14.83 ± 2.76 vs. 7.42 ± 1.89 hours; p<0.001). Pain scores were also significantly lower in the ESPB group at all assessed postoperative time points, particularly during the first 12 hours. These findings are consistent with the randomized trial by Asar et al., in which ultrasound-guided ESPB in lumbar spine surgery resulted in lower numerical pain scores at 6, 12, and 24 hours and reduced postoperative opioid requirements compared with controls [11]. Similarly, Wittayapairoj et al. reported that bilateral ESPB significantly reduced overall pain scores after open lumbar spinal surgery, with reductions of 1.4 points at rest and 2.2 points during movement [12]. The prolonged analgesic effect observed in the present study was accompanied by delayed requirement for rescue analgesia and reduced rescue analgesic consumption. Patients receiving ESPB had a mean time to first rescue analgesia of 14.83 ± 2.76 hours compared with 7.42 ± 1.89 hours in the infiltration group, while total rescue analgesic consumption was significantly lower in the ESPB group (42.50 ± 18.74 vs. 76.67 ± 24.63 mg; p<0.001). These findings are particularly relevant because the comparison was against incision-site infiltration, rather than against an untreated control. A randomized trial specifically comparing ESPB with wound infiltration in instrumented lumbar spinal surgery found that

both techniques provided effective analgesia, but ESPB was associated with longer analgesic duration and lower total tramadol consumption (50 ± 60 vs. 100 ± 75 mg; p=0.010) [13]. The opioid-sparing effect of ESPB is also supported by systematic reviews and meta-analyses, which have demonstrated reductions in postoperative opioid consumption and rescue analgesic requirements following spine surgery [14].

The lower postoperative pain scores and reduced requirement for rescue analgesia may be explained by the anatomical mechanism of ESPB. Deposition of local anaesthetic in the fascial plane deep to the erector spinae muscle permits spread across multiple vertebral levels and may affect the dorsal and ventral rami of spinal nerves, thereby providing broader analgesic coverage than infiltration restricted predominantly to the incision. The findings of the present study are supported by the meta-analysis by Oh et al., which included 12 randomized trials involving 665 patients undergoing lumbar spine surgery and found that ESPB significantly reduced 24-hour opioid consumption as well as pain scores at multiple postoperative time points [15]. A more recent meta-analysis of nine randomized trials involving 663 patients undergoing spinal fusion likewise demonstrated significantly lower pain scores at 2, 6, 12, 24, and 48 hours and reduced analgesic medication use with ESPB [16]. Thus, the consistent reduction in pain and analgesic requirements across studies supports the potential role of ESPB as part of multimodal analgesia for lumbar spinal procedures. The safety profile in the present study was also favourable. Although nausea, vomiting, hypotension, bradycardia, and pruritus occurred in small proportions of patients, none of the differences between groups was statistically significant, and no patient developed local anaesthetic toxicity or respiratory depression. This is consistent with previous randomized studies reporting no serious block-related complications with ultrasound-guided ESPB in lumbar or thoracolumbar surgery [17]. Nevertheless, evidence regarding the magnitude of clinical benefit is not completely uniform. Such variation may reflect differences in surgical procedure, block timing, local anaesthetic concentration and volume, multimodal analgesic protocols, and the definition of rescue analgesia. Importantly, the present findings favour ESPB specifically over incision-site infiltration, suggesting that the broader fascial-plane analgesia achieved with ESPB may provide a clinically useful advantage over conventional wound infiltration.

Conclusion

Bilateral ultrasound-guided erector spinae plane block using levobupivacaine provided significantly prolonged postoperative analgesia and superior pain control compared with incision-site infiltration in patients undergoing lumbar spinal surgery. ESPB was associated with delayed requirement for rescue analgesia, lower postoperative pain scores, and reduced rescue analgesic consumption, while maintaining a comparable postoperative safety profile. These findings suggest that bilateral ultrasound-guided ESPB may be a useful component of multimodal analgesia for improving postoperative pain management in lumbar spinal surgery.

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