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ORIGINAL ARTICLE

Surgical vs ultrasound-guided lumbar erector spinae plane block for pain management following lumbar spinal fusion surgery

Ahmet Kaciroglu[1] · Mursel Ekinci[1] · Hande Gurbuz[1] · Emre Ulusoy[1] · Mehmet Ali Ekici[2] · Özgür Dogan[2] · Birzat Emre Golboyu[3] · Selcuk Alver[4] · Bahadir Ciftci[4]

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Abstract

Purpose Spinal surgery is associated with severe diffuse pain in the postoperative period. Effective pain management plays an essential role in reducing morbidity and mortality. This study is designed to compare the ultrasound-guided erector spinae plane (ESP) block and surgical infiltrative ESP block for postoperative analgesia management after lumbar spinal fusion surgery.

Methods The patients who underwent two or three levels of posterior lumbar spinal fusion surgery were randomly allocated into one of three groups with 30 patients each (Group SE = Surgical ESP block; Group UE = ultrasound-guided ESP block; Group C = Controls). The primary aim was to compare postoperative opioid consumption, and the secondary aim was to evaluate postoperative dynamic and static pain scores and the incidence of opioid-related adverse effects.

Results There was a significant difference in terms of opioid consumption, rescue analgesia on demand, and both static and dynamic pain scores between groups at all time periods ($p < 0.05$). Group SE and Group UE had lower pain scores and consumed fewer opioids than the controls ($p < 0.05$). However, the Group UE had lower pain scores and opioid consumption than the Group SE. The sedation level of patients was significantly higher in the control group than in the other two groups. Also, nausea was more common in controls than in the other groups.

Conclusion While both surgical and ultrasound-guided ESP blocks reduced opioid consumption compared to the controls, the patients who received ultrasound-guided ESP blocks experienced better postsurgical pain relief than those in the other groups (surgical ESP and controls).

Keyword Lumbar spinal fusion surgery · Postoperative analgesia · Multimodal analgesia · Erector spina plan block

Introduction

Spinal surgery is associated with severe diffuse pain in the postoperative period [1–3]. Effective pain management plays an important role in reducing morbidity and mortality [4]. The main cause of postsurgical pain is mechanical injury, retraction, and denervation of tissues in the surgical area. The pain mechanism is multifactorial and has nociceptive, neuronal and inflammatory components [5]. Therefore, a multimodal approach to pain management is recommended for spinal surgery [6]. Parenteral opioids are frequently used to treat acute postoperative pain; however, opioids can cause a range of adverse effects, such as itching, nausea, vomiting, drowsiness, and potentially dangerous respiratory depression [7]. Hence, implementing regional block techniques in the multimodal analgesic regimen promotes early mobilisation and shortens hospital stay time, consequently minimising the

✉ Mursel Ekinci
drmurselekinci@gmail.com

1 Department of Anesthesiology and Reanimation, Bursa City Hospital, Sciences Bursa Faculty of Medicine, University of Health, 16110 Bursa, Nilufer, Turkey

2 Department of Neurosurgery, Bursa City Hospital, University of Health Sciences Bursa Faculty of Medicine, Bursa, Turkey

3 Department of Anesthesiology and Reanimation, Izmir Katip Celebi University Ataturk Education and Research Hospital, Izmir, Turkey

4 Department of Anesthesiology and Reanimation, Istanbul Medipol University, Istanbul, Turkey

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likelihood of hospital-related complications like infection and thromboembolism [8, 9]. Furthermore, the utilisation of ultrasound to assist in the placement of regional blocks is gaining popularity.

An ultrasound-guided erector spinae plane (ESP) block has been previously used for various indications including chronic and acute pain management [10]. The ESP block is performed by injecting a local anaesthetic solution between the transverse process and the erector spinae muscle [11]. With the help of ultrasound, it is possible to observe the spread of the local anaesthetic solution within the fascia while allowing for clear visualisation of the sonoanatomy [11, 12]. Previous reports show ESP block can offer effective pain relief following lumbar spine surgery [13–15]. Also, some studies suggested that administering local anaesthetics to the wound area and deep tissues can potentially decrease postoperative opioid consumption [16–18]. Based on this idea, we thought that the ESP block performed by the surgical team by administering a local anaesthetic solution between the erector spinae muscle and the transverse process with the direct view might also provide similar effects to the ultrasound-guided ESP block. The main objective of the study is to compare the two ESP block techniques, which are surgical and ultrasound-guided, in terms of postoperative opioid consumption. The secondary objectives are to assess postoperative pain scores and the incidence of opioid-related adverse effects.

Materials and methods

This randomised controlled prospective study was approved by the ethics committee of Bursa City Hospital, and the study protocol was registered on ClinicalTrails.gov (registration number: NCT05630404). All participants provided written informed consent. The study was conducted between November 2022 and April 2023 at Bursa City Hospital. The study included patients with an American Society of Anaesthesiologists (ASA) classification score of I–III, aged 18–65 years, and underwent two or three levels of posterior lumbar spinal fusion surgery using the same surgical technique by the same surgical team. Patients with a bleeding diathesis history or known allergy to local anaesthetics or opioids, those taking anticoagulant treatments, and those with a skin infection at the needle entry site and pregnant or breastfeeding women were excluded from the study. Patients who did not agree to participate were excluded as well.

Randomisation and grouping

All participants were assigned to one of three groups with 30 patients each by a randomising computer program before the surgery. Patients in Group SE underwent surgical infiltration ESP block, and those in Group UE received ultrasound-guided ESP block. The patients allocated in Group C did not receive any regional blocks but were only provided intravenous analgesics. Group C was evaluated as the control group.

General anaesthesia

All patients received intravenous midazolam (2 mg) before surgery. The ASA standard protocol was used to monitor patients. Fentanyl (1–1.5 mcg/kg), propofol (2–2.5 mg/kg) and rocuronium (0.6 mg/kg) were used for general anaesthesia. After that, patients underwent orotracheal intubation and were placed in a prone position. General anaesthesia was maintained with inhaled sevoflurane in oxygen and fresh air mixture and remifentanil infusion (0.25 mcg/kg/hr). All patients were administered intravenous tenoxicam 20 mg and tramadol 100 mg 30 min before the end of the surgery. All patients also received intravenous 4 mg of ondansetron. After the extubation, patients were then transferred to the post-anaesthesia care unit.

Block technique

For patients in Group UE, an ultrasound-guided ESP block was performed after the closure of the surgical incision and before extubation while the patient was still in the prone position. A convex transducer was placed in sagittal orientation 4 cm lateral to the L3 transverse process. A 22 G × 80 mm block needle was inserted in the craniocaudal direction, and the needle tip was placed under the erector spinae muscle and over the hyperechoic transverse process (Fig. 1). The position of the needle's tip was verified by saline injection. After the confirmation of the correct placement of the needle tip, 20 mL of 0.25% bupivacaine was administered on each side (a total of 40 mL for both sides).

For patients in group SE, the surgical ESP block technique included injections at four consequent levels (5 mL per injection), starting from one level above the operated vertebra and covering all the surgical segments (20 mL per side). This procedure was repeated for the other side (a total of 8 injections and 40 mL of 0.25% bupivacaine for both sides).

Patients included in the control group did not receive local anaesthetic infiltration.

Postoperative multimodal pain management

Patients were administered 20 mg of tenoxicam intravenously every 12 h in the postoperative period. An intravenous patient-controlled analgesia device containing 5 mg/mL tramadol was given to all patients. A patient-controlled analgesia protocol was implemented for all patients, including a 10 mg bolus within a 20-min lockout time and a

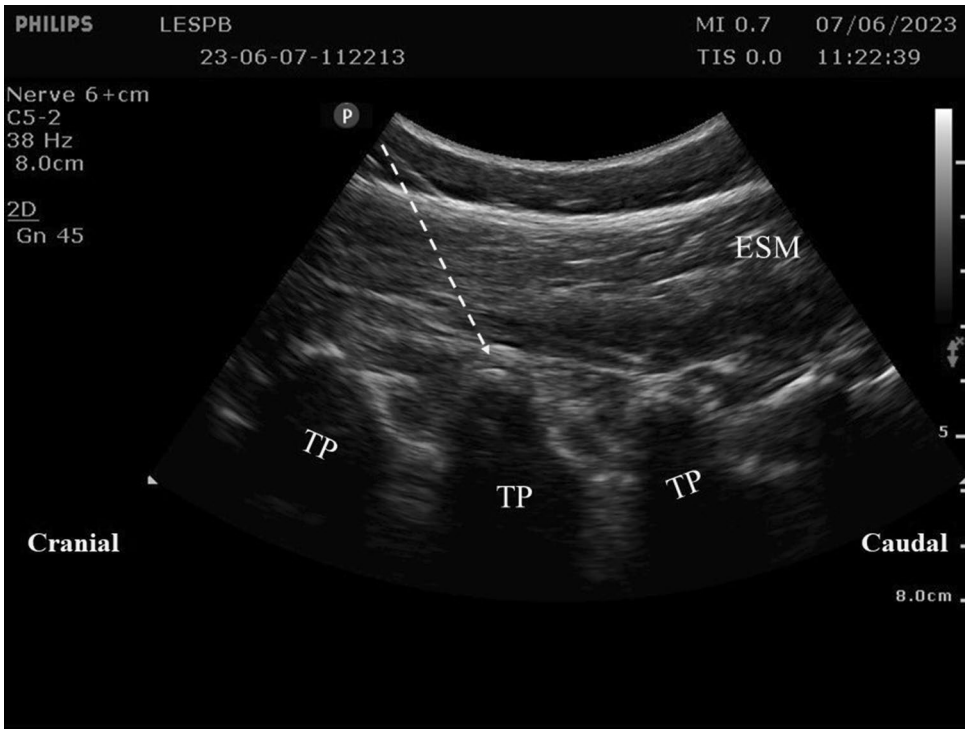


Fig. 1 Sonographic visualisation of ESP block. Dashed arrow indicates the target of the needle under ESM fascia. ESM: Erector spinae muscle, TP: Transverse process

four-hour limit without an infusion dose. Patients were evaluated by an anaesthesiologist blinded to the study protocol in the postoperative period.

The assessment of postoperative pain involved using the numeric rating scale (NRS) score, where 0 denotes no pain, and 10 represents the most intense pain ever experienced. Dynamic and static NRS scores were recorded in the postoperative period at the 1st, 2nd, 4th, 8th, 16th, and 24th hours. Patients with NRS scores ≥ 4 were administered meperidine (0.5 mg/kg) for the rescue analgesic. The sedation levels of patients were evaluated using a four-point scale, where 0 indicates that the patient is awake with open eyes, 1 denotes drowsiness with responsiveness, 2 indicates sleepiness with difficulty in arousing, and 3 signifies that the patient cannot be awakened by shaking. The time when the first rescue analgesic was used, postoperative opioid consumption, and any adverse effects and complications associated with the opioids and the ESP block were recorded.

Sample size calculation and statistical analyses

The analysis revealed an effect size of 0.59 (within a 95% confidence interval) and a power of 0.99 at the significance level, suggesting that 90 volunteers were adequate for the study's sample size.

All statistical analyses were conducted using the software SPSS for Windows (v.20.0, IBM Corp., Armonk, NY, USA).

The Shapiro–Wilk test was utilised to analyse the data distribution. The mean ± standard deviation and median (25th–75th percentiles) values were displayed for the continuous variables, while counts (percentages) were provided for categorical data. Parametric data were analysed using ANOVA and *post-hoc* Tukey test, where non-parametric data were tested with Kruskal–Wallis and *post-hoc* Dunn's correction. The Monte Carlo was used to compare categorical variables. Statistical significance was considered with a two-sided p-value < 0.05.

Results

Figure 2 shows participant enrolment. One hundred nine patients underwent lumbar spinal fusion surgery during the study period. Nine patients were excluded from the study; four declined to participate, while five did not meet the inclusion criteria. A total of 90 patients were included in the study (30 in each group). Patients in the groups did not differ significantly in age, weight, height, ASA status, duration of anaesthesia or duration of surgery ($p > 0.05$ for all variables) (Table 1).

The static and dynamic pain scores of the groups are shown in Table 2. Opioid consumption and the use of rescue analgesia are compared in Table 3. The surgical ESP block and ultrasound-guided ESP block groups had lower pain scores and consumed fewer opioids than the controls. Furthermore, the ultrasound-guided ESP block group had lower pain scores and opioid consumption than the surgical ESP block group.

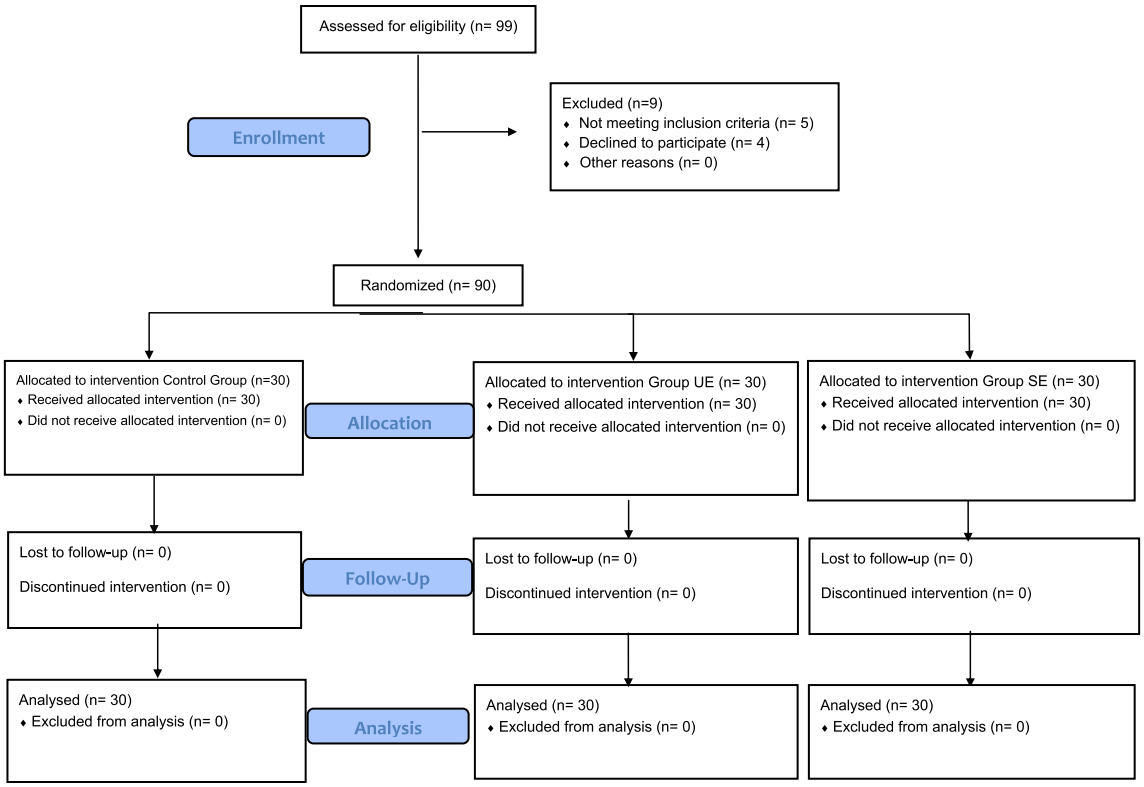


Fig. 2 CONSORT flow diagram of the study

Table 1 Demographic data, duration of surgery and anaesthesia of the groups

	Group SE (*n*:30)	Group UE (*n*:30)	Group control (*n*:30)	*p*
Age	63 ± 8.6	59 ± 14.4	61 ± 8.5	0.516
Gender (M/F)	13/17	13/17	12/18	0.955
ASA (I/II/III)	1/26/3	4/19/7	1/21/8	0.164
Height (cm)	167.5 ± 7	167 ± 8.1	166 ± 7.8	0.899
Weight (kg)	79.4 ± 9.7	80.1 ± 12.8	81.3 ± 11.9	0.856
Duration of surgery (min)	185.9 ± 22.1	190.5 ± 37.5	195 ± 34.5	0.536
Duration of anesthesia (min)	204.5 ± 23.8	213 ± 40.5	215.8 ± 36.8	0.417

Values are expressed mean ± standard deviation or number

ASA American society of anaesthesiologists, *cm* Centimetre, *kg* Kilogram, *min* Minutes

The rates of side effects are presented in Table 4. The sedation level of patients was significantly higher in the control group than in the other two groups. Also, nausea was more common in Group C than in the other groups. The rate of vomiting did not differ amongst the groups. There were no block-related complications in this study.

Discussion

The bones, muscles, ligaments, joints, subcutaneous, and cutaneous tissues of the back and intervertebral discs, which are supplied by the dorsal branches of spinal nerves, are affected during lumbar spinal surgery [13]. The main target of the ESP block is both the dorsal and ventral branches of spinal nerves; therefore, it is a viable option for postoperative analgesia following spinal surgery [11–13]. Also, several case reports and studies emphasise the efficacy of ESP blocks for lumbar spinal surgery [13, 19–24]. Although the effectiveness of ultrasound-guided ESP block has been demonstrated, we investigated whether surgically applied ESP block would yield similar results.

Most of the ESP blocks in previous studies were placed with ultrasound guidance, except one research in which the procedure was performed free-hand delivery intraoperatively [25]. Yesiltas et al.'s [25] study indicated

Table 2 Comparisons of static and dynamic pain scores between groups

	Group SE (*n*:30)	Group UE (*n*:30)	Group C (*n*:30)	*p* value (overall group effect)	*p* value (pairwise comparison)		
					SE versus UE	SE versus C	UE versus C
At rest							
1st hour	4 (4–5)	3 (2–4)	5 (4–5)	0.001*	0.002*	0.258	0.001*
2nd hour	4 (4–5)	3 (2–4)	5 (4–5)	0.001*	0.001*	0.390	0.001*
4th hour	4 (3–4)	3 (2–4)	5 (4–5)	0.001*	0.001*	0.146	0.001*
8th hour	3 (3–4)	2 (1–3)	4 (3–4)	0.001*	0.001*	0.225	0.001*
16th hour	3 (2–4)	2 (1–2)	4 (3–4)	0.001*	0.001*	0.007*	0.001*
24th hour	3 (2–3)	2 (1–2)	3 (3–4)	0.001*	0.001*	0.031*	0.001*
On movement							
1st hour	6 (5–7)	4 (4–7)	6 (5–7)	0.005*	0.018*	0.360	0.001*
2nd hour	5 (5–7)	4 (4–6)	6 (5–7)	0.001*	0.005*	0.385	0.001*
4th hour	5 (4–6)	4 (3–4)	5 (4–7)	0.001*	0.013*	0.104	0.001*
8th hour	4 (4–5)	4 (3–4)	5 (4–7)	0.001*	0.014*	0.006*	0.001*
16th hour	4 (3–5)	3 (3–4)	5 (4–6)	0.001*	0.064	0.002*	0.001*
24th hour	3 (3–4)	3 (2–4)	4 (4–6)	0.001*	0.098	0.001*	0.001*

Data are expressed as median (percentiles 25–75)

*$p < 0.05$

Table 3 The comparison of opioid consumption and rescue analgesia between groups

	Group SE (*n*:30)	Group UE (*n*: 30)	Group C (*n*:30)	*p*	*P* (pairwise comparison)		
					SE versus UE	SE versus C	UE versus C
PCA 0–8 h (μg)	115 (80–150)	70 (50–100)	140 (110–160)	0.001*	0.003*	0.050	0.001*
PCA 8–16 h (μg)	90 (70–110)	60 (40–80)	135 (100–160)	0.001*	0.002*	0.000*	0.001*
PCA 16–24 h (μg)	70 (60–100)	50 (40–70)	100 (80–130)	0.001*	0.002*	0.010*	0.001*
PCA total (μg)	280 (220–350)	175 (130–250)	395 (340–470)	0.001*	0.006*	0.001*	0.001*
Rescue analgesia (Y/N)	21/9	14/16	24/6	0.020*			

Opioid consumption amounts via PCA device in the time intervals are expressed as median (percentiles 25–75). Rescue analgesia indicates the number of patients given rescue analgesics on demand

hr Hours, *μg* Microgram, *min* Minutes, *N* No, *PCA* Patient controlled analgesia, *Y* Yes

*$p < 0.05$

Table 4 Comparison of the incidence of side effects between groups

	Group SE (*n*:30)	Group UE (*n*: 30)	Group C (*n*:30)	*p*
Sedation (Awake, eyes open/ Sleepy but responding verbal stimulus/ Sleepy and hard to evoke)	24/6/0	21/9/0	10/17/3	0.001*
Nausea (Y/N)	1/29	4/26	11/19	0.002*
Vomiting (Y/N)	1/29	2/28	4/26	0.354

Values are expressed as numbers

N No, *Y* Yes

*$p < 0.05$

the superiority of intraoperative free-hand delivery ESP blocks over the sham block group. Another trial conducted by Oezel et al. [26] compared the surgeon-placed ESP catheters with single-shot ESP blocks and found similar postoperative pain scores and opioid consumption. However, in that study, the local anaesthetic was given after the wound closure, although the ESP catheters were placed intraoperatively under direct vision [26].

Our trial compared the efficacy of single-shot ESP blocks after wound closure and intraoperative free-hand delivery ESP blocks. Similar to Yesiltas et al.'s results, our study demonstrated that the intraoperative surgeon-assisted free-hand delivery ESP blocks provided a superior analgesic effect than the controls. However, the efficacy of the postoperative ultrasound-guided ESP blocks was much better than the intraoperative surgically delivered ESP blocks. A possible explanation for this result may be the improper spread of local anaesthetic when injected intraoperatively (before fascial closure) due to the disturbed anatomy. Failure to ensure tissue integrity during surgical injection may have resulted in the injected solution not remaining within the intended area of effect. Additionally, it is possible that the surgical injection failed to reach the target interfascial tissue with the local anaesthetic solution. In contrast, real-time display of local anaesthesia distribution in ultrasound-guided ESP block allows for more accurate administration.

The target area of the ESP block is the interfascial plane between the transverse process and the erector spinae muscle in the paraspinal region. The spread of local anaesthetic is in the craniocaudal direction; however, it is highly variable, mainly depending on the individual differences of the fascial plane and the structure of vertebras [27–31]. The local anaesthetic can also spread into the foramina and rarely to the epidural space; furthermore, the epidural spread is more prominent when the lamina and ligaments are compromised [31]. A denser block than ESP block and sympatholytic adverse events (such as hypotension and bradycardia) would be expected in such a condition. However, none of our study participants showed any of these sympatholytic symptoms. Therefore, the results can be interpreted as the surgically injected local anaesthetic solution staying in the interfascial plane at a lower volume than the ultrasound-guided ESP block. This theory can also explain the limited efficacy of the free-hand surgical delivery of the ESP blocks. Yet, the distribution of the local anaesthetic can be visualised, which is another advantage of ultrasound.

A limitation of the study is that the sample size of our study was calculated based on opioid consumption. Therefore, the sample size may be insufficient for measuring the likelihood of rare adverse effects, such as inadvertent epidural spreading. The distribution of local anaesthetics can be traced by means of magnetic resonance imaging. Therefore, the distribution of local anaesthetic in tissues with compromised integrity cannot be clearly interpreted. Moreover, a preoperatively performed regional block (before the tissues were surgically disturbed) would provide more consistent results. Furthermore, it is important to note that our study did not assess the preoperative pain status and the use of preoperative analgesia. Understanding these factors is crucial for evaluating the development of chronic pain, and it would be valuable to consider them in future research.

Conclusion

While both surgical and ultrasound-guided ESP blocks reduced opioid consumption compared to the controls, the patients who received ultrasound-guided ESP blocks experienced better postsurgical pain relief than those in the other groups (surgical ESP and controls). Therefore, using ultrasound-guided ESP blocks may be beneficial as a part of a multimodal analgesia approach for postoperative pain management in spinal surgery patients.

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Data availability The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no competing interests.

Ethical approval This study has been approved by Bursa City Hospital Ethics and Research Committee.

(17.02.2021, decision no. 2021–3/7) The study was registered and recorded on ClinicalTrials.gov (NCT05630404).

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