Bilateral Ultrasound-guided Erector Spinae Plane Block for Postoperative Analgesia in Lumbar Spine Surgery: A Randomized Control Trial

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Background: Major lumbar spine surgery causes severe postoperative pain. The primary objective of this randomized controlled study was to compare the effect of ultrasound (US)-guided erector spinae plane (ESP) block on 24-hour postoperative cumulative opioid requirements with standard (opioid-based) analgesia. Postoperative pain control and patient satisfaction were also assessed.

Materials and Methods: Adults scheduled for elective lumbar spine surgery under general anesthesia were randomly assigned to the following (and they are): Control group-no preoperative ESP block, or ESP block group-preoperative bilateral US-guided ESP block. Both groups received standard general anesthesia during surgery. Postoperative pain score, number of patients requiring rescue analgesia, and total morphine consumption during the first 24 postoperative hours were recorded. Patient satisfaction was assessed 24 hours after surgery.

Results: Postoperative morphine consumption was significantly lower in patients in the ESP group compared with those in the control group (1.4 ± 1.5 vs. 7.2 ± 2.0 mg, respectively; $P < 0.001$). All patients in the control group required supplemental morphine compared with only 9 (45%) in the ESP block group ($P = 0.002$). Pain scores immediately after surgery ($P = 0.002$) and at 6 hours after surgery ($P = 0.040$) were lower in the ESP block group compared with the control group. Patient satisfaction scores were more favorable in the block group ($P < 0.0001$).

Conclusions: US-guided ESP block reduces postoperative opioid requirement and improves patient satisfaction compared with standard analgesia in lumbar spine surgery patients.

Key Words: lumbar spine surgery, postoperative analgesia, nerve block

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Major lumbar spine surgery causes severe postoperative pain, which typically persists for at least 3 days.[1] Various studies have reported that maximal pain occurs in the first 4 postoperative hours, and gradually declines by the third postoperative day.[1] Efficient and safe methods for postoperative analgesia after lumbar spine surgery are beneficial for early recovery and thus mandatory.

Conventional opioid-based analgesia techniques are associated with the known side effects of opioids, including nausea, vomiting, pruritus, and sedation. Epidural analgesia is advocated by some as the gold standard for postoperative analgesia in lumbar spine surgeries.[2] As preoperative placement of epidural catheters may interfere with spine surgery, intraoperative catheter placement has been introduced as an effective measure for treating postoperative pain.[3] This technique may be effective, but it is not without complications; spine surgery can damage the dura mater, leading to a risk of intrathecal penetration of local anesthetic.[3] Recently, bilateral ultrasound (US)-guided erector spinae plane (ESP) block has been demonstrated to produce similar analgesic effects to epidural block.[4] Furthermore, the block is performed away from the spinal cord, and has procedural simplicity and minimal complications.

The aim of this study was to assess the efficacy of US-guided ESP block for postoperative analgesia after lumbar spine surgery compared with conventional (opioid-based) postoperative analgesia. The primary objective was the assessment of cumulative morphine consumption during the first 24 hours after surgery. Secondary objectives included evaluation of pain at rest and patient satisfaction.

MATERIALS AND METHODS

This study was conducted between February 2018 and September 2018. It was approved by the local institutional research ethics committee and registered with the clinical trial registry, India (CTRI/2018/02/012143). Written informed consent was obtained from all participants. Patients aged 18 to 65 years with American Society of Anesthesiologists physical status I to III scheduled to undergo elective lumbar spine surgery (prolapsed lumbar intervertebral disk, lumbar stenosis, or laminectomy) were suitable for inclusion in the study. Patients receiving chronic analgesic therapy, those with a history of opioid dependence, those receiving anticoagulation or experiencing any bleeding disorder, or those who were unable to communicate with the investigators were excluded.

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All patients underwent preoperative assessment on the day before surgery and received premedication with oral diazepam 0.1 mg/kg at night and 2 hours before surgery. Participants were randomly allocated to 1 of 2 groups using a computer-generated random table: Control group-standard analgesia with no preoperative ESP block, and ESP block (test) group-preoperative US-guided ESP block. Both groups received standard general anesthesia (see below).

Technique for US-guided ESP Block

Patients were placed in the left lateral position and the spine palpated downwards from C7-T10; the position of T10 was marked on the skin. After ensuring skin asepsis in a standard manner, a high frequency linear US probe in a sterile sheath was placed longitudinally 3 cm lateral to the T10 spinous process. The trapezius and erector spinae muscles were identified from outwards to inwards (Fig. 1). The skin was then infiltrated with local anesthetic, and an 18-G Tuohy needle was inserted using an in-plane superior to inferior approach, so that the tip was placed into the fascial plane on the deep (anterior) aspect of the erector spinae muscle. The correct location of the needle tip was confirmed by visible fluid spread below the erector spinae muscle off the bony shadow of the transverse process (Fig. 1). A total volume of 20 mL of 0.5% bupivacaine was injected through the needle. The procedure

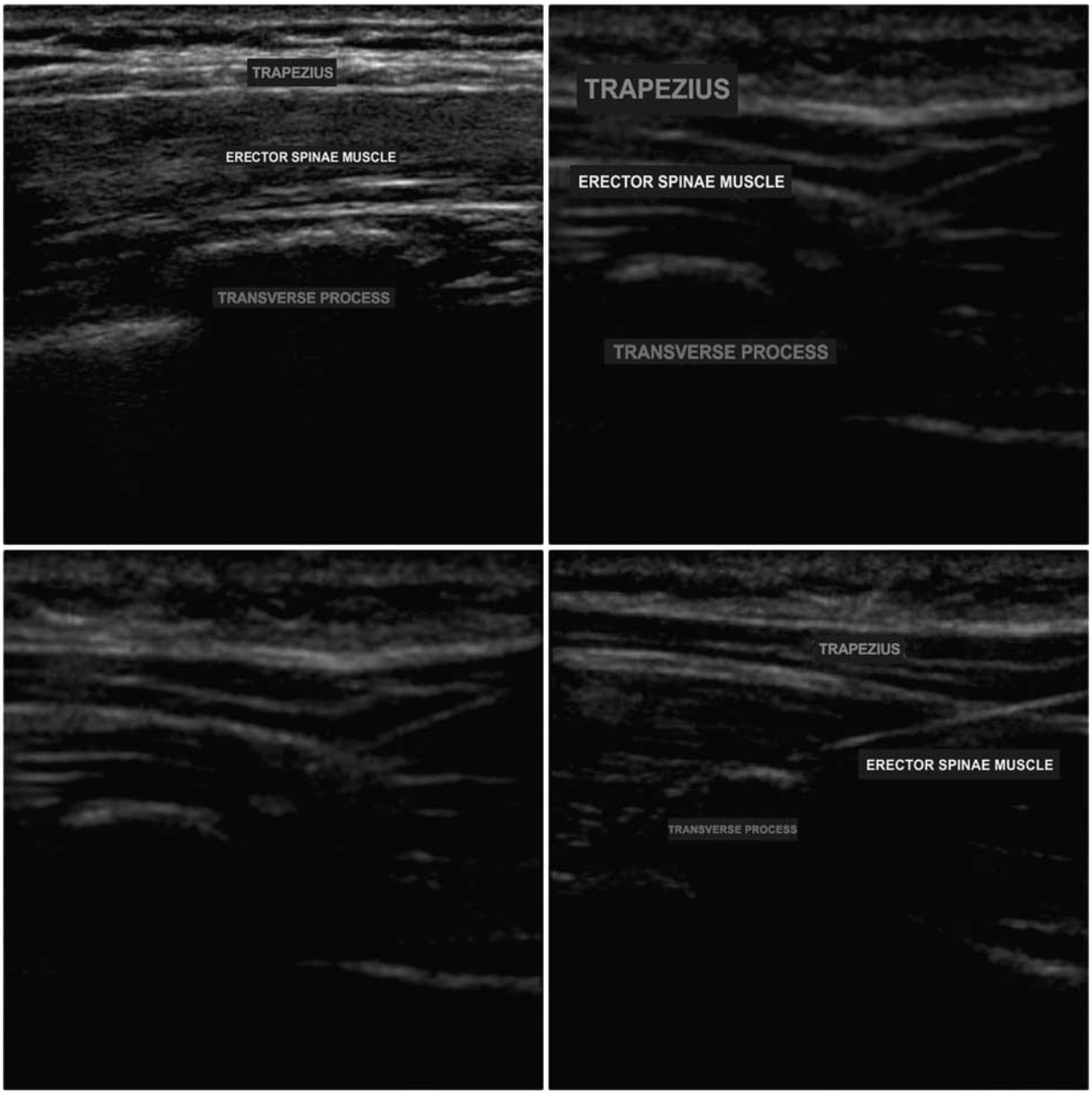

FIGURE 1. Ultrasound view of the trapezius muscle and erector spinae muscles, and transverse process of T10 vertebrae. The needle tip can be visualized in the space below the erector spinae muscle. Following injection of local anesthetic through the needle, elevation of the muscle due to the injected drug can be seen.

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was then repeated on the opposite side. Following the block, patients were observed for 30 minutes, and the sensory level of the block was assessed by a blinded observer every 5 minutes with pin-prick sensation in each dermatomal distribution from T6-L3. If the pin-prick sensation did not decrease in any segment by 30 minutes, the ESP block was considered a failure. Electrocardiography and oxygen saturation were monitored continuously, and heart rate and noninvasive blood pressure recorded at baseline, after performing the block, and every 5 minutes for 30 minutes. Any block-related complications, such as hypotension or vascular puncture, were recorded.

Anesthesia Technique

Anesthesia was induced in all patients with propofol 2 to 3 mg/kg and morphine 0.1 mg/kg; tracheal intubation was facilitated with vecuronium 0.1 mg/kg. Anesthesia was maintained with isoflurane in 66% nitrous oxide and oxygen. In the intraoperative period, fentanyl was titrated to maintain blood pressure and heart rate within 20% of baseline values. Intraoperative monitoring included electrocardiography, noninvasive arterial pressure, oxygen saturation, end-tidal carbon dioxide, and nasopharyngeal temperature (Datex-Ohmeda S5 Avance work station).

Study Parameters

The primary outcome of this study was cumulative morphine consumption during the first 24 hours after surgery. Secondary outcomes included pain score at rest and patient satisfaction score. Patients were observed for 24 hours after surgery in the postanaesthesia care unit by an anesthesiologist who was not aware of the patients' group assignment. Postoperative analgesia was provided with intravenous diclofenac 1.5 mg/kg every 8 hours. The pain score was evaluated using an 11-point Numerical Rating Scale (0 = pain, 10 = worst pain imaginable) on arrival in the postanaesthesia care unit and then at 2, 4, 6, 8, 12, and 24 hours postoperatively. Rescue analgesia was provided with intravenous morphine 3 mg boluses on demand or whenever the Numerical Rating Scale pain score was ≥ 4. The number of patients requiring rescue analgesia and total morphine consumption during the first 24 hours after surgery was recorded. Any adverse events, including hypotension, bradycardia, dry mouth, dizziness, diplopia, and nausea and vomiting, were noted. Patients' satisfaction with the anesthesia technique was assessed at 24 hours after surgery using an 11-point satisfaction score (0 = completely unsatisfied, 10 = most satisfied).

Statistical Analysis

On the basis of a pilot study of 7 patients, we calculated that a sample size of 20 patients per group would be sufficient to detect a 50% reduction in 24-hour morphine consumption with a statistical power of 0.8 and a false-positive error rate of P-value ≤ 0.05 on a 2-tailed Student t test. Sample sizes were calculated using StatMate 2 for Macintosh (GraphPad Software, San Diego, CA). Normality of distribution was determined using the Shapiro-Wilk test. Differences between the 2 groups were analyzed using the Mann-Whitney U test for non-normally distributed continuous data and noncontinuous data, or a 2-tailed Student t test for normally distributed continuous data. Categorical data were analyzed using the Fisher exact test or the v2 test. A P-value <0.05 was considered statistically significant for comparison between groups.

RESULTS

Forty patients were randomly assigned to either the control or ESP block (test) groups, and all completed the study (Fig. 2). The groups were comparable with regard to age, sex, body mass index, American Society of Anesthesiologists physical class, and duration of surgery (Table 1). The cumulative morphine requirement in the 24 hours after surgery was significantly lower in the ESP block compared with that in the control group (1.4 ± 1.5 vs. 7.2 ± 2.0 mg; $P < 0.001$) (Table 2). All 20 patients in the control group required morphine for rescue analgesia, compared with only 9 (45%) in the ESP block group ($P = 0.002$) (Table 2). Postsurgical analgesia was more prolonged in the block group; patients in this group required their first dose of rescue analgesia after 5.8 ± 0.75 hours compared with 2.42 ± 0.59 hours in the control group ($P = 0.003$) (Table 2). Compared with the ESP block group, pain scores were higher in the control group immediately after surgery and at 6 hours after surgery (Table 3). Patients in the ESP block group were more satisfied than those in the control group; the mean (median deviation) satisfaction scores were 5.5 (0.74) and 7.7 (0.45) in the control and ESP block groups, respectively ($P < 0.0001$).

There were no block failures and no block-related complications. Two patients in the control group developed severe nausea and vomiting requiring intravenous metoclopramide at 24 hours, whereas no patients in the block group developed nausea and vomiting requiring medication.

DISCUSSION

In this study, preoperative bilateral US-guided ESP blocks were more effective than conventional postoperative analgesia in providing postoperative pain management after lumbar spine surgery. Compared with the control group, pain scores were lower immediately after surgery and at 6 hours after surgery in patients in the ESP group. The ESP blocks also increased the duration of intraoperative analgesia, decreased the amount of opioid required for postoperative analgesia, and increased patient satisfaction. There were no block-related complications, and the US-guided ESP technique was simple and easily reproducible.

To the best of our knowledge, this is first prospective, randomized, controlled trial comparing the efficacy of bilateral US-guided ESP block with conventional (opioid-based) postoperative analgesia in lumbar spine surgery patients. This novel technique is a paraspinal block in which local anesthetic is injected deep into the erector spinae muscle.[5] The erector spinae complex comprises a set of muscles and tendons that extend through the lumbar, thoracic, and cervical regions, and thus this plane permits the extensive craniocaudal spread of local anesthetic and coverage of multiple dermatomes.[6]

Numerous cadaveric studies have confirmed successful staining of both ventral and dorsal rami of multiple spinal nerves above and below the site of injection when dye is

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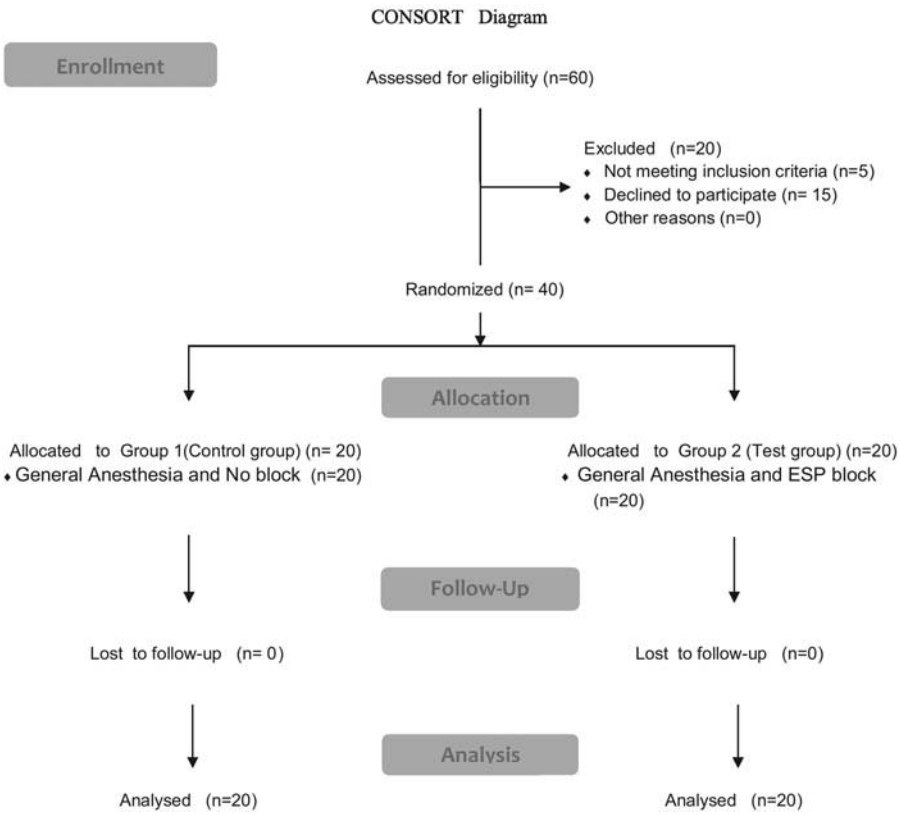

FIGURE 2. Study flow diagram. ESP indicates erector spinae plane.

injected deep into the erector spinae muscle.[4,7] However, a recent study found that the ventral rami are not always blocked.[8] In addition, there may be differences in the quality of block between lumbar and thoracic ESP blocks.[8] The sparing of the ventral rami in cadaver studies is not consistent with the clinical results in patients. US-guided ESP block has been reported to provide analgesia for somatic and visceral pain by effects on the ventral rami, dorsal rami, and rami communicantes of various spinal nerves. Clinical studies have shown excellent result with this block during surgeries involving thoracic and abdominal regions. ESP has also been used to manage acute postoperative pain following thoracic surgeries, including video-assisted thoracic procedures,[9] pneumothorax surgery,[10] open thoracotomy,[11] and breast surgery when it is performed at the T4-T5 level.[12,13] ESP blocks have also been used in the management of rib fractures,[14] postthoracotomy pain syndrome,[15] and chronic shoulder pain.[16] As the erector spinae muscle extends throughout the lumbar region, ESP block can also produce abdominal analgesia when performed at a lower level. A cadaveric study showed that when 20 mL of contrast material was injected at T7, there was extensive craniocaudal spread of the dye between C5-T2 levels and L2-L3 transverse processes.[7] When performed at the T7-T8 level,

TABLE 1. Demographic and Clinical Characteristics of the 2 Study Groups

	Group 1 Control Group (N = 20)	Group 2 Test Group (N = 20)	*P*
Age (y)	34.9 ± 10.1	35.4 ± 8.3	0.852
Sex (male/female)	18/2	17/3	0.752
Body mass index (kg/m^2)	24.7 ± 1.6	25.1 ± 1.8	0.524
American Society of Anesthesiologists (I/II/III)	10/5/5	12/5/3	0.525
Duration of surgery	145.2 ± 8.0	149.3 ± 6.3	0.088

Data are expressed as mean ± SD or ratio.
$P < 0.05$ is considered as a statistically significant difference.

TABLE 2. Postoperative Comparison for Morphine Requirement and Time for the First Rescue Analgesia

	Group 1 Control Group (N = 20)	Group 2 Test Group (N = 20)	Test of Significance (*P*)
Total morphine consumption, mean (SD) (mg)	7.2 (2.0)	1.4 (1.5)	$t = 11.3$, $df = 38$ (< 0.0001)
Patients requiring morphine, n (%)	20 (100)	09 (45)	$\chi^2 = 15.2$ (< 0.0001)
Time for first rescue analgesia, mean (SD) (h)	2.4 ± 0.59	5.8 ± 0.75	$t = 15.9$, $df = 38$ (< 0.0001)

Unpaired *t* test applied for continuous data and χ^2 test for categorical data.
df indicates degrees of freedom.

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TABLE 3. Pain Score Assessed by an 11-Point Numerical Rating Scale (0 = Pain, 10 = Worst Pain Imaginable) During the First 24 Hours After Surgery

Time (Hours After Surgery)	Group 1 Control Group (N = 20)	Group 2 Test Group (N = 20)	Independent Sample Mann-Whitney *U* Test
0	4 (3-4)*	2 (1-4)	0.001
2	2 (1-3)	2 (1-3)	0.925
4	2 (1-3)	2 (1-4)	0.429
6	5 (3-6)*	4 (1-4)*	0.002
8	3 (2-4)	2 (1-3)	0.001
10	2 (1-3)	4 (1-4)	0.024
12	2 (1-3)	2 (1-3)	0.602
24	2 (1-3)	2 (1-3)	0.718

Data are expressed as median (interquartile range).
*Rescue analgesia was given.
$P < 0.05$ is considered as a statistically significant difference.

ESP has been used during a variety of abdominal surgeries including ventral hernia repair,[17] bariatric surgery,[18] and various laproscopic procedures.[19,20] In 1 case series, ESP block performed at a lower thoracic level was used for perioperative analgesia during lumbosacral spine surgery.[21] When performed at L2, it has also been used to provide analgesia in lower back pain,[22] and at L4 for proximal femur surgery.[23] A retrospective study demonstrated lower pain scores after lumbar spine surgery in patients who received ESP blocks.[24] On the basis of these data, we performed preoperative bilateral ESP blocks at the T10 level in lumbar spine surgery patients and also found a significant reduction in postoperative opioid requirements.

The main advantage of the ESP block is its procedural simplicity. The sonoanatomy is easily recognizable, and it is distant from the spinal cord and other vital structures such as the pleura. Therefore, there are no structures at risk of needle injury in the immediate vicinity to the site of the block. In addition, the autonomic blockade that accompanies paravertebral and thoracic epidural techniques is not seen with the ESP block. Thus, it offers greater hemodynamic stability and lower requirements for extensive monitoring. An indwelling catheter can also be inserted with this technique, extending the duration of analgesia as required.

The major limitation of this study is that patients, surgeons, anesthesiologists, and investigators could not be blinded to the intervention; this may have added an element of bias.

In conclusion, bilateral US-guided ESP block seems to be a useful intervention for providing adequate postoperative analgesia after lumbar spine surgery. The block is simple and safe, which makes it unique when compared with other blocks. More prospective, randomized clinical studies investigating the use of US-guided ESP block for different surgery types are required to establish its clinical role.

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