Comparison of Two Ultrasound-guided Plane Blocks for Pain and Postoperative Opioid Requirement in Lumbar Spine Fusion Surgery: A Prospective, Randomized, and Controlled Clinical Trial

Lizhen Wang · Ying Wu · Lianjie Dou · Ke Chen · Yuesheng Liu · Yuanhai Li

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ABSTRACT

Introduction: The erector spinae plane (ESP) block and thoracolumbar interfascial plane (TLIP) block were two novel plane blocks. The purpose of this study was to investigate TLIP block and ESP block on the effect of analgesic and opioid consumption in lumbar spine fusion surgery in the perioperative period.

Methods: Three hundred and four patients who suffered lumbar spine fusion were included and randomly divided into three groups: a control group \((n = 102)\), an ESP block group \((n = 100)\), and a TLIP block group \((n = 102)\). We recorded the numerical rating scale (NRS) pain at movement and static during the postoperative 48 h, opioid consumption, additional analgesic requirement, frequency of patient-controlled analgesia (PCA) compressions, Bruggemann Comfort Scale (BCS) score, side effects, duration of hospital stay, and the life quality score (LQS) after operation at 6 months.

Results: The patients in the ESP block group have better analgesia during 12–48 h postoperative time at static state, a lower frequency of PCA compressions at 24–48 h after surgery, and the opioid consumption in the PCA (sufentanil) were less than those in the TLIP block group \((P < 0.05)\). However, the BCS and LQS scores were no different between the two plane block groups after surgery at 6 months. There was no difference in hospital stay and the incidence of side effect among the three groups.

Conclusions: Our results found that patients who suffered ESP block have better analgesic effects and less pain scores in static states and less frequency of PCA compression and opioid analgesic consumption compared with those that suffered TLIP block.

Trial Registration: ChiCTR1800019639.

Keywords: Plane block; Opioid consumption; Analgesia; Lumbar fusion surgery
INTRODUCTION

Patients with lumbar spine fusion have always had serious surgery-related acute pain and chronic preoperative pain before the surgery [1–4]. Until now, there have been no effective regional analgesia techniques to help reduce the surgery-related acute pain of lumbar spine surgery. Recent studies suggest that effective regional anesthesia techniques may help reduce the development of chronic pain and reduce the use of opioids advocated [5, 6]. Novel plane blocks have been developed to improve the management of perioperative pain in the last decade due to the ease of application, low risk of complications, analgesic efficacy, and reduction of opioid consumption [7, 8]. In particular, after the introduction of ultrasonography technology, many plane blocks have gained wide application in surgeries, including transversus abdominis plane block, pectoral I and II blocks, serratus plane block, erector spinae plane block, rhomboid intercostal and subseratus block, and thoracolumbar interfascial plane (TLIP) block [9–12].

The erector spinae plane (ESP) block and TLIP block are the two newest techniques developed in 2015–2016, and since then, publications referring to the two blocks have increased significantly. The ESP block is performed by depositing the local anesthetic between the deep fascia of the erector spinae muscle and the transverse vertebral process [13], while the TLIP targets the fascial plane between the longissimus and iliocostalis muscles away from the midline [14]. Research has shown that both TLIP block and ESP block are useful in pain relief and reducing opioid consumption in lumbar surgery [13, 15, 16]. However, it is still unclear whether one block is superior to the other in terms of effectiveness of analgesia and side effects in lumbar fusion. To address this important gap in understanding, we conducted a comparison study of patients undergoing lumbar spine fusion surgery who received either ESP block or TLIP block as part of their analgesia management.

METHODS

Six hundred eighty-nine patients undergoing lumbar spine fusion surgery at the First Affiliated Hospital of Anhui Medical University were enrolled between November 1, 2018, and January 1, 2020. The study was approved by the Ethics Committee of First Affiliated Hospital of Anhui Medical University (No. PJ2018-11-01) and registered at the Chinese Clinical Trial Registry (ChiCTR1800019639). This study was performed in accordance with the Helsinki Declaration of 1964 and its later amendments. The data were collected by an anesthetist during the operation, and every patient was followed up by phone by the same nurse who was blinded to the entire experiments.

All of the patients signed consent forms and were randomly divided into three group (Group CON, Group ESP, and Group TLIP) according to a computer-generated random number and a 1:1:1 allocation ratio. The patients in Group ESP and Group TLIP were we suffered nerve plane
block as part of analgesia, the patients in Group CON were not suffered nerve plane block. Patients with a history of severe psychiatric illness (major depression or generalized anxiety disorder), preplanned overnight hospitalization, pre-existing chronic pain (lasting at least 3 months), or being opioid-dependent with an average of more than 30 mg of oxycodone per day or the equivalent were excluded.

General anesthesia was induced by intravenous propofol (2–6 mg/kg), sufentanil (0.3–0.5 μg/kg), and cisatracurium (0.15–0.3 mg/kg). During maintenance of general anesthesia, propofol (TCI, 1–2 ul/kg), remifentanil (0.15–0.3 μg/kg/min), and cisatracurium (0.2 mg/kg/h) were used. After surgery, all patients were transferred to the postoperative recovery room and received patient-controlled analgesia (PCA) (sufentanil 4.5 μg/kg + flurbiprofen 100 mg + saline 200 ml, background dose 3 ml/h, self-control supplementary dose 3 ml, locking time 15 min). When the numerical rating scale (NRS) score exceeded 5 at static state, patients were administered intravenous sufentanil (5 μg) one or more times.

After general anesthesia was administered, the ESP block and TLIP block were performed before surgery in the operation room. The TLIP block was performed as described by Hand et al. [10]. A high-frequency linear transducer (EDGE; Sonosite, Bothell, WA, USA) was placed in the midline position at the third lumbar vertebra (L3), and 30 ml of 0.375% ropivacaine was injected bilaterally into the interfascial plane between the longissimus muscle (LF) and multifidus muscles (MFs) of the patient. The ESP block was performed approximately, as described by Melvin et al. [17]. The appropriate T12 vertebral body level was determined by surface dissection or ultrasound, and a high-frequency linear array ultrasonic commutator was placed in the longitudinal sagittal position 3 cm from the midline to determine the tip of the transverse process. The needle pointed from a cranial to a caudal direction. After determining the correct position of the needle tip, 30 ml of 0.375% ropivacaine was bilaterally administered for block performance (Fig. 1).

The primary outcomes of our interest were the NRS pain scores at movement state and static state and the total consumption of opioids at the perioperative period during the 48 h.

The second outcomes of our interest include the side effects of opioids (nausea and vomiting, pruritus, respiratory depression), frequency of PCA compressions, remedial analgesic administration, and the life quality score during the 6 months after surgery.

Statistical analysis was performed using SPSS 23 software (SPSS Inc., Chicago, IL, USA) and GraphPad Prism 8.01 (GraphPad Software, San Diego, CA, USA). Calculations regarding the sample size were performed using an online power sample size calculator based on our previous pilot study data. Our previous pilot study shows that an effective frequency of PCA compressions number for patients under general anesthesia combined with TLIP block and ESP block (7.6 ± 2.2 and 5.2 ± 2.7, respectively) as part of anesthesia after surgery. To detect differences in postoperative PCA compression use 48 h between the ESP block group and TLIP block group, the sample size was 78 per group at a power of 80% and a two-tailed \( \alpha = 0.05 \). We asked 300 patients \( (n = 100/\text{group}) \) to participate in this study.

The ordinal variables are presented as the median and interquartile range. The categorical variables are presented as percentages. The object of baseline data such as age, height, and intraoperative drug dosage, operation time and postoperative press the number using single-factor analysis of variance, and use of LSD method are compared, and two for sex, age, height, intraoperative drug dosage, operation time, and the comparison of postoperative complications such as infections, using a Chi-square test to explore the differences. Repeated measures analysis of variance was used to compare the changes in ASA scores between groups in experimental group TLIP, ESPB, and control group value with a probability lower than \( \alpha = 0.05 \) was accepted as an indicator of significant differences between the groups.
RESULTS

Participants Flow

The Flow diagram (Fig. 2) shows that 689 patient charts were screened; 103 patients did not meet inclusion criteria, 134 patients had other surgical techniques, 137 patients declined to participate the experiments, and 13 patients were lost to follow-up. Three hundred and four patients were finally included in our studies; 100 were assigned Group CON, 102 to Group TLIP, and 102 to Group ESP.

In Table 1, we found that no significant differences in age, gender, surgical site, anesthesia duration, and surgery duration among the three groups.

Primary Outcome

Opioid (sufentanil and remifentanil) consumption was less in Group ESP and Group TLIP compared with Group CON during the perioperative time ($P < 0.05$) and sufentanil consumption in PCA was decreased in Group ESP compared with Group TLIP ($P < 0.05$) (Table 2).

The NRS scores during the 48h postoperative period in Group ESP and Group TLIP were significantly lower than those in Group CON at the static state and movement state ($P < 0.05$). The static NRS scores of Group ESP have lower static NRS pain scores than those in Group at 12h, 24h, and 48h after surgery ($P < 0.05$), however, there is no difference at movement state between the two-block group during postoperative 48h ($P > 0.05$)(Figs. 3, 4).

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Fig. 1 Image of the spread of ESP block and TLIP block. Illustration landmarks and needle approach to the TLIP block and ESPB block. $L$ longissimus muscle, $I$ iliocostalis muscle, $M$ multifidus muscle, $TP$ transverse process, $SP$ spinous process, $ESPB$ erect spine plane block, $TLIP$ thoracolumbar Interfascial plane. (Source credit part A: Ke Chen)
Both the patients in the ESP group and the TLIP group showed fewer PCA compressions and decreased amounts of remedial analgesia and shorter hospital stays than the patients in the control group ($P < 0.01$). The frequency of PCA compressions was decreased in Group ESP compared with Group TLIP at 24–48 h after surgery ($P < 0.05$) (Table 2). The Bruggemann Comfort Scale (BCS) scores and life quality scores (LQS) after surgery showed no difference between the two plane groups, however, better than Group CON (Figs. 5, 6). The side effects of opioids (nausea and vomiting, pruritus, respiratory depression) were no difference among 3 groups (Table 3).

No statistically significant differences were found in the rate of side effects among the three groups.

**DISCUSSION**

Ultrasound-guided plane blocks are a new development in modern regional anesthesia research and practice in recent years, opening new ways for local anesthesia to be transmitted to various anatomic locations [7, 18]. Contrary to traditional peripheral regional anesthesia with defined neural endpoints, the exact targets of the plane blocks have not been well studied, and the indications are not well defined. Plane blocks can simply provide satisfactory consistent and sufficient analgesia when used in combination with multi-modal analgesic method in the context of enhanced recovery after surgery (ERAS) [19–21].

Lumbar fusion surgery is a classic conservative treatment method, which is to limit the progress of deformity and provides better relief [22]. However, spinal fusion surgery of the lumbar region causes severe postoperative pain, which affects rapid postoperative recovery. Although the number of spinal surgeries has increased in recent years, the options for
perioperative pain relief remain limited. The novel regional anesthetic techniques, including TLIP block and ESP block, have been performed for postoperative pain at lumbar surgery in recent years. Ciftci B found that both ESP block and mTLIP block provide adequate analgesia after lumbar discectomy surgery [23]. Our results found that patients who suffered ESP block have better analgesic effects and less pain scores in static states, less frequency of PCA compression, and less opioid analgesic consumption compared with those who suffered from TLIP block.

TLIP block targets the dorsal ramus and its branches exclusively in the lumbar distribution, which is the opposite of ESP block, which depends on local anesthetics craniocaudally diffusing from the plane, deep into the erector spinae muscles and superficial to the vertebrae (especially transverse process and intertransverse ligament) [24]. The local anesthetic in group ESP was injected in the ESP muscle avoids washout during the surgical procedure, and this translates to an increase in the quality and duration of analgesia, which will make patient analgesia last over 12 h [25, 26]. In our study, we found that the ESP block has a better quality of analgesia at static state during postoperative time than TLIP block. Possible explanations for these variations include the anatomic complexity of the thoracolumbar fascia, the volume of injectate administered, and differences in operator technique. These explanations indicate that the TLIP block is difficult to operate with the ESP block in spine fusion surgery and may not provide focused analgesia.

| Characteristic variable | CON group | TLIP group | ESP group | $F/\chi^2$ | $P$ value |
|-------------------------|-----------|------------|-----------|-----------|-----------|
| Age (years)             | 55.69 ± 12.01 | 52.73 ± 12.08 | 53.78 ± 10.16 | 1.736 | 0.178 |
| Height (cm)             | 164.93 ± 11.5 | 166.86 ± 6.95 | 164.03 ± 6.94 | 2.757 | 0.065 |
| Weight (kg)             | 64.13 ± 10.45 | 65.35 ± 10.02 | 64.78 ± 9.93 | 0.368 | 0.692 |
| BMI (kg/m$^2$)          | 24.28 ± 11.26 | 23.4 ± 2.7 | 24 ± 2.71 | 0.431 | 0.65 |
| Gender                  |            |            |           | 4.469 | 0.107 |
| Male                    | 51 (50)    | 58 (58)    | 44 (43.1) |        |        |
| Female                  | 51 (50)    | 42 (42)    | 58 (56.9) |        |        |
| ASA                     |            |            |           | 4.6    | 0.331 |
| 1                       | 11 (10.8)  | 16 (16)    | 21 (20.6) |        |        |
| 2                       | 90 (88.2)  | 83 (83)    | 81 (79.4) |        |        |
| 3                       | 1 (1)      | 1 (1)      | 0 (0)     |        |        |
| The operation section   |            |            |           | 2.473  | 0.649 |
| 1                       | 67 (65.7)  | 70 (70)    | 67 (66.3) |        |        |
| 2                       | 31 (30.4)  | 28 (28)    | 33 (32.7) |        |        |
| 3                       | 4 (3.9)    | 2 (2)      | 1 (1)     |        |        |
| Surgery time (min)      | 130.92 ± 26.91 | 128.32 ± 27.4 | 127.29 ± 30.45 | 0.445 | 0.641 |
| Propofol                | 565.89 ± 158.39 | 554.64 ± 152.54 | 565.78 ± 145.06 | 0.182 | 0.834 |
| Anesthesia time (min)   | 156.58 ± 27.7 | 151.43 ± 28.27 | 148.67 ± 30.88 | 1.956 | 0.143 |
Do ESP blocks provide more focused analgesia than TLIP blocks in lumbar spine surgery? Although the two plane blocks were described and performed for 5 years, many clinical and cadaveric studies have been devoted to the study of its mechanisms, but it is not clear. In near few years, many studies found that ESP block at T12 vertebrae could provide effective analgesia and reduce acute postoperative pain in lumbar surgery, because extensive analgesia could be obtained by depositing a volume of local anesthetic either superficial or deep to the erector spine muscle [27]. In our previous study, we found that ESP block could make the sensory loss to pinprick from the L1 spinous process to S2 spinous process and from left anterior axillary line to right anterior axillary line over the posterior lumbar, however, the scope of analgesia in TLIP block only from L1 to L4 and from left to right posterior axillary line.

### Table 2 Comparison of opioid consumation, PCA compression, and postoperative recovery

| Characteristic variable | CON group | TLIP group | ESP group | F    | P value | P for ESP and TLIP |
|-------------------------|-----------|------------|-----------|------|---------|-------------------|
| Sufentanil at OR        | 42.85 ± 7.84 | 27.82 ± 3.88 | 28.72 ± 3.99 | 233.376 | < 0.001 | 0.249 |
| Remifentanil            | 1233 ± 359.04 | 329.62 ± 365.73 | 359.18 ± 410.81 | 186.078 | < 0.001 | 0.58 |
| Sufentanil in PCA       | 192.38 ± 31.34 | 163.38 ± 25.06 | 126.38 ± 18.86 | 188.385 | < 0.001 | < 0.001 |
| PCA compressions (1–24 h) | 6.28 ± 0.69 | 3.9 ± 0.67 | 3.86 ± 0.58 | 458.725 | < 0.001 | 0.684 |
| PCA compressions (24–48 h) | 4.78 ± 0.6 | 3.28 ± 0.78 | 2.69 ± 0.8 | 222.087 | < 0.001 | < 0.001 |
| Remedial analgesic administration | 10.785 | 0.005 | < 0.05 |
| No                      | 71 (69.6) | 83 (83) | 90 (88.2) |
| Yes                     | 31 (30.4) | 17 (15) | 12 (11.8) |
| Hospital stay (days)    | 5.56 ± 0.57 | 5.19 ± 0.42 | 5.17 ± 0.4 | 22.214 | < 0.001 | 0.725 |

*OR* operation room, *PCA* patient-controlled analgesia

**Fig. 3** NRS at movement state

**Fig. 4** NRS at static state
In order to allow patients to discharge more quickly after surgery and reduce the consumption of opioids, multi-modal analgesia, including regional blocks, was used to minimizing the consumption of other analgesics and their side effects. We found that the consumption of opioids decreased in ESP block compared with the TLIP group and the effective PCA compressions were significantly lower in the ESP block groups than those in the TLIP group. However, there were no differences between patient satisfaction and hospital stay. We also found that early effective regional anesthesia techniques during the perioperative period may help reduce the development of chronic pain and increase life quality compared with control group. However, based on the available evidence, at this point it is hard to argue that either technique is consistently superior for analgesia in lumbar spine surgery.

In addition, this capacity for extensive cranial-caudal diffusion is a unique advantage of the ESP block, which can be performed away from the surgical site, thereby minimizing the risk of microbial contamination. The distortion of the lumbar spine anatomy provoked by surgical intervention (interference due to edema, placement of hardware, bony element removal, or sutures) could interfere with the

**Table 3** Comparison of side effects after operation

| Characteristic variable   | CON group | TLIP group | ESP group | $\chi^2$ | $P$ value |
|---------------------------|-----------|------------|-----------|---------|-----------|
| Respiratory depression    |           |            |           | 0.684   | 0.71      |
| No                        | 95 (93.1) | 95 (95)    | 94 (92.2) |         |           |
| Yes                       | 7 (6.9)   | 5 (5)      | 8 (7.8)   |         |           |
| Skin pruritus             |           |            |           | 2.953   | 0.228     |
| No                        | 92 (90.2) | 94 (94)    | 98 (96.1) |         |           |
| Yes                       | 10 (9.8)  | 6 (6)      | 4 (3.9)   |         |           |
| Nausea or vomiting        |           |            |           | 1.934   | 0.38      |
| No                        | 81 (79.4) | 86 (86)    | 87 (85.3) |         |           |
| Yes                       | 21 (20.6) | 14 (14)    | 15 (14.7) |         |           |
| Sleepness Sleeplessness   |           |            |           | 2.953   | 0.228     |
| No                        | 92 (90.2) | 94 (94)    | 98 (96.1) |         |           |
| Yes                       | 10 (9.8)  | 6 (6)      | 4 (3.9)   |         |           |
identification of the injection site and LA diffusion, which would increase the risk of complications associated with TLIP block performed in the postoperative period. However, in our study, we did not find a high rate of contamination among the three groups. No side effects or complications occurred.

This study has some limitations. First, all of the patients suffered plane block after general anesthesia was administered, so the scope of analgesia was not described by patients. Second, the lack of data makes it impossible to examine certain acute pain risk factors, such as genetics, race, and anxiety. Our work is a small, randomized trial and is designed to be closely integrated with clinical applications. Therefore, there is a need to investigate preclinical toxicity and clinical application in order to elaborate on the mechanism and provide a maximum benefit while minimizing side effects in peripheral nerve blocks.

CONCLUSIONS

In conclusion, our results suggest that the addition of ESP block is associated with early analgesic benefits, including a reduction opioid following lumbar fusion surgery.

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Disclosures. Lizhen Wang, Ying Wu, Lianjie Dou, Ke Chen, Yuesheng Liu, and Yuanhai Li have no conflicts of interest to disclose.

Compliance with Ethics Guidelines. This study was approved by the Academic Committee of Anhui Medical University (No. PJ2018-11-01) and registered at the Chinese Clinical Trial Registry (ChiCTR1800019639). The study was conducted according to the principles of the Helsinki Declaration. All the data analyzed in our study were retrieved from published literature, and we confirmed that written informed consent was obtained. We confirm that we have read the Journal’s position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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