Ultrasound-Guided Erector Spinae Plane Block versus Modified-Thoracolumbar Interfascial Plane Block for Lumbar Discectomy Surgery: A Randomized, Controlled Study

Bahadir Ciftci[1], Mürsel Ekinci[1], Erkan Cem Celik[2,3], Ahmet Murat Yayik[2,3], Muhammed Enes Aydin[2,3], Ali Ahiskalioglu[2,3]

■ OBJECTIVE: **This study aimed to compare the ultrasound (US)-guided erector spinae plane block (ESPB) and modified-thoracolumbar interfascial plane (mTLIP) block for postoperative pain management in lumbar discectomy surgery patients.**

■ METHODS: **A total of 90 patients scheduled for lumbar discectomy were randomly assigned into 3 groups (n = 30 per group): an ESPB group, an mTLIP group, and a control group. In the ESPB and mTLIP groups, a single-shot US-guided block was administered with 20 mL of 0.25% bupivacaine bilaterally. All patients received intravenous patient-controlled postoperative analgesia with fentanyl, and 1 g intravenous paracetamol every 6 hours. Fentanyl consumption, Visual Analog Scale (VAS) pain scores, rescue analgesia, block procedure time, and side-effects were evaluated.**

■ RESULTS: **Postoperative opioid consumption at all time intervals were significantly lower both in ESPB and mTLIP groups compared with the control group ($P < 0.05$). No significant difference was observed concerning intra- and postoperative opioid consumption between the ESPB and the mTLIP group ($P < 0.001$). Passive VAS score at the postanesthesia care unit, second, fourth, and eighth hours, and active VAS score at the postanesthesia care unit, second, fourth, eighth, and 16th hours were significantly lower in the ESPB and mTLIP groups compared with the control group ($P < 0.05$). The use of rescue analgesia was significantly lower in the ESPB and mTLIP groups than in the control group (9/30, 7/30, and 21/30, respectively, $P < 0.001$). The block procedure time was similar between groups ($P = 0.198$).**

■ CONCLUSIONS: **US-guided ESPB and mTLIP block may provide adequate pain control after discectomy surgery. However, there is a nonsuperiority between ESPB and the mTLIP groups.**

INTRODUCTION

Postoperative pain after spinal surgery may lead to severe suffering in patients.[1] Regional analgesia techniques may be preferred for an effective analgesic treatment after spine surgery.[2] The erector spinae plane block (ESPB) is an interfascial plane block that was introduced by Forero et al.[3] The ESPB may be performed for analgesia management in the thoracic, abdominal, and lumbar regions.[4-7] Recently, the ESPB was reported to provide effective analgesia treatment after lumbar spine surgery in several studies.[5,6]

The thoracolumbar interfascial plane (TLIP) block is a method that provides sufficient analgesia for lumbar spine surgeries. It was introduced as a classic approach by Hand et al.[8] However, this technique has the risk of neuraxial injury, and its sonographic imaging may be difficult.[8,9] Therefore Ahiskalioglu et al.[9,10] presented the modified-thoracolumbar interfascial plane (mTLIP) block as a novel approach. Since its introduction, the

Key words
- Erector spinae plane block
- Lumbar discectomy surgery
- Modified-thoracolumbar interfascial plane block
- Postoperative analgesia

Abbreviations and Acronyms
ASA: American Society of Anesthesiologists
CONSORT: Consolidated Standards of Reporting Trials
ESPB: Erector spinae plane block
IV: Intravenous
mTLIP: Modified-thoracolumbar interfascial plane
PACU: Postanesthesia care unit
PCA: Patient-controlled analgesia
TLIP: Thoracolumbar interfascial plane
US: Ultrasound
VAS: Visual Analog Scale

From the [1]Department of Anesthesiology and Reanimation, Medipol University School of Medicine, Istanbul; [2]Department of Anesthesiology and Reanimation, Ataturk University School of Medicine, Erzurum; and [3]Clinical Research, Development and Design Application and Research Center, Ataturk University School of Medicine, Erzurum, Turkey

To whom correspondence should be addressed: Ali Ahiskalioglu, M.D.
[E-mail: aliahiskalioglu@hotmail.com; ali.ahiskalioglu@atauni.edu.tr]

Citation: World Neurosurg. (2020) 144:e849-e855.
https://doi.org/10.1016/j.wneu.2020.09.077

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

mTLIP block was reported to provide analgesia management after spine surgery in different studies.[11,12]

ESPB targets both the ventral and dorsal rami of the spinal nerves, and it spreads over the paravertebral and epidural spaces. However, TLIP targets only the dorsal rami of the spinal nerve, which provides more focused dermatomal coverage for back muscles.[13] To the best of our knowledge, to date there is no comparative study between the ESPB and TLIP for lumbar spinal surgery. In this study, we evaluated and compared the analgesic efficacy of the ultrasound (US)-guided mTLIP block and ESPB following lumbar discectomy surgery. The primary aim of the study was to compare postoperative total opioid consumption. The secondary objective was to compare the postoperative pain scores, the intraoperative opioid consumption, the use of rescue analgesia, the block procedure times, and the adverse effects of opioids.

METHODS

This randomized, prospective, controlled study was approved by the Clinical Research Ethical Committee of Istanbul Medipol University and registered at ClinicalTrails.gov (registration number: NCT04073095). The Consolidated Standards of Reporting Trials (CONSORT) was followed in composing the article (Figure 1). Written informed consent was obtained from all participants.

A total of 90 patients who underwent single-level lumbar discectomy and hemilaminectomy surgery were included in this trial. The participants were aged 18–65 years, underwent general anesthesia, and were classified per the American Society of Anesthesiologists (ASA) classification as ASA I-II. The exclusion criteria were a history of bleeding diathesis, receiving anticoagulant treatment, known allergies to medications used in the study (local anesthetics, nonsteroidal anti-inflammatory drugs, and opioids), skin infections at the site of block area, pregnancy or lactation, and refusal to participate in the study. A computer program was used to randomize the participants into 3 groups. Each group (mTLIP block, ESPB, and control) was composed of 30 patients.

General Anesthesia

All patients were monitored with the standard ASA criteria, electrocardiography, noninvasive blood pressure, and pulse oximetry. Midazolam (2 mg) was administered intravenously (IV) for sedation. Anesthesia induction was performed with IV propofol (2–2.5 mg/kg), fentanyl (1–1.5 μg/kg), and rocuronium bromide (0.6 mg/kg). The patients were placed in the prone position following intubation. Sevoflurane was used in a mixture of oxygen and fresh air for anesthesia maintenance. Remifentanil was administered at an infusion rate of 0.01–0.1 μg/kg/min for intraoperative analgesia. The infusion rate of remifentanil was adjusted according to the baseline heart rate and mean arterial pressure of the patients.

The intraoperative data (heart rate, peripheral oxygen saturation, noninvasive arterial pressure, and end-tidal carbon dioxide level) were recorded at 5-minute intervals during the operation. All patients underwent lumbar discectomy/hemilaminectomy surgery by the same surgical team using the same technique.

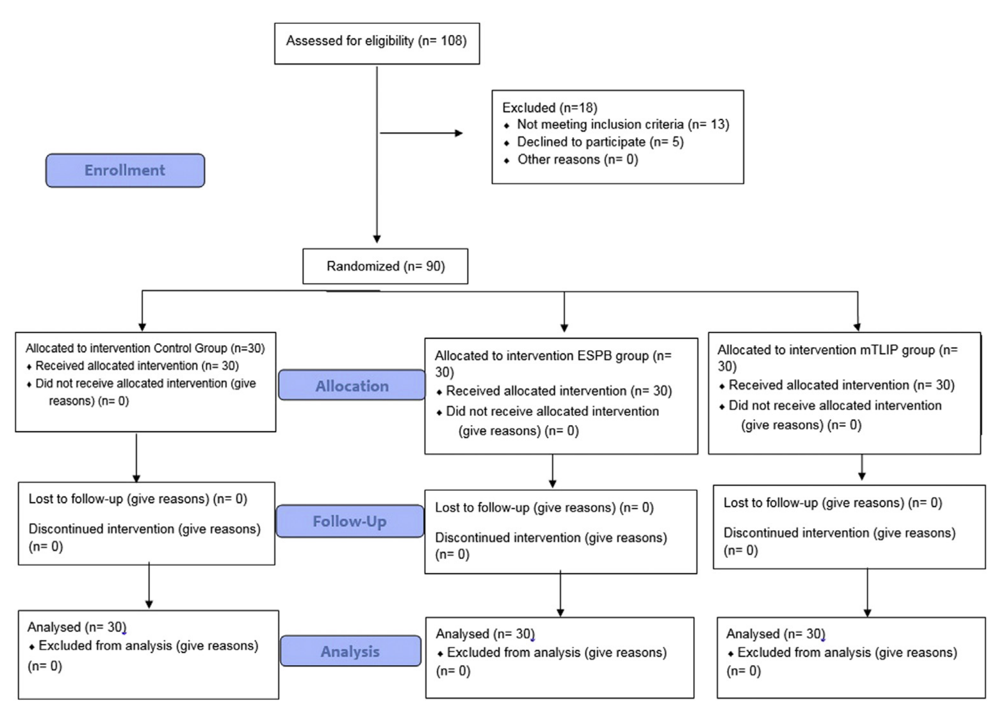

Figure 1. Study flow diagram. ESPB, erector spinae plane block; mTLIP, modified-thoracolumbar interfascial plane.

Block Technique

After the induction of anesthesia, either the US-guided mTLIP block or ESPB was performed in the prone position. A US device (Vivid q, GE Healthcare, Wauwatosa, Wisconsin, USA) with a linear US probe (12 MHz frequency, sterile sheath covered) was used to assist block performance. A 22G sonovisible block needle with a length of 100 mm (Stimuplex Ultra 360, B. Braun, Melsungen, Germany) was used to create a puncture. The control group did not receive any intervention.

ESPB Technique

In the ESPB group, the probe was placed in the parasagittal plane at the level of the L3 vertebrae. The spinous process was visualized, and the probe was moved 3 cm laterally from the midline. The erector spinae muscle was visualized above the transverse process. The needle was punctured in the craniocaudal direction using the in-plane technique. The needle was directed superior to the transverse process (Figure 2). Then, 2 mL normal saline solution was injected into the deep fascia of the erector spinae muscle to confirm the proper injection site. After ensuring the location of the needle, 20 mL of 0.25% bupivacaine was administered. The same ESPB procedure was performed on the other side. In total, 40 mL of 0.25% bupivacaine was administered.

mTLIP Technique

In the mTLIP group, the probe was placed vertically at the L3 vertebrae level. The spinous process and the interspinous muscles (i.e., multifidus, longissimus, and iliocostalis) were visualized as the anatomic guide points. The probe was moved laterally to identify the longissimus and iliocostalis muscles (Figure 2). The needle was inserted between the longissimus and iliocostalis in the medial-to-lateral direction using the in-plane technique. After confirming the location of the needle, 20 mL of 0.25% bupivacaine was administered. The same mTLIP procedure was performed on the opposite side. In total, 40 mL of 0.25% bupivacaine was administered.

A dose of 1 g paracetamol and 100 mg of tramadol were administered IV at the end of the surgery to all patients in the mTLIP, ESPB, and control groups. The patients were extubated after exhibiting sufficient spontaneous respiration and were transferred to the postanesthesia care unit (PACU). After they attained a modified Aldrete score of 12, the patients were discharged from the PACU.

Standard Postoperative Analgesia Protocol and Measurement of Pain

The postoperative analgesic treatment was managed using the classic protocol of our department. At the PACU, a fentanyl patient-controlled analgesia (PCA) device was attached to the patients. The PCA device was prepared with the following protocol: no infusion dose, a 2-mL (10 μg ml^{-1}) bolus, a 20-minute lockout time, and a 4-hour limit of 200 μg. IV 1 g paracetamol was ordered every 6 hours postoperatively.

A pain nurse anesthetist, who was blinded to the trial, evaluated and recorded the opioid consumption and the pain scores using a

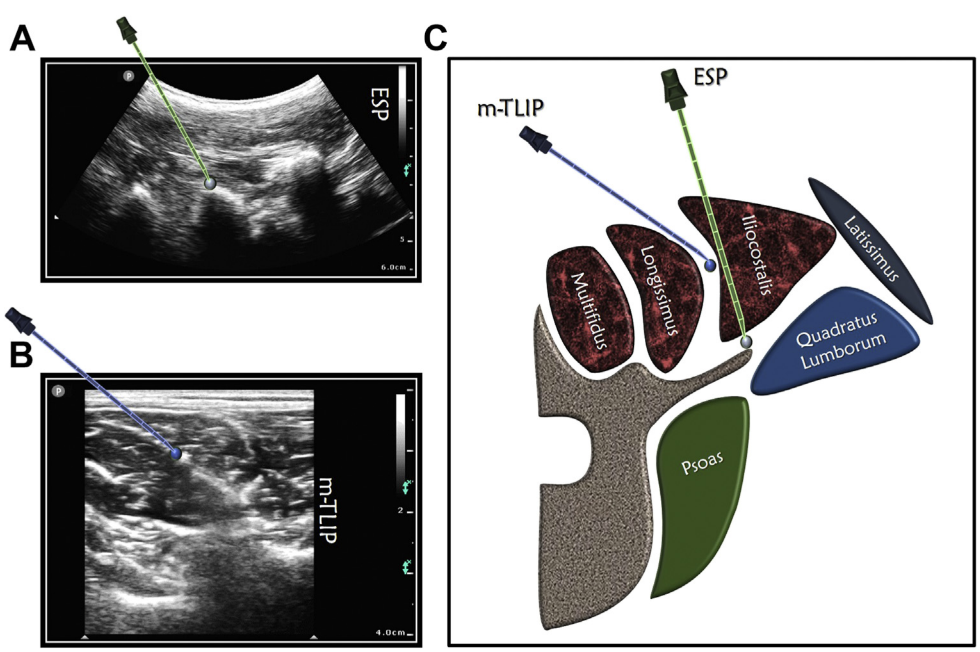

Figure 2. This image shows the real-time sonographic and classic anatomy of the erector spinae plane (ESP) and modified-thoracolumbar interfascial plane (mTLIP) blocks. (**A**) A sonographic image of the ESP block; (**B**) the sonographic image of the mTLIP. (**C**) The illustration of the anatomic differences between the 2 techniques and anatomic block performing areas.

Visual Analog Scale (VAS; 0 = no pain, 10 = the most severe pain). Passive (at rest) and active (while mobilized) VAS scores were recorded in the PACU at 2, 4, 8,16, and 24 hours during the postoperative period. If VAS was higher than or equal to 4, IV meperidine (0.5 mg kg^{-1}) was administered as rescue analgesia within the postoperative 24-hour period. The opioid-related adverse effects (itching, nausea, vomiting, etc.) and the block procedure times were also recorded. The block procedure time was defined as the time interval from the start of the visualization of the sonoanatomy to the injection of the local anesthetic solution.

Sample Size Calculation and Power Analysis

The post hoc sample size calculation was based on the primary outcome variable total fentanyl consumption (µg). Calculations were done with the GPower program (Heinrich-Heine-University, Düsseldorf, Germany). The effect size was calculated from our findings. Given a common standard deviation of 35.0, mean fentanyl consumptions of 32.0 µg, 38.0µg, and 144.0 µg in the ESPB, mTLIP, and control groups, respectively, provided an effect size of 1.46. Sample size calculation for a 2-sided hypothesis with 3 groups having 30 patients in each group (total 90 participants) provides a power of 81% and a Cohen's f effect size of 0.34 (medium-large) to compare the 3 groups with the 1-way ANOVA.

Statistical Analyses

Data analyses were performed by the IBM SPSS 20.0 software (IBM Corporation, Armonk, New York, USA). The distribution of variables was evaluated for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive data were expressed as the mean ± standard deviation. Categorical variables were analyzed using the Pearson χ^2 test. Normally distributed data, including continuous variables, were analyzed using 1-way ANOVA-Robuts Statistic: Brown-Forsythe, nonnormally distributed data were analyzed using Kruskal-Wallis Monte Carlo (post hoc Dunn's test). $P < 0.05$ was considered statistically significant.

RESULTS

The CONSORT flow diagram chart shows the enrollment of the patients for the study (Figure 1). This study included 90 patients, with 30 in each group. The descriptive findings of the participants are presented in Table 1.

The median (minimum-maximum) postoperative total fentanyl consumption was 20.0 (0–140) µg, 20.0 (0–140) µg, and 140.0 (80.0–160.0) µg in the ESPB, mTLIP, and the control groups, respectively. A significant difference was found between the groups ($P < 0.001$). Post hoc comparisons showed a significant difference between the ESPB and control groups ($P < 0.001$), as well as between the mTLIP and control groups ($P < 0.001$), but not between the ESPB and mTLIP groups ($P > 0.05$). Fentanyl consumption at all time intervals was significantly lower both in the ESPB and mTLIP groups than in the control group. No statistical difference was found between the ESPB and mTLIP groups in any time interval for postoperative fentanyl consumption. Rescue analgesia (meperidine) was used in 9 (30.0%) patients in the ESPB group, 7 (23.3%) in the mTLIP group, and 21 (70.0%) in the control group. The use of rescue analgesia was significantly lower in the ESPB and mTLIP groups than in the control group (Table 2). As to the post hoc Dunn's test comparisons, a significant difference was found between the ESPB and control groups ($P < 0.001$) and between the mTLIP and control groups ($P < 0.001$) but not between the ESPB and mTLIP groups ($P > 0.05$) regarding intraoperative opioid consumption. No significant difference was observed concerning the block procedure time between the ESPB group and the mTLIP group (9.1 ± 1.2 min vs. 9.6 ± 1.2 min, respectively) ($P = 0.198$) (Table 2).

No statistical difference was found between the ESPB and mTLIP groups regarding the active and passive VAS score at any time interval. However, the passive VAS score was significantly higher in the control group than in the ESPB and mTLIP groups at PACU, and at 2, 4, and 8 hours (Table 3). Also, the active VAS score was significantly higher in the control group than in the ESPB and TLIP groups at PACU, 2, 4, 8, and 16 hours (Table 3).

Table 1. Demographic Data and Comparison of Operative Procedures Between Groups

	ESPB Group (n:30)	mTLIP Group (n:30)	Control Group (n:30)	*P* Value
Age (years)	46.1 ± 10.1	45.9 ± 9.8	44.1 ± 8.3	0.655*
Sex (M/F)	16/14	16/14	15/15	0.956†
Height (cm)	166.4 ± 8.9	168.2 ± 7.6	164.1 ± 8.0	0.155*
Weight (kg)	80.2 ± 11.0	75.4 ± 10.2	74.8 ± 10.3	0.098*
ASA (I/II)	17/13	15/15	18/12	0.730†
Duration of surgery (min)	71.7 ± 16.7	81.1 ± 23.9	76.8 ± 20.3	0.206*
Duration of anesthesia (min)	94.3 ± 18.7	99.7 ± 22.8	96.6 ± 19.0	0.586*
Level of surgery (L2-L3/L3-L4 /L4-L5/ L5-S1)	4/11/15/0	2/17/10/1	3/13/10/4	0.194†

Values are expressed mean ± standard deviation or number.
ESPB, erector spinae plane block; mTLIP, modified-thoracolumbar interfascial plane; M, male; F, female; ASA, American Society of Anesthesiologists.
*One-way ANOVA between groups.
†Pearson χ^2 test between groups.

Table 2. The Comparison of Intraoperative (Remifentanil) and Postoperative (Fentanyl) Opioid Consumptions and the Use of Rescue Analgesia (Meperidine) Between Groups

	ESPB Group (n:30)	mTLIP Group (n:30)	Control Group (n:30)	*P* Value
PCA 0–8 hr (mcg)	20 (0–100)§	20 (0–100)§	100 (60–140)	**<0.001***
PCA 8–16 hr (mcg)	0 (0–60)§	0 (0–40)§	40 (20–80)	**<0.001***
PCA 16–24 hr (mcg)	0 (0–40)§	0 (0–20)§	0 (0–40)	**0.029***
PCA total (mcg)	20 (0–140)§	20 (0–140)§	140 (80–260)	**<0.001***
Intraoperative opioid consumption (μg)	250 (150–375)§	263 (150–375)§	375 (245–550)	**<0.001***
Rescue analgesia (Y/N)	9/21§	7/23§	21/9	**<0.001**†
Block procedure time (min)	9.1 ± 1.2	9.6 ± 1.2	N/A	0.198‡

Bold values denote statistical significance at the $P < 0.05$ level.
Values are expressed mean ± standard deviation or median (minimum-maximum).
ESPB, erector spinae plane block; mTLIP, modified-thoracolumbar interfascial plane; PCA, patient-controlled analgesia; Y, yes (indicates the number of the patients who used rescue analgesia); N, no; N/A, not applicable.
*Kruskal-Wallis (Monte Carlo), post hoc test: Dunn's test.
†Pearson χ^2 test between groups.
‡Mann-Whitney *U* test.
§$P < 0.05$ compared with control group.

Postoperative nausea was experienced significantly higher in the control group compared with the ESPB and mTLIP groups. No significant difference was found between the groups in terms of other adverse effects (Table 4). No block-related complications, such as vascular or neuraxial injury and motor blockade, were observed in any group.

DISCUSSION

This study was designed to evaluate the practicality and analgesic efficacy of the ESPB and mTLIP block against the no intervention control group following lumbar disc herniation surgery. The intra- and postoperative opioid consumption and VAS scores were lower in both the ESPB and mTLIP groups than the control group in the first

Table 3. Comparisons of Active and Passive Visual Analog Scale Assessment Between Groups

	ESPB Group (n:30)	mTLIP Group (n:30)	Control Group (n:30)	*P* Value†
VAS passive				
PACU	1 (0–4)*	2 (0–5)*	4 (2–6)	**<0.001**
Second hr	1 (0–3)*	2 (0–5)*	3 (2–4)	**<0.001**
Fourth hr	1 (0–3)*	1 (0–3)*	2 (1–3)	**<0.001**
Eighth hr	1 (0–2)*	1 (0–2)*	2 (0–3)	**0.002**
16th hr	1 (0–4)	1 (0–2)	1 (0–2)	0.443
24th hr	0 (0–1)	0 (0–1)	0 (0–1)	0.113
VAS active				
PACU	2 (0–5)*	2 (0–5)*	5 (3–7)	**<0.001**
Second hr	2 (0–4)*	2 (1–5)*	4 (3–5)	**<0.001**
Fourth hr	2 (0–4)*	1 (0–3)*	3 (2–4)	**<0.001**
Eighth hr	2 (0–2)*	1 (0–2)*	3 (1–4)	**<0.001**
16th hr	1 (0–5)*	1 (0–3)*	2 (0–3)	**0.003**
24th hr	0 (0–3)	0 (0–2)	1 (0–2)	0.801

Bold values denote statistical significance at the $P < 0.05$ level.
Values are expressed as median (minimum-maximum).
VAS, Visual Analog Scale; PACU, postanesthesia care unit.
*$P < 0.05$ compared with control group.
†Kruskal-Wallis (Monte Carlo), post hoc test: Dunn's test.

Table 4. Comparison of the Incidence of Side Effects Between Groups and the Comparison of Block Performance Times Between ESPB and mTLIP Groups

	ESPB Group (n:30)	mTLIP Group (n:30)	Control Group (n:30)	*P* Values
Breathing depression	0	0	0	N/A
Sedation/confusion	0	0	0	N/A
Nausea (Y/N)	3/27*	3/27*	13/17	**0.001**†
Vomiting (Y/N)	2/28	3/27	7/23	0.133†
Itching (Y/N)	7/23	4/26	4/26	0.487†

Bold value denotes statistical significance at the $P < 0.05$ level.
N/A, not applicable; Y, yes; N, No.
*$P < 0.05$ compared with control group.
†Pearson χ^2 test between groups.

24 hours after the surgery. No difference was found between the ESPB and mTLIP groups concerning block performance time.

Patients may complain from moderate-to-severe pain after lumbar spine surgery. Postoperative analgesia treatment is essential for patient satisfaction and early mobilization. Pain management after surgery is also crucial to prevent postoperative complications, such as atelectasis and thromboembolism.[14,15]

US-guided ESPB was first introduced by Forero et al.[3] for the analgesia management of chronic thoracic pain. Since then, ESPB has been performed in a wide indication range, from the cervicothoracic to the lumbar spine region.[16-20] ESPB acts on the dorsal and ventral rami of the thoracic spinal nerves, and thus provides multidermatomal sensory block through the craniocaudal spread of local anesthetics.[21,22] Although it is an interfascial block recently ESPB has been described as a paraspinal block. Cadaveric and radiologic studies have demonstrated the action mechanism of ESPB as the spread of local anesthetics to the paravertebral and epidural space.[21-23] ESPB is similar to a paravertebral block and epidural analgesia, and therefore may provide both visceral and somatic analgesia. ESPB has been reported to provide adequate analgesia management for several lumbar spine surgical procedures in randomized studies and case reports.[16-18]

US-guided mTLIP block is an interfascial plane block similar to ESPB. In the classic approach of Hand et al.,[8] a local anesthetic solution is injected into the interfascial area between the multifidus and longissimus muscles at the third lumbar vertebra level. Ahiskalioglu et al.[9,10] demonstrated the novel modified approach of US-guided TLIP block (mTLIP block) because of the risk of neuraxial injury and the difficulty in sonographic imaging. In this modified technique, a local anesthetic solution is injected into the interfascial area between the longissimus and iliocostalis muscles. The mechanism of mTLIP is to target the dorsal rami of the lumbar nerves. It provided effective analgesia management following lumbar spine surgical procedures in several studies. Moreover, the mTLIP block could block the dorsal rami of the lumbar nerves.[24] In several randomized studies and case reports, the mTLIP block was found to provide adequate pain management following lumbar spine operations.[11,25-27]

No research has yet compared these 2 effective analgesic techniques for spine surgeries. Thus this study aimed to evaluate ESPB and mTLIP block against the control group following lumbar discectomy surgery. Our results showed that both ESPB and the mTLIP block provide effective and similar quality of analgesia compared with the control group by reducing the opioid consumption and VAS scores. Additionally, the block performance times of the ESPB and mTLIP block were nearly similar.

Possible benefits of the interfascial plane block include the ease of performance with clear landmarks for sonographic anatomy. Both lumbar ESPB and TLIP block technique is nearly safe, as the point of the injection site is a muscular plane, and there is practically no risk for neuraxial puncture and nerve damage. Although only 1 case of the motor block due to ESPB is described in the literature, the possibility of motor block is very low, depending on the concentration of local anesthetic used. This provides an advantage in a neurologic examination for detecting complications that may occur after surgery.

However, the TLIP block may provide more focused analgesia than the ESPB in lumbar spine surgical procedures.[13] The TLIP block targets only the dorsal rami, and thus it may be an ideal analgesic technique for lumbar operations. The ESPB targets both the ventral and dorsal rami of the spinal nerves. It provides adequate analgesia for lumbar surgeries as well, but it may lead to the unintended motor blockade.[28] The spread of the local anesthetic solution was observed in the lumbar plexus in several anatomic and radiologic studies. Case reports about motor blockage owing to the ESPB were reported in the literature. This could be a disadvantage for neuromonitorization in patients who underwent lumbar spine surgery because early neurologic evaluation is assessed at the postoperative period in these patients.[29] Therefore the mTLIP block may be a better choice for analgesia management after lumbar surgeries. Further studies evaluating the efficacy of the ESPB and mTLIP block with neuromonitorization techniques are needed at this point.

This study has some limitations. First, we did not perform dermatomal sensory testing because, the blocks were performed after the general anesthesia induction. Second, we did not perform neuromonitorization techniques to evaluate the efficacy of the ESPB and mTLIP block. Another limitation of the study is that no sham injection was applied to the control group. Therefore the study is not a double-blind study.

CONCLUSIONS

Both the ESPB and mTLIP blocks provide adequate analgesia after lumbar spinal surgery. Clinicians can choose either the mTLIP block or the ESPB for pain control after lumbar spinal surgery based on their clinical experience and choice.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Bahadir Ciftci: Conceptualization, Methodology, Writing - original draft. **Mürsel Ekinci:** Data curation, Writing - original draft. **Erkan Cem Celik:** Visualization, Investigation. **Ahmet Murat Yayik:** Supervision. **Muhammed Enes Aydin:** Validation. **Ali Ahiskalioglu:** Writing - review & editing.

REFERENCES

1. Kraiwattanapong C, Arnuntasupakul V, Kantawan R, Woratanarat P, Keorochana G, Langsanam N. Effect of multimodal drugs infiltration on postoperative pain in split laminectomy of lumbar spine: a randomized controlled trial [e-pub ahead of print] *Spine (Phila Pa 1976)*; 2015. https://doi.org/10.1097/brs.0000000000003679, accessed September 1, 2020.

2. Mergeay M, Verster A, Van Aken D, Vercauteren M. Regional versus general anesthesia for spine surgery. A comprehensive review. *Acta Anaesthesiol Belg*. 2015;66:1-9.

3. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. *Reg Anesth Pain Med*. 2016;41:621-627.

4. De Cassai A, Bonvicini D, Correale C, Sandei L, Tulgar S, Tonetti T. Erector spinae plane block: a systematic qualitative review. *Minerva Anestesiol*. 2019;85:308-319.

5. Chin KJ, Adhikary SD, Forero M. Erector spinae plane (ESP) block: a new paradigm in regional anesthesia and analgesia. *Curr Anesthesiol Rep*. 2019; 9:271-280.

6. Tulgar S, Ahiskalioglu A, De Cassai A, Gurkan Y. Efficacy of bilateral erector spinae plane block in the management of pain: current insights. *J Pain Res*. 2019;12:2597-2613.

7. Ciftci B, Ekinci M, Celik EC, Tukac IC, Bayrak Y, Atalay YO. Efficacy of an ultrasound-guided erector spinae plane block for postoperative analgesia management after video-assisted thoracic surgery: a prospective randomized study. *J Cardiothorac Vasc Anesth*. 2020;34:444-449.

8. Hand WR, Taylor JM, Harvey NR, et al. Thoracolumbar interfascial plane (TLIP) block: a pilot study in volunteers. *Can J Anaesth*. 2015;62: 1196-1200.

9. Ahiskalioglu A, Yayik AM, Alici HA. Ultrasound-guided lateral thoracolumbar interfascial plane (TLIP) block: description of new modified technique. *J Clin Anesth*. 2017;40:62.

10. Ahiskalioglu A, Alici HA, Selvitopi K, Yayik AM. Ultrasonography-guided modified thoracolumbar interfascial plane block: a new approach. *Can J Anaesth*. 2017;64:775-776.

11. Ahiskalioglu A, Yayik AM, Doymus O, et al. Efficacy of ultrasound-guided modified thoracolumbar interfascial plane block for postoperative analgesia after spinal surgery: a randomized-controlled trial. *Can J Anaesth*. 2018;65: 603-604.

12. Ueshima H, Ozawa T, Toyone T, Otake H. Efficacy of the thoracolumbar interfascial plane block for lumbar laminoplasty: a retrospective study. *Asian Spine J*. 2017;11:722-725.

13. Hamilton DL. Does thoracolumbar interfascial plane block provide more focused analgesia than erector spinae plane block in lumbar spine surgery [e-pub ahead of print]? *J Neurosurg Anesthesiol* https://doi.org/10.1097/ANA.0000000000000643, accessed September 17, 2019.

14. Efthymiou CA, O'Regan DJ. Postdischarge complications: what exactly happens when the patient goes home? *Interact Cardiovasc Thorac Surg*. 2011;12:130-134.

15. McGirt MJ, Ambrossi GL, Datoo G, et al. Recurrent disc herniation and long-term back pain after primary lumbar discectomy: review of outcomes reported for limited versus aggressive disc removal. *Neurosurgery*. 2009;64:338-344 [discussion: 344-335].

16. Yayik AM, Cesur S, Ozturk F, et al. Postoperative analgesic efficacy of the ultrasound-guided erector spinae plane block in patients undergoing lumbar spinal decompression surgery: a randomized controlled study. *World Neurosurg*. 2019;126:e779-e785.

17. Singh S, Choudhary NK, Lalin D, Verma VK. Bilateral ultrasound-guided erector spinae plane block for postoperative analgesia in lumbar spine surgery: a randomized control trial. *J Neurosurg Anesthesiol*. 2020;32:330-334.

18. Melvin JP, Schrot RJ, Chu GM, Chin KJ. Low thoracic erector spinae plane block for perioperative analgesia in lumbosacral spine surgery: a case series. *Can J Anaesth*. 2018;65:1057-1065.

19. Altiparmak B, Toker MK, Uysal A, Kuşçu Y, Demirbilek SG. [Efficacy of ultrasound-guided erector spinae plane block for analgesia after laparoscopic cholecystectomy: a randomized controlled trial]. *Rev Bras Anestesiol*. 2019;69:561-568.

20. Ahiskalioglu A, Tulgar S, Celik M, Ozer Z, Alici HA, Aydin ME. Lumbar erector spinae plane block as a main anesthetic method for hip surgery in high risk elderly patients: initial experience with a magnetic resonance imaging. *Eurasian J Med*. 2020;52:16-20.

21. Yang HM, Choi YJ, Kwon HJ, O J, Cho TH, Kim SH. Comparison of injectate spread and nerve involvement between retrolaminar and erector spinae plane blocks in the thoracic region: a cadaveric study. *Anaesthesia*. 2018;73:1244-1250.

22. Greenhalgh K, Womack J, Marcangelo S. Injectate spread in erector spinae plane block. *Anaesthesia*. 2019;74:126-127.

23. Celik M, Tulgar S, Ahiskalioglu A, Alper F. Is high volume lumbar erector spinae plane block an alternative to transforaminal epidural injection? Evaluation with MRI. *Reg Anesth Pain Med*. 2019;44: 906-907.

24. Ueshima H, Otake H. Ultrasound-guided "lateral" thoracolumbar interfascial plane (TLIP) block: a cadaveric study of the spread of injectate. *J Clin Anesth*. 2017;40:54.

25. Ekinci M, Ciftci B, Atalay YO. Ultrasound-guided modified thoracolumbar interfascial plane block is effective for pain management following multilevel lumbar spinal fusion surgery. *Ain-Shams J Anesthesiol*. 2019;11:24.

26. Li C, Jia J, Qin Z, Tang Z. The use of ultrasound-guided modified thoracolumbar interfascial plane (TLIP) block for multi-level lumbar spinal surgery. *J Clin Anesth*. 2018;46:49-51.

27. Ahiskalioglu A, Yayik AM, Celik EC, Aydin ME, Uzun G. Ultrasound guided modified thoracolumbar interfascial plane block for low back pain management. *J Clin Anesth*. 2019;54:138-139.

28. Selvi O, Tulgar S. Ultrasound guided erector spinae plane block as a cause of unintended motor block. *Rev Esp Anestesiol Reanim*. 2018;65:589-592.

29. Xu JL, Doherty T, Patel R, Galeno J, Dotzauer B. Analgesic efficacy of ultrasound-guided modified thoracolumbar interfascial plane block performed with the use of neurophysiology monitoring for postoperative lumbar surgery. *J Clin Anesth*. 2019;52:21-23.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 18 June 2020; accepted 15 September 2020

Citation: World Neurosurg. (2020) 144:e849-e855.
https://doi.org/10.1016/j.wneu.2020.09.077

*Journal homepage: **www.journals.elsevier.com/world-neurosurgery***

*Available online: **www.sciencedirect.com***